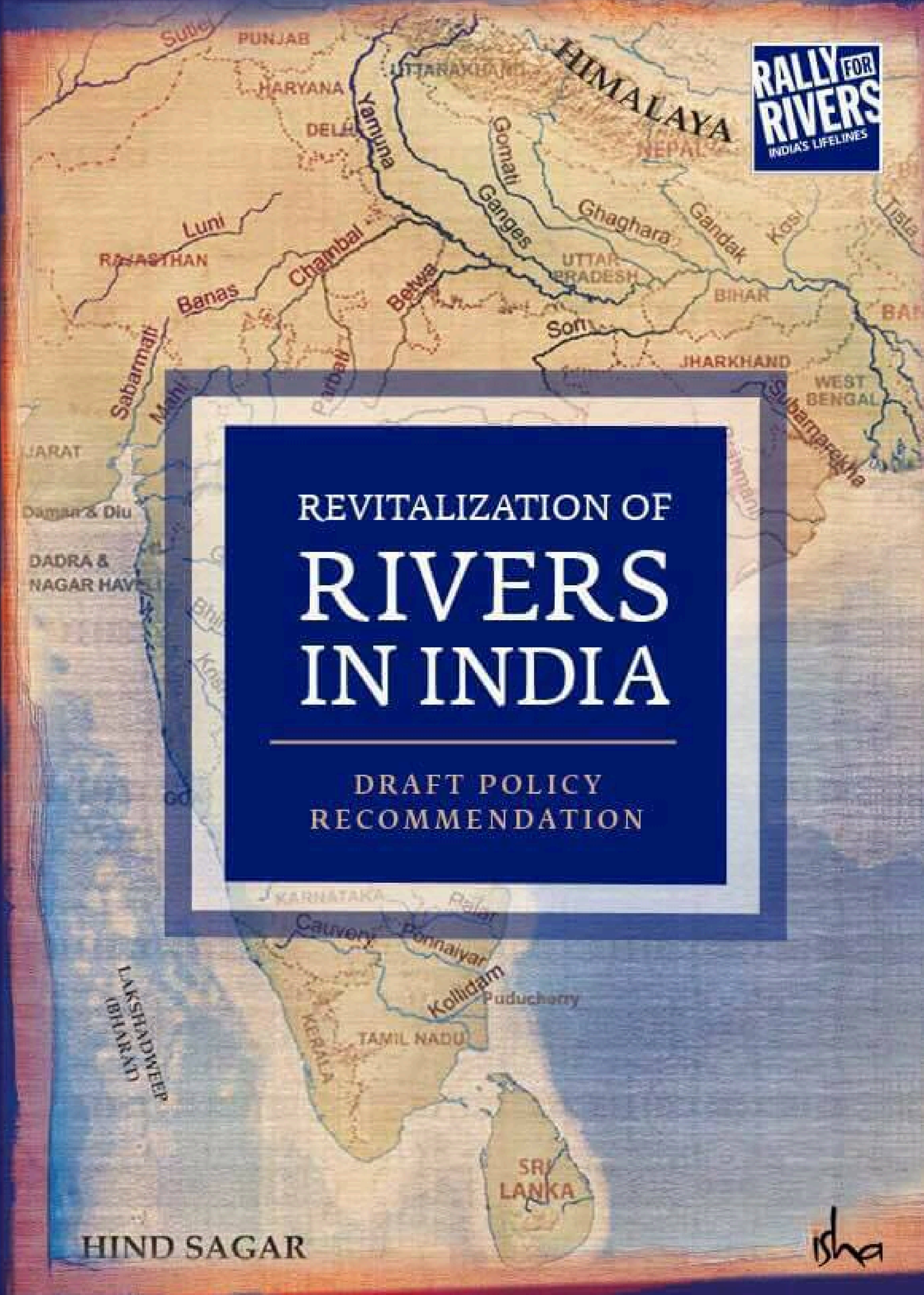
RALLY FOR RIVERS
INDIA'S LIFELINES

REVITALIZATION OF RIVERS IN INDIA

DRAFT POLICY RECOMMENDATION



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RallyForRivers.org
policy@RallyForRivers.org

Nadi Stuti

Bharatam Mahabharatam
Ganga Narmada Punya Teertham
Sindhu Saraswati Kaveri
Jeevana Kaarana Moola Tatvam
Nadi Raashtrasya Maha Amritam
Bharatam

Bharat – The Great Land
The land with the pure waters of
Ganga, Narmada, Sindhu, Saraswati and Kaveri
Where water is seen as that element which
is the basis and the source of all life.
Rivers are the lifelines of this
nation – Bharat

This document is about the augmentation of river waters. The health and life of the river as a living entity is the prime concern of this document. How river waters are put to use for hydroelectricity generation, agriculture, waterways, etc is not within the purview of this draft. The exploitation of the river as a source of economic and human well-being must come from a scientific basis and not from emotional or political considerations. This effort is towards preserving and revitalizing India's rivers. All concerned should join hands in this effort.

Preface

My engagement with mountains, forests and rivers goes back to my early childhood – not just in terms of nature and its resources that one enjoys, but as experiencing them as an integral part of myself. With four truck tubes and bamboo poles tied together, I have traversed the river Kaveri for 13 days alone. I saw the river as a life much larger than myself. People like you and me come and go, but the river has flowed for millions of years and sustains life in proportions that you cannot imagine. A river is not a resource to me; it is an immense Life. The very nature of our existence is such that literally three-fourths of our body is water. So water is not a commodity – water is life-making material. When it is in this body, how much of attachment we have towards it! When it is flowing out there, why are we treating it any differently?

In the last 25 years I have been watching with concern, the gradual depletion of river flows across the country. The flow is not one year up and one year down, but steadily, gradually depleting. Last year this depletion has taken a very steep downturn. If our rivers deplete like this in our own lifetime, we are clearly making a statement that we are not interested in the future of our children, in the wellbeing of future generations in this land.

I am not a scientist and have no appropriate scientific knowledge or words to articulate this. But in my simple observation, I see it is lack of vegetation and excessive groundwater exploitation that have together wrought havoc upon our rivers. When there is not enough vegetation, especially in a tropical climate, the soil will turn into sand. Soil and rivers are deeply connected. If we deplete our soil, we will also deplete our rivers. This is what has happened to us today – our water bodies have depleted and our soil is degraded.

The greatest achievement in this country has been that our farmers – without much infrastructure, without any science, with just traditional knowledge –have been able to provide food for 1.3 billion people of this nation. But depletion of organic content in the soil and inadequate water

has driven our farmers to a corner and suicides are becoming common. If you and I were asked to produce food from a land with no fertility and not enough water, we would also be driven to do the same. The farmer, who gives us food, who nourishes our life, is barely nourished himself – and his children are starved. How can we walk with our heads held high when we know that the one who provides food for us is starved to a point where he wants to take his own life? This is a point of great shame. I put my head down in shame, because somehow we have not been able to take care of this.

The majority of the population in the country is involved in farming. There is a phenomenal amount of knowledge in the farmer because of a history of 8000 to 12,000 years of agriculture. There is a *samskara* of agriculture in them. It is not just hard work – there is a knowledge that we have taken for granted. Only less than 15% of farmers wish for their children to get into farming. If we do not create the right situation for them, if we do not harness this knowledge now, it may be lost forever. Using our farmers' traditional knowledge in improving soil, augmenting the source of water by vegetating the land in all possible ways, and managing water use with appropriate modern technologies, is the way forward.

The solution we are proposing is that for at least one kilometer-width on either side of all major rivers, and at least five hundred meters for smaller rivers, the land must have tree cover. The land should be under shade so that organic material in the soil can build up. Only then will the soil retain water and allow it to percolate into the river. Where the government owns the land, afforestation is a must. Where farmers own the land, it must transition from regular crop farming to tree-based agriculture. This shift is a better economic proposition for an Indian farmer, as it can multiply his income at least 3 to 5 times.

This Draft Policy Recommendation is an effort to make the solution into an economic policy with significant ecological impact. It is an outcome of our consultation with specialists from various fields of expertise and experience, taking into consideration the interest of all stakeholders: the first and foremost stakeholder being the river; then the life sustained by the river; then the farmer; the larger community; and the governments – state and central. Making this into an implementable and enforceable policy is the prime goal. The scientific team or I myself shall always be available to clarify any aspects that need elaboration.

Over millennia, for generations, our rivers have embraced us and nourished us. A time has come when we have to embrace and nourish our rivers. It is our humble hope that the needed legislative and administrative steps will be taken as per our suggestions and will be made into a mandatory law. Let us move towards making a law that will treat our rivers, water bodies and soil as National treasure.

~ Sadhguru

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1. PREAMBLE

Rivers have been the origins of the earliest human civilizations. They have etched their paths, cutting through rocky terrain to create fertile floodplains. Being home to a wide range of biodiversity, the rivers have assumed a distinct identity as 'life givers' across the world. What's more, rivers in India have a significance beyond economic wellbeing – as they are inextricably intertwined with our cultural and spiritual heritage.

In the past few decades, our rivers have been depleting drastically due to various factors like over-extraction, deforestation, pollution from point and non-point sources, and climate variation (increasing temperatures and differential precipitation patterns). Major rivers are rapidly shrinking, and many perennial rivers have turned seasonal, not even reaching the oceans for many months of the year. Godavari has shrunk by almost 20% from historical flows. Kaveri has shrunk by 40%, while Krishna and Narmada have shrunk by 60%.[1] According to estimates, by 2030 we will have only 50% of the water that we need for our survival. Further, 25% of India is becoming desert. As compared to 1947, we have about 25% water per capita available today. Rivers meet one-third of the total irrigation and twenty percent of the drinking water needs of the country.[2] Groundwater and other water bodies/resources that meet the rest of our water needs, are already over-stressed across the nation and are being over-utilized at an alarming rate. Twenty-two out of thirty-two major Indian cities deal with daily water shortages. Water scarcity and drought has become a reality for today's generation in India.[3] In case priority action is not initiated to enhance water supply and reduce over-exploitation of our water resources, in another fifteen to twenty years' time, the country may face a severe water and food crisis.

Recognizing this crisis, the Government has launched programs like Namami Gange and Namami Devi Narmada to improve the state of

1 Gupta, Harish, Shuh-Ji Kao, and Minhan Dai. "The role of mega dams in reducing sediment fluxes: A case study of large Asian rivers." Journal of Hydrology 464 (2012): 447-458

2 Improving Water Security in India, India Policy Paper, OECD, Link: https://goo.gl/8qpGU9

3 A Quarter of India's Land Is Turning into Desert, Scientific American, Link: https://www.scientificamerican.com/article/a-quarter-of-india-s-land-is-turning-into-desert/

rivers. However, what are now needed are large-scale interventions that seek to protect and revitalize our riverine ecosystem. Given the state of affairs, what is desirable is a holistic **policy framework**, focusing on river revitalization that combines source augmentation and conservation of rivers. This needs to happen both at the national and state government levels.

Furthermore, such an effort to revitalize rivers needs to happen in conjunction with improving the livelihoods of riverine communities. This will ensure ownership and economic benefits for the community, leading to an effective protection and conservation of the river in the long run.

At the international level, India stands committed to the **United Nations' Sustainable Development Goals (SDG) 2030**, that lay stress on "leaving no one behind". A holistic policy framework aimed at revitalizing our rivers and enhancing the livelihoods of riverside farmers and communities will also help India achieve SDG 6 (Clean Water and Sanitation), Goal 15 (Life on Land) and Goal 13 (Climate Action). It will also have an important impact on other SDGs – in particular Goal 1 (Poverty), Goal 2 (Zero Hunger), Goal 3 (Good Health and Wellbeing), Goal 8 (Decent Work and Economic Growth), Goal 9 (Industry, Innovation and Infrastructure), Goal 10 (Reduce Inequality), Goal 11 (Sustainable Cities and Communities) and Goal 12 (Sustainable Production and Consumption).

Rivers need to be recognized as a **'national treasure'.** The protection of rivers should encompass: a) ensuring full ecological/environmental flows; and b) preserving biological, chemical and physical characteristics of the water that protect the gene pool. Rivers need to be accorded due place in India's development agenda, since they support a sizeable population directly and indirectly. Hence the demand to conserve and revitalize our rivers becomes paramount. Revitalizing rivers and safe-guarding the livelihoods of communities should be guided by robust research and use of appropriate innovative technologies like remote sensing/GIS, and data analysis.

2. THE OVER-ARCHING IDEA OF RIVERSIDE AFFORESTATION

Revitalization of dying rivers is possible through riverside afforestation. The proposed solution and policy recommendation is to develop tree cover by planting trees for a minimum of 1 kilometer-width along the entire river's length on either side of the river. All public land beside the river should be converted entirely into forest with native and endemic tree species. In riverside farmlands, there should be a multi-tier tree-based agriculture practiced for a minimum width of 1 kilometer on either sides of the river. The agro-forestry in riverside farmlands is suggested to encompass as a whole all villages that fall within the target area, i.e. the minimum 1-kilometer lateral distance from the river. This will ensure that a village functions as the unit of operation, thus applying the 73rd Amendment of the Constitution that empowers the village panchayat as the most decentralized unit of self-governance.

Figure 1 illustrates how the proposed solution will translate into increased water flow in the rivers.

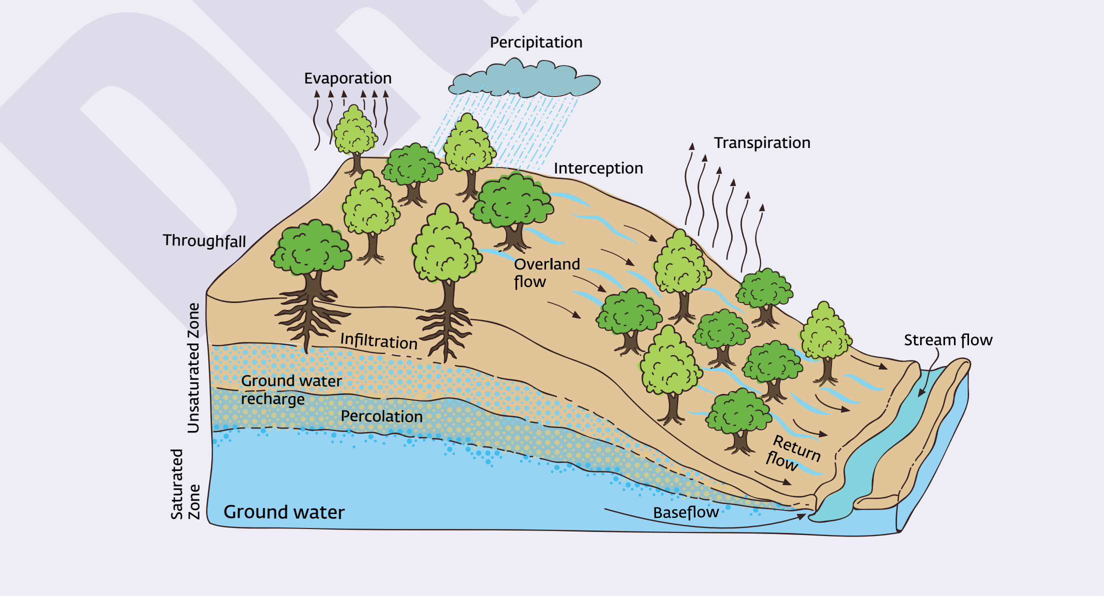


FIGURE 1: PHYSICAL PROCESS THROUGH WHICH TREES CONTRIBUTE TO INCREASED RUNOFF AND BASE FLOW IN RIVERS

The proposed policy recommendation is, in fact, an economic program with a beneficial ecological consequence. The proposal will primarily improve the condition of rivers while increasing riverine farmers' incomes, strengthening social inclusion, advancing environmental sustainability, and ensuring inter-generational equity of access to adequate water. It provides for a coherent framework with a 'people centric' approach, while drawing upon the National Water Policy 2012, National Environment Policy 2006, National Agroforestry Policy 2014 and National Policy for Farmers 2007. The policy also promotes linkages with government schemes like: MGNREGA; Paramparagat Krishi Vikas Yojana (PKVY); Pradhan Mantri Krishi Sinchai Yojana (PMKSY); National Initiative on Climate Resilient Agriculture; National Mission on Sustainable Agriculture (NMSA); Green India Mission (GIM); Skill India Mission/Pradhan Mantri Kaushal Vikas Yojana (PMKVY); Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDSA); MUDRA scheme; and others.

3. THE DETAILED RECOMMENDATIONS

Our rivers face challenges on two fronts – quality and quantity, which need to be addressed simultaneously.

Revitalizing Indian rivers is essential to sustain ecosystem functions and provides livelihood security for a large number of communities dependent on them. Therefore, it will be essential that a river satisfies the following two characteristics provided as the definition of a river by the Government of India: *aviral dhara* – unhindered and unfettered minimum flows; and *nirmal dhara* – an unpolluted flow. A solution should be promoted that facilitates revitalization of rivers and their dependent communities, while mitigating risks from pollution and misuse. This notion is succinctly captured in the dual thought of needing both 'Life for River' and 'River for Life':

Life for River: the dying rivers need a surge of life to protect them from extinction

River for Life: human beings and biodiversity need the river for their survival and growth, and to secure livelihoods.

Consequently, the recommendations are divided broadly into four categories and are detailed as follows.

3.1. RIVER REVITALIZATION

(a) **Environmental Flows:** A minimum environmental flow of water till the sea coast – enough to sustain the flora and fauna in the ecologically sensitive zones along the river – must be mandated for every river under the Environment Protection Act, 1986.

(b) **Ecologically Sensitive Zone:** The minimum lateral distance of 1-kilometer from the river should be demarcated and declared as an ecologically sensitive zone under the Environment Protection Act, 1986, with do's and don'ts prescribed to protect it.

(c) **Saturation Model:** For any work on a river to have the desired effect, it has to be implemented along the entire length of the river. Farmers in the mentioned target area should be eligible to participate in the revitalization program and access compensation or incentives irrespective of the size of their land-holding.

(d) **Production of Quality Planting Material (QPM) by Establishing Nurseries:** A tree-plantation activity of this scale, along the entire stretch of a river for hundreds of kilometers, will require millions of QPM to ensure optimal economic returns.

(e) **Declaration of Floodplains to Be Chemical-Free Zones:** According to the Government of India's definition of a river, "*nirmal dhara*", or unpolluted flow, is compulsory. Therefore, use of chemicals for cultivation on target areas should be prohibited, in order to ensure good water quality in the river.

(f) **Identification, Delineation, and Notification of River Lands**: The area encompassing the river and its surrounding land that is part of the riverine ecosystem must be demarcated. Additionally, clear responsibilities need to be delineated for any institutional entity that maintains or manages the river, so as to function effectively.

(g) **Regulatory Framework**: Effective implementation of an appropriate regulatory framework must happen, to control river pollution – both point source (e.g. industrial sewage), and non-point source (e.g. agricultural runoff) – and prevent misuse of riverbeds by unsustainable sand mining. The former can be addressed by incentivizing adaptation of wastewater treatment technologies and heavy dis-incentivizing of polluters. For the latter, building and construction regulations can mandate use of alternatives to river sand like manufactured sand (M-sand) for work on areas larger than a designated size (e.g. 3000 sq. ft.), which is decided by the concerned authority.

3.2. COMMUNITY OWNERSHIP

(a) **Participative Planning Along with Gram Panchayats and Urban Local Bodies:** With the Constitutional mandates of the 73rd and 74th Amendments, both Panchayati Raj Institutions (PRI) and Urban Local Bodies (ULB) are responsible for the overall wellbeing of the people, and the environment of their political jurisdiction, respectively. It has been observed in the past that large-scale projects undertaken with participation from the local government bodies have been quite successful. PRIs and ULBs should be given the mandate to implement the policy recommendation and facilitate community participation in the decision-making process.

(b) **Institutionalization of Riverine Farmers through Farmer Producer Organizations (FPO):** The biggest bane of India's farming community is its lack of organization. By facilitating this organization through FPOs, the government can seamlessly provide and implement schemes to these large groups. FPOs also give farmers the strength to participate in markets, as their graded and aggregated produce will now become substantial in quantity.

(c) **Behavior Change Communication to Stakeholders:** The proposed solution of large-scale tree plantation of native and endemic species in public land, and multi-tier tree-based agriculture in farmlands, must take into consideration all the stakeholders. Every individual who consumes water is a stakeholder in revitalizing rivers. Stakeholders must undergo a change in mindset and take up their respective responsibilities in this process: farmers and tribal communities have to plant the trees; consumers must use the fruits/produce; government departments have to facilitate implementation; and industrialists must build partnerships with FPOs. A persistent, recurring, long-term behavior change communication is required.

3.3. DE-RISKING FARMERS

(a) **Financing and Risk Insurance:**

(i) **Compensation of notional loss of farmers' income:** Transitioning to multi-purpose/fruit tree cultivation involves a loss of income for the farmer until there is commercial yield from the trees. Therefore, the farmer's notional loss of income should be suitably compensated. This compensation should not be viewed as a subsidy but as an investment, through which the farmer will benefit from attractive financial returns and livelihood security in the years to come.

(ii) **Financial linkages** through existing government schemes/programs or financial institutions/banks need to be facilitated to help farmers transition from annual crops to multi-purpose trees and fruit-tree cultivation. This financial assistance, in the form of low interest or zero interest loans, is required to help farmers adapt to the practice of intercropping (which will reduce the transition period and income loss).

(iii) **Compulsory Fruit Crop and Livestock Insurance:** We need to protect the farmers from unforeseen risks. Therefore, farmers must have crop and livestock insurance as a qualifying parameter for applying for the scheme. During droughts and other difficult times, livestock play an important role in augmenting the farmers' subsistence. Hence integrating livestock management and insurance will provide a safety net for the farmers during the transition period.

(b) **Facilitating and incentivizing the transition** from a chemical system of farming to non-pesticide management, and finally to totally organic farming, must happen.

(c) **Training and exposure** to help smoothen the transition from annual crops to trees plantation, and from inorganic to organic farming, will improve productivity, harvesting, grading, value addition, as well as facilitate formation of FPOs and marketing through the FPOs.

(d) **Mandatory Practice of Micro-Irrigation:** Micro-irrigation has been proven effective in reducing water consumption and increasing yields of produce in horticulture plantations. As this river revitalization solution intends to augment the source of water, micro-irrigation is an important intervention that prudently manages the water demand.

(e) **Institutional Setup to Provide Certification of Organic Produce:** Looking at it through a larger vision, farming must provide safe food for the country. It is important for the government to aid in the transition from chemical farming to organic farming through group certification of the farm and its produce. Keeping native livestock on the farm is an essential requirement in this transition. The government should facilitate livestock ownership if required.

(f) **Branding and Marketing of Graded and Value-Added Produce:** The government and industry (in PPP mode) need to develop clear branding and marketing strategies for the yield of fruits, and for the processed value-added fruit products.

(g) **Food Parks (Hub and Spoke Model):** We recommend the setting up of a 'hub and spoke' configuration – with the processing units being the hub; the pre-processing centers being the spokes at the village cluster level, and the collection centers the spokes at the individual village level. We recommend that the village and cluster level operations be managed by FPOs, while the processing units be managed by industry.

(h) **Online Platform:** We recommend that online platforms be made available to farmers to: i) facilitate certification of produce; ii) provide seamless access to government schemes; and iii) obtain crop and livestock insurance. A case in point is the crop insurance given to farmers of Rajasthan through an online portal, which saw historically high registrations within two months of the portal's creation.

3.4. COORDINATED INSTITUTIONAL FUNCTIONING

We must have convergence of all institutional activities through a nodal agency for each river. This can happen through an appropriate national level agency, and a key state level coordination agency. The following key aspects would need to be taken care of:

(a) **A single window support system for a given farmer can be achieved** by establishing one nodal agency which will make the process very efficient.

(b) **ICT support** like a Dashboard could be instrumental in tracking and monitoring the progress.

(c) **The program implementing team** should be permanent for at least 10 years, so as to facilitate long-term sustainable implementation and ensure accountability.

(d) **A robust management and monitoring plan** must be set up to ensure and oversee the implementation of the provisions of the river policy. An integrated river resources management should be fostered through a group of stakeholders comprising of government officers, elected representatives, community members, non-governmental organizations, etc.

(e) **Convergence** must happen across various government departments/ agencies (Agriculture, Water Resources, Environment, Fisheries, Rural Development, Pollution Control, Horticulture and others), farmer co-operatives, consumer groups, private sector players, NGOs/Community Based Organizations, elected representatives and Panchayats. The Panchayat could be empowered to play a crucial role in promoting the twin strategy of conservation and livelihood security.

(f) **Collaboration for Reduction of Pollution and Misuse of Rivers:** Sewage, industrial effluent, non-degradable solid waste (especially plastic), and non-point source agricultural runoff need to be regulated. We have a regulatory regime in place for most of the sources of pollution. Pollution is under the purview of Pollution Control Boards, but on standalone basis they have limited impact. If the parent ministries of the industries, Urban Local Bodies, or Panchayats do not dis-incentivize the respective stakeholders from polluting, there may not be effective reduction in pollution. Coordination between the regulators (like the Pollution Control Board) and the Ministries of Agriculture, etc. is needed to act on pollution. We suggest involving private participation in sewage treatment so as to use the output from the sewage as a product of commercial value. To finance this initiative, a sewage treatment tax can be considered towards financial viability of the enterprise.

4. CONCLUSION

Indian rivers need urgent nationwide attention to revitalize them. In order to use rivers for economic or development purposes, they must first flow. The intervention proposed in the policy recommendation is: tree plantation for a minimum of 1-kilometer width along the entire river's length on either side of the river. The riverside land can be broadly classified, based on ownership, as public land and private farmland. Tree plantation on the public land can begin immediately; the scope of plantation need not be limited to the 1-kilometer lateral distance from the river, but should be determined by the topography of the area. To initiate tree plantation on farmland, the policy recommendation covers different means to de-risk farmers, who form the majority of stakeholders in these lands. To see the effect of this intervention, governments can choose a contiguous stretch of 100-200 kilometers along a river and implement the solution – like the state of Maharashtra has decided to do on the Chandrabhaga River. The idea of a contiguous stretch is now christened as a "saturation model". A saturation model is emphasized because the effect of tree plantation on rivers will be visible and convincing for a farmer only when done on a substantial scale. Further, the resulting visible changes and economic wellbeing for the farmers will also inspire others to plant trees on riversides – thereby becoming a peoples' movement to revitalize our rivers. Every inch of land can act as a catchment and augment river flow and groundwater. We must clear the misconception that only a certain valley in the upper riparian region is a catchment. Hence, it is recommended to act quickly on the revitalization of rivers, with every state planting trees in the target area along a contiguous stretch of about 100 kilometers, as a precursor to a saturation model.

A DETAILED APPROACH FOR IMPLEMENTATION

Acknowledgement

This book is the outcome of generous contributions from a diverse group of people. Farmers, Farmer Producer Organizations (FPO), agro-industry professionals, as well as experts in fields relating to rivers and forestry have lent us their invaluable inputs. The courageous farmers and the pioneering FPOs, who have taken up tree-based farming, have shared with us their experiences in transitioning and implementing this model of agriculture. They are the inspiration for this book. The numerous experts and scientists who have contributed and/or authored supporting material have helped build the book's solid technical foundation. In particular, the Tamil Nadu Agricultural University (TNAU) experts from the Departments of Agriculture, Horticulture, Forestry and Research, deserve a special mention, as they have been providing their unstinting assistance to us from the very first day. Also, as this book delves deeply into issues surrounding farmer welfare, we could not have done it without the agro-industrial professionals imparting their knowledge about various successful partnerships with farmers that have improved their livelihood. When it came to designing the solution process, many senior bureaucrats have unfailingly been our sounding boards in making it effective and realistic. Last, but not least, we cannot forget the many Isha volunteers who have offered themselves in making this book happen.

We wish to acknowledge and express our gratitude to all of you.

Note to the Reader

In this country, generations of experiential understanding of our relationship with rivers shaped a culture which perceived rivers as living entities. However, this traditional reverence for rivers has fallen on bad times. Today we conduct rituals on the riversides while simultaneously pumping sewage directly into the river. Our actions show that we have forgotten the deep relationships our ancestors had with rivers.

The rivers of our nation are dying. All rivers are at a dangerous level of depletion. In another 15-20 years' time most of the perennial rivers will become seasonal. If we do not act now, we as a nation may have to face a civil strife of unimaginable proportions – one that results from having no water for 1.3 billion people.

If we want our rivers to flow in their full glory once again, it is time that all of us understand why our rivers are dying and work towards a solution. With our rivers being forest-fed, we can revitalize our rivers only by reviving forests. Thus, the Rally for Rivers campaign initiated by Sadhguru aims to raise mass awareness in the country about the state of our rivers so that concerted action can be taken. This can happen only out of our collective and steadfast support – irrespective of our various backgrounds and affiliations – towards a long-term solution spanning 20-25 years. If we fail to act now, the effort needed to revitalize our rivers in the future will be multiplied manyfold. The sense of urgency is palpable across the political leadership as for the first time, Chief Ministers of 16 states, hailing from different political parties, have taken to one cause – saving our rivers.

The fundamental solution proposed for revitalizing our rivers is: tree plantation on either sides of the river for the entire length of the river. In all public land beside the river, the entire land should be converted into forest with native and endemic tree species. In farmland, there should be multi-tier tree-based agriculture practiced for a minimum of 1 kilometer stretch on either sides of the river. The technical sturdiness of this solution has been vouched for by experts from various fields including: policy making, hydrogeology, forestry, natural resource management, soil science, horticulture, micro-irrigation, veterinary science, Farmer Producer Organizations, agri-business, agri-marketing, senior level bureaucrats, project financing, social behavior, farmers' union leadership, health and nutrition, and from the Food Safety and Standards Authority. While they all gave feedback about different details of the solution – which we fine-tuned accordingly – all were in agreement that the fundamental approach of tree plantation is a feasible and effective solution.

Implementing this solution requires: mass awareness of the problem among citizens; development of national and state level policies detailing how to revitalize our rivers; and translation of these policies into programs. This book articulates how to revitalize rivers – technically and practically, based on certain fundamental principles, and also provides a broad implementation framework.

The book is divided into four chapters along with a set of Annexures that contain papers and contributions from many experts. The content of the book draws from our experiences of tree plantation, bettering farmers' livelihoods and expert contributions (some of which are presented in the annexures). The book is structured as – Chapter 1: Defining the problem and its root causes; Chapter 2: Assessing the technical strength and appropriateness of the solution, i.e. tree plantation and efficient irrigation; Chapter 3: A detailed techno-economic plan of tree plantation for public and farm lands and the required policy support system to assess the principle stakeholders in the adaptation of a solution; finally Chapter 4: The implementation framework for the techno-economic solution and the regulatory framework required to control pollution and misuse.

CHAPTER 1: INDIAN RIVERS. This chapter describes the change in people's attitude towards rivers, from reverence to apathy, and the reasons behind it. This change in attitude translated into action that has been detrimental to rivers – deforestation on river banks, over-exploitation of groundwater, and pollution of rivers. Besides these, we look at other factors that have further put stress on riverine ecosystems, such as an increase in population and climate change.

CHAPTER 2: PRINCIPLES OF REVITALIZING RIVERS. In this chapter we discuss the technical fundamentals of the solution that is proposed in the book – the primary solution of tree plantation for source augmentation and the secondary, micro-irrigation for demand management of water use for agriculture. We begin by tracing the recent history of the Integrated Watershed Management paradigm as an approach to revitalizing rivers. We explore the strengths of this paradigm's holistic approach and also reflect on why, in all these years, it has not taken off in a big way. Therefore, we propose source augmentation as the primary approach to revitalizing rivers. We analyze how tree plantation helps in source augmentation by improving the rainfall pattern and recharging groundwater aquifers. The role of trees in preventing soil erosion and enabling runoff into the river during the dry season is also assessed technically. Other effects of tree plantation on climate change and their ability to sequester carbon and stabilize local environments is discussed in subsequent sections. One section of this chapter is *Efficient Demand Management*. Although a demand management paradigm does exist for domestic, industrial and agricultural water use, it has not been implemented in a full-fledged manner. In particular, irrigation water use (which amounts to 80% of water use) has not been efficient. Flood irrigation is still a common practice across the majority of farmlands. We suggest micro-irrigation as a more efficient method and explain technically how it reduces water demand. Change in cropping pattern from regular farming to tree-based agriculture also saves water. The effect of micro-irrigation on the yield of produce is discussed in the next chapter as a characteristic of the sample techno-economic model suggested.

CHAPTER 3: WATER-EFFICIENT TREE PLANTATION. The title spells out the solution to revitalizing rivers, and is technically explained in detail here. This solution is broadly divided into two parts: first, tree plantation on public land that lies (to the maximum extent possible) beside the rivers; and second, tree plantation on farmlands. The solutions proposed for both public land and farmland are generic. Along with the technical solution, we also look at the specific policy interventions that need to happen to facilitate the technical intervention for stakeholders. These are called "policy ecosystem conditions". There are some common policy ecosystem conditions for the public and farm lands and some specific ones for the farmland. These policy ecosystem conditions are detailed before going into the techno-economic solution for each category of land. They have been suggested to support and financially de-risk a farming community's transition to tree-based agriculture. The characteristics and economics of a sample agro-forestry model for farmland, in comparison to that of a land tilled for annual crops, is detailed to illustrate the possible income change upon transitioning to tree-based agriculture. Organic multi-fruit crop plantation along with drip irrigation are two major characteristics of the sample model discussed here. The setup of Farmer Producer Organizations (FPOs) is another major policy ecosystem condition for de-risking farmers. We elaborate on the role FPOs can play in organizing farmers and the different income generation avenues they can tap. Case studies are shared throughout the chapter to substantiate the solutions detailed for both public and farm lands.

CHAPTER 4: CONSERVE AND USE – AN IMPLEMENTATION FRAMEWORK.
This chapter presents all the different actors (farmers, tribals, industries, citizens / fruit consumers) and institutions (all government ministries or departments relevant to the proposed solution) that have to work together in the implementation of tree plantation for revitalizing rivers. It maps out the activities of the actors, as well as the institutional support they need, to accomplish what they must do. Additionally, the chapter details the policy ecosystem conditions required to facilitate coordinated effort from different ministries and regulatory framework to restrict / prohibit pollution and misuse of rivers.

TABLE OF CONTENTS

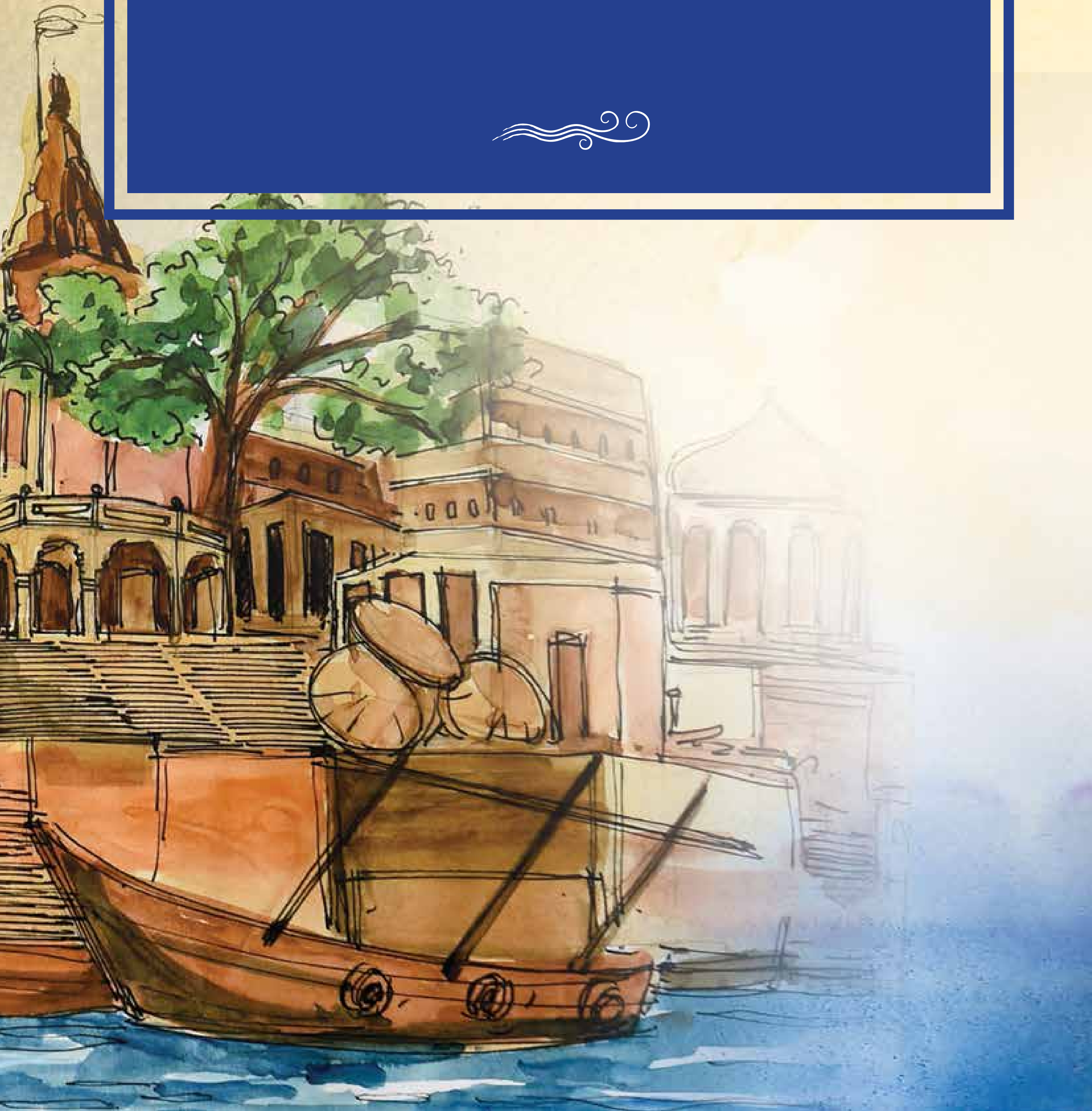
LIST OF ABBREVIATIONS

BAIF	Bharatiya Agro Industries Foundation
BCE	Before Common Era
CC	Climate Change
CCD	Covenant Centre For Development
CE	Common Era
CFR	Community Forest Resource
CIPHET	Central Institute of Post-Harvest Engineering and Technology
CM	Chief Minister
CPCB	Central Pollution Control Board
CPCRI	Central Plantation Crops Research Institute
CRZ	Coastal Regulation Zone
CSR	Corporate Social Responsibility
CVD	Cardiovascular disease
DBO	Design Build Operate
DDP	Desert Development Programme
DoA	Department of Agriculture
DPAP	Drought Prone Areas Programme
DPR	Detailed Project Report
EGS	Employment Guarantee Scheme
EIA	Environmental Impact Assessment
ET	Evapotranspiration
F&V/ F and V	Fruits and Vegetables
FO	Farmer Organization
FPO	Farmer Producer Organization
FRA	Forest Rights Act
GDP	Gross Domestic Product
GI	Geographical Indicator
GoI	Government of India
ICAR	Indian Council of Agriculture Research
IFR	Individual Forest Right
IHD	Ischaemic Heart Disease
IPC	Irrigation Potential Created
IPU	Irrigation Potential Utilized
IWM	Integrated Wateshed Management
IWMP	Integrated Watershed Management Programme
IWRM	Integrated Water Resources Management
JNU	Jawaharlal Nehru University
KVK	Krishi Vigyan Kendra
LULC	Land Use and Land Cover
M&E	Monitoring and Evaluation

MFP	Minor Forest Produce
MLD	Million Litres per Day
MMDR Act	Mines and Minerals (Regulation and Development) Act
MNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MoEFCC	Ministry of Environment, Forest and Climate Change
MoU	Memorandum of Understanding
MSP	Minimum Support Price
MT	Metric Tonnes
N,P,K / NPK	Nitrogen, Phosphorus, and Potassium
NABARD	National Bank For Agriculture And Rural Development
NAIS	National Agricultural Insurance Scheme
NCD	Non-Communicable Diseases
NCPAH	National Committee on Plasticulture Applications in Horticulture
NCR	National Capital Region
NDHP	Non-destructively Harvested Perennials
NGO	Non-Governmental Organization
NHB	National Horticulture Board
NMOF	National Mission on Organic Farming
NPM	Non-Pesticide Management
NTFP	Non-Timber Forest Produce
PGH	Project Green Hands
PGS	Participatory Guarantee System
PMKSY	Pradhan Mantri Krishi Sinchayee Yojna
POPs	Persistent Organic Pollutants
PRI	Panchayati Raj Institution
QPM	Quality Planting Material
RRZ	River Regulation Zone
SDG	Sustainable Development Goals
SEZ	Special Economic Zone
SFAC	Small Farmers Agribusiness Consortium
SHG	Self Help Group
STP	Sewage Treatment Plant
TNAU	Tamil Nadu Agricultural University
ToR	Terms of Reference
U.N.	United Nations
ULB	Urban Local Body
UP	Uttar Pradesh
WRI	World Resources Institute
ZLD	Zero Liquid Discharge

Chapter 01

INDIAN RIVERS



“A river is not just a resource to be exploited, it is life.”

~ Sadhguru

A CULTURE OF REVERENCE

Civilizations across the world have sprouted on the banks of rivers. South Asia's first cities were established around 2600 BCE in what is now northwestern India and further west. The people who built and ruled these cities belonged to what we today refer to as the Harappan Culture or Indus Valley Civilization. Besides its namesake, the Indus River, the civilization may have seen another major river run in parallel to the east. The northern part of this lost river's bed is usually dry now and is called "Ghaggar" in India. A group of channels in this area is sometimes referred to as "Saraswati". Its lost banks are slowly being traced by researchers. Along and within its dry bed, archaeologists are discovering a whole new set of ancient settlements.[1]

Rig Veda[2] is one of the oldest texts of the Indian subcontinent. Around 45 of its verses repeatedly speak of river Saraswati. She is described as "great among the great, the most impetuous of rivers".[3] Whether the Saraswati was a real river that was lost to tectonic plate movement or was a mythical one still remains a mystery, but the reverence for rivers has undisputably been a tradition since the times of the Rig Veda.

River Ganga, that now enjoys the status of "national river" was worshipped as *mokshadayini*. Taking a dip in Ganga is believed to rid one of all sins and sorrows. For ages, people from across this subcontinent have been going on *yatras* to Prayag, Kashi and other cities on the banks of Ganga, walking thousands of kilometers to pay their tribute to her. The Kumbha Mela which happens every 12 years is celebrated at the confluence of river Ganga, Yamuna and Saraswati (now believed to be underground) at Prayag in Allahabad. Even today, there is deep faith among Indians that if they take a dip in the confluence at Prayag during the Kumbh Mela, they will attain *mukti*. One can behold in these Melas, lakhs of people from all over the country, from all walks of life and the economic spectrum – from the poorest to the richest – bringing their belongings and travelling all the way to the Mela just to witness the confluence and bathe in it. Ganga's water is held sacred for its self-cleansing properties. Even British soldiers carried water from the Ganga from India back to England as it remained “sweet and fresh” throughout the long sea voyage.

All the places of origin of our rivers – Gangotri of Ganga, Yamunotri of Yamuna, Amarkantak of Narmada, Krishnabai of Krishna, or Talakaveri of Kaveri have temples built in honor of the rivers.

The many temples for rivers reflect the way these rivers were perceived by the people of this country. The primary emotion a river evoked was utmost reverence. A remnant of this feeling is still visible today in the rituals of these temples and the aartis performed on the rivers, such as the famous Ganga Aarti in Kashi. But the system of practices that were followed in the past to nurture the river systems as ecological entities is all but forgotten.

THE TRADITION OF "CONSERVE AND USE"

India's spiritual ethos of reverence towards rivers ensured that societies upheld the fundamental practice of using a resource only within the limits of its ability to replenish itself in a short period of time. With the rivers giving humans life-giving water, and humans, in turn, taking care not to exploit the river to depletion, our relationship with rivers over the ages has been one of interdependence.

The current exploitation of rivers cannot be blamed entirely on the growth of our population or the development of our society over time. Irrigation development can be traced back to prehistoric times in India. Ancient scriptures refer to construction of wells, canals, tanks and dams and their efficient operation and maintenance.[4] Evidence of the use of irrigation to produce food grains in the Indus Valley Civilization traces back to over 5000 years ago. Most of the water needs were met from surface water bodies and a small section of needs were met through shallow aquifer wells. Small construction works harnessed river water for irrigation. In Maharashtra, 3700 year old irrigation structures have been found. In the Mauryan period it is recorded that farmers paid taxes for irrigation water from neighboring rivers.[5] Poems were written on palm leaves in the Sangam period which dates back to 150 BCE - 200 CE. In the Sangam literature one finds mentions of paddy, which was cultivated even in those times on the banks of Thamirabarani river. It is also recorded that irrigation in Tamil Nadu grew during the Chola and Pandya Kings' time (750-1300 CE).[6] The grand anicut across Kaveri was built 1800 years ago and its basic design is still in use.

The emphasis on irrigation systems were initially on run-of-the-river schemes. It then moved on to systems of storage through man-made tanks called *eries* in Tamil Nadu and *kalyanis* in Karnataka and the *bedis* and stepwells of Rajasthan. These storage structures were built to hold the excess water from the runoff during rainy seasons, with the remaining water flowing into the rivers. The technologies they developed ensured that the water cycle was closed; there were no open loops.

We as a civilization have lived sustainably well since the Harappan times without the threat of depleting water resources, which we are facing today. We were irrigating, conducting trade, using our water resource for our daily needs, all of it reasonably well. So how did we reach the present water crisis – drying up of rivers, ponds and lakes, and overexploited groundwater? Before we try to understand this, it will be useful to have a perspective on what rivers mean to human beings.

RIVERS, ARTERIES OF OUR PLANET

NIRMAL AND AVIRAL

Rivers were always seen as living entities in our country. This perception was not just an outcome of cultural influences, but was supported by sound scientific understanding. It is just that our culture has been oral and dialectic in nature and therefore the reasoning and the science of it was lost over time as a number of invasions riddled the country. Today, based on modern scientific studies and a more holistic understanding of rivers and their ecosystems, the Government of India has recognized the following as a holistic definition of a river:

A river is wholesome if it has the characteristic of "aviral dhara" *(continuous flow),* "nirmal dhara" *(unpolluted flow), geologic entity, and ecological entity, across the basin in all seasons.*[7]

Nirmal dhara means unpolluted flow. This requires tightening of the pollution control norms and a coordination between the different departments in charge of the waterways and pollution. *Aviral Dhara,* meaning an unhindered and unfettered minimum flow, is to ensure that the river flows continuously. This must be so, for the river flows for the entire stretch of its length – from its origin until it meets another river or the ocean. While the discussion on flow of rivers looks at their drying in the plain or in the fertile zones, we miss the repercussions of their drying up in the coastal regions. When the rivers dry up upstream and do not reach the ocean, the coastal area aquifers slowly start to dry up. This leads to salinity intrusion of the freshwater aquifers. Hence, *aviral dhara* is most important.

This understanding has dawned upon us as a nation after we have exploited our rivers to a very dangerous extent. Our rivers reflect a high degree of disturbance from their pristine state. Dams have been built extensively to create reservoirs for irrigation and hydropower, and barrages built for water diversion. Human settlements, deforestation and mining have degraded river catchments and increased sediment load in rivers. Industrial and agro-chemical effluents, and domestic waste have been discharged untreated into rivers.[8]

All these disturbances have affected riverine biota. The composition of species has changed and many species have become extinct. Out of 30 river basins in the world prioritized for protection of aquatic biodiversity, nine are from India. They consist of: Kaveri, Ganga-Brahmaputra, Godavari, Indus, Krishna, Mahanadi, Narmada, Pennar and Tapi.[9] There has been inadequate appreciation of rivers as ecosystems, whose ecological integrity depends upon their physical, chemical, and biological characteristics and interactions with their catchment.[10]

Environmental flow is the water regime provided within a river to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated. "Environmental flows provide critical contributions to river health, economic development and poverty alleviation. They ensure the continued availability of the many benefits that healthy river and groundwater systems bring to society". In the medium- and long-term, there will be disastrous consequences for many river users if environmental flow requirements are not met.[11]

Rivers have been used to meet human needs in varied ways. They have been channelized for irrigation, used as waterways to transport goods, and in recent times they are also one of the sources of freshwater for industrial activities. It is important to understand that rivers do not exist only to be exploited by human beings. It is human beings who are dependent on rivers for their life on this planet. Therefore, it is important to ensure that this precious source of freshwater is intact so that the human species does not perish.

COMPONENTS OF RIVERS

It will be useful and important to understand technically why rivers and their ecosystems are essential to human societies.

A river that we see as a huge gurgling stream or as a placid, wide and long flowing water body, is a dynamic phenomenon. Rivers are not only water bodies that meet human water needs, they are essential elements for vast ecosystems, and for the health and survival of billions of people.[12]

Rivers are made up of their tributaries, which are fed by rivulets, that are in turn fed by springs in deep forests, or large lakes or glacial meltwater, or simply from rains that flow off the surface or that come through rocks or man-made channels. Many times the water in the river is also sourced from underground aquifers that may have a higher water table than the river itself.

The volume of water that flows in the river comprises of the visible volume of free water flow along with substantial sub-surface water flows contributed by rocks, gravel and the river's floodplains. For many rivers, the sub-surface volume of water flow may exceed greatly the visible free water flows.[13]

Throughout its entire course, the river not only transports water but also sediments and other micronutrients from the upper reaches of the river to the plains. The plains are usually the food basket of any river basin. The sediments and micronutrients have a very important role to play in keeping these plains fertile.

The entire area from which water is drained into a river is called its catchment, drainage basin or watershed. The channel through which a river usually traverses is called the river channel. The water that flows in the river is usually confined to that river channel. In larger rivers, and rivers where the seasonal flow changes, flood waters overflowing from the regular river channels create wider floodplains.Floodplains may be wider than the river channels when the river hydrographs are not straight lines, i.e. when there is marked variation in the quantity of flow over time. Neither the floodplains nor the river channels are clearly demarcated by Nature. The `100-year floodplain' is the riverside land that has a 1% probability of flooding in any year, and is one of the accepted measures of demarcating a floodplain.

Flooding of any river is a natural part of a river cycle. It is a mechanism through which fertile and nutrient-rich sediments are transported into the plains.

Rivers also are habitat to a wide variety of flora and fauna. The diversity housed in riverine ecosystems range from species found in torrential waterfalls through lowland mires to estuaries. Many of these species play a vital role in cleansing the river as it traverses from one settlement to another, thus maintaining the river quality at safe standards. The ecosystems that have evolved on different sections of the river have been responsible for stabilizing the river habitat and its climatic conditions over millennia. They have evolved to resist the shocks from natural calamities too. For example, in the aftermath of the 2004 tsunami, it was observed that the impact of the tsunami on coastal communities wherever mangrove forests were intact, was significantly less severe compared to those communities where the mangroves were uprooted.

PHYSIOLOGY OF RIVERS

Rivers can be viewed as living entities that can become sick and die, if not appropriately taken care of. Viewing a river as a living entity is not merely rhetoric; there is a scientific explanation for this analogy.

In May 2017 the government of Madhya Pradesh moved to accord the Narmada river the legal status of a "living entity".[14] And earlier in April 2017, the Uttarakhand High Court declared Ganga and Yamuna and their tributaries as "living entities having the status of a legal person".[15]

A renowned scientist and aquatic ecologist, Professor Brij Gopal of JNU, in an essay about river Yamuna in *Living Rivers and Dying Rivers,* compares the river Yamuna and all rivers to living entities. He starts the essay with this clear statement – "Living beings are characterized by their function and homeostasis."

All living entities function through transformation of energy and nutrients through various physical and chemical processes. Each organism differs in its ability to perform specific functions. Any organism is a composite of different organs, but the *function* of the organism is not just a composite of the functions of all its organs. And failure of an organ or even a few cells of an organ impairs the functioning of the entire organism.

Homeostasis, according to the Oxford Dictionary means:

"the tendency towards a relatively stable equilibrium between interdependent elements, especially as maintained by physiological processes."

Homeostasis is a dynamic equilibrium among living cells, among organs, among organisms or an ecosystem under ever changing environmental conditions. All organisms have a certain ability to handle changes or disturbances in this dynamic equilibrium. The organisms have a self-regulating ability to return to the previous equilibrium or come to a new state of equilibrium. Another ability of organisms to withstand adverse conditions without adversely affecting their functioning or growth is called resilience. All ecosystems exhibit this ability for homeostasis and resilience. But their capabilities are not limitless. And every ecosystem has different ways to cope and adapt to the changes or disturbances within an ecosystem.

Rivers, like all living beings, function and have their states of homeostasis. But when we look up the meaning of a river, this is what we get:

"a large natural stream of water flowing in a channel to the sea, a lake, or another river"[16]

It won't be completely wrong to say that this rudimentary understanding of rivers as just another resource, is one of the reasons why we have used and exploited them across the world. We have abused the rivers to a point where the disturbances we have caused to many riverine ecosystems are irreversible.

People, to a great extent, are concerned with that particular stretch of the river that they interact with. This applies to those who are dependent on the river or live on its banks. But for city dwellers, a river is just the source of water that comes from the taps. Others see rivers as waterways to transport goods, and still others view it as a resource to be stored in some structure or whose flow will generate energy.[17]

Yet, it is crucial to have a look at the larger picture to understand the importance of rivers. One of the most critical roles of a river is that it carries water from precipitation to the ocean, thus closing the hydrological cycle.

Along its journey a river changes its course, its temper, its attitude, from its inception like a newborn baby in the snow-melts or in the forest – until it meets the ocean as a mature elderly person.

The description of what a river as an entity is, given by Professor Brij Gopal, is one of the holistic ones:

"Rivers are three-dimensional, dynamic ecological systems which depend upon longitudinal, lateral, and vertical transfers of material, energy, and biota that are determined by their specific flow regimes. The rivers change, over time, in response to hydrological and biological processes and human interventions. Each river has a characteristic identity based on the totality of its physical, chemical, biological, and functional attributes."[18]

The quality and health of a river as an ecosystem is related to the uninterrupted flow from its origin until it meets the ocean. This is its longitudinal connectivity. It is also decided by the quality of interaction with the landmass on either side of the river throughout its course. This is lateral connectivity. The seasonal variation in flow will be determined by natural climatic factors.

An important function of the river is its ability to assimilate waste generated by human and other natural activity and convert it into input for other organisms in the riverine ecosystem. Another function is to transport materials and nutrients to downstream areas of the basin and finally to the sea, where they support growth of mangroves and fisheries.

The high flows of rivers, especially in India, during the monsoons distribute sediments along with organic matter and nutrients on floodplains. The floodplains also support the river flow throughout the year by modulating the discharge into the river, providing a feeding ground for biodiversity that lives in the riverine ecosystem, and recharging groundwater aquifers interacting with the river.

FLOODPLAINS AND THEIR SIGNIFICANCE

The area on either side of a river that becomes part of the extended river bed when the river floods is called the floodplain. The extent of the floodplain is defined by the area a river would occupy in the event of a 100-year return flood.[19] This area should belong to the river, for the river to survive and also for the larger human civilization to not perish. The diversity of the ecosystem housed in a floodplain is sometimes 100 or even 1000 times that of the river water ecosystem.

Floodplains are classified into active and passive floodplains. Active floodplains are where the river is still free and there is no encroachment. Passive floodplains are those areas where there is some human activity. But these areas anyway get flooded if there is a high volume of water flowing through river during very high floods.

Manoj Misra, known for his work on the revitalization of Yamuna, in an essay on the importance of floodplains lists the following[20]:

- Floodplains spread water safely and harmlessly when it floods
- Recharge groundwater aquifers connected to the river
- Spread and deposit sediments brought down from the catchment
- Provide heat sinks
- Provide fertile land for seasonal cultivation for farmers
- Floodplains have been home to highly diverse organisms of the river ecosystem

If the floodplains, both active and passive, are not maintained sustainably, all the above mentioned benefits will never be realized. Rather the opposite effects will be seen to pan out – flooding of habitations, drying of the underground aquifers, increase in average temperatures, run off of fertile soil into sea rather than deposition into seasonal farm lands and loss of biodiversity found in the floodplains.

PLIGHT OF OUR RIVERS TODAY

When one looks at the state of the rivers of our country, it is depressing and overwhelmingly complicated. The issues that plague our rivers are not one or two – they are many. Our rivers are polluted across the country, they are drying up in the summers, and there are inter-state disputes over them. If we turn on any news channel, there is at least one report on how floods or droughts are affecting some part of the country. The current devastation of India's rivers and water bodies, which support the livelihood of hundreds of millions of people, is a precursor for the gravest crisis of our times. Water resources and soil are being destroyed at such a rate that in another few decades we may no longer be able to feed or quench the thirst of the Indian population. When water scarcity hits a land of 1.3 billion people the situation that emerges will be that of civil strife. The images of women flocking to one well in a dry desert, or the strikes and fights between Karnataka and Tamil Nadu are only brief hints of what could happen if we do not attend to the state of our rivers.

A river should ideally remain ecologically healthy and biodiversity rich throughout the year, i.e. during monsoon, lean, and non-monsoon seasons with minimum but, differential flow. This minimum quantum of flow with seasonal variations has to be ensured as that will keep it rejuvenated. A river will remain rejuvenated when it is capable of sustaining a healthy ecology and catering to the developmental and livelihood needs of the people.

Death of rivers happens when the river ceases to function as a resilient self-cleansing organism, which slowly begins to deteriorate. Before we can call a river as a dead entity, the health of the river and its ability to revive itself decides how near it is to its death. Many rivers in India are gradually dying. Major Indian rivers have depleted dramatically in a matter of just a few decades. Some rivers like the Palar have totally dried up.[21] Many other rivers have already changed from being perennial rivers to seasonal rivers – reaching the ocean just for a few months a year. This problem is as acute for the rivers of peninsular India as it is for the rivers of northern India. The "lifeblood" of a river is its water flow throughout the year. If one were to visualize rivers as trees, water and nutrients move from the topmost branches to the trunk, and then to the roots which end up in the sea.[22] Any human intervention that causes a decline in flow or obstructs the flow impacts the health of the river and could lead to its death. Another cause of the death of rivers is waste that is dumped into the river that is more than the assimilative capacity of the river.

Recognizing the perils before our major rivers, the government launched integrated programs like Namami Gange (at the national level) and Namami Devi Narmada (at the State level) with twin objectives of: abatement of pollution; and conservation and revitalization of the river ecosystem. Another major initiative, "Save the Yamuna" campaign drew considerable attention to the plight of river Yamuna flowing through NCR Delhi leading to enforcement of laws/regulations. Apart from these, there are hardly any large-scale government initiatives that seek to protect and nurture our riverine ecosystem. Such efforts need further strengthening and support from all stakeholders given the stark facts below:

1. Perennial major rivers are moving towards being seasonal. Many of India's minor river systems have vanished.[23]

2. **For the 91 water reservoirs in India** with recorded data by the government, the average water levels **in May 2016 have fallen by 30%** compared to the average levels over the last decade.[24]

3. Major rivers are rapidly shrinking. **Godavari has shrunk by almost 20%** from historical flows. **Kaveri has shrunk by 40%**, while **Krishna and Narmada have shrunk by 60%.**[25]

4. According to a report by the Water Resources Group, by 2030, India will have only half the water it needs.[26]

5. 25% of India is rapidly turning into desert.[27]

6. The desertification of northern India is not far away. **By 2050, estimates suggest a 50% reduction in wheat yields**, and the resulting displacement of millions of people from what were hitherto agricultural lands.[28]

7. **22 out of 32 major Indian cities deal with daily water shortages.**[29]

8. Delhi, Kolkata, Bengaluru, Chennai and Hyderabad – will be under water stress (cities that use at least 40% of all available water from watersheds).[30]

And here are some specific examples on the state of some of India's major rivers:

1. **Ganga** is one of the world's 10 most endangered rivers.[31] A scientific study published in August 2015 suggests that the felling of trees and destruction of other vegetation to make way for urbanization and road construction has dramatically reduced the flow of water. The depletion of natural water sources in the last few decades is estimated to be 45 percent from Kumaon region, 39 percent from Garhwal region, 47 percent from Yamuna catchment area, 37 percent of Byans catchment area in Himachal, and 37 percent natural water resources of Teesta river catchment area of Sikkim.[32]

   The Ganga is the most threatened by water over-extraction. Barrages control all of the tributaries to the Ganga and divert roughly 60% of the river's flow to large-scale irrigation.[33] The groundwater level in the Ganga-Brahmaputra is falling by 15-20 mm every year.[33]

2. **Indus** is another one of the world's 10 most endangered rivers. It is the most threatened river by climate change. Himalayan glaciers provide the Indus with 70-80% of its water. The Indus basin has already lost over 90% of its original forest cover.[23] The Indus basin is the second-most overstressed on the planet, its groundwater levels falling by 4-6 mm/year. The Indus and Ganga basins support the livelihood of 370 million Indians in 1.2 million sq. km[23].

3. **Kaveri** depleted so severely that in 2017, Tamil Nadu suffered its worst drought in 140 years.[34] Compared to ten years ago, Tamil Nadu's reservoir levels have fallen by 49%, and Karnataka's have fallen by 30%[35].The evergreen forest in the Kaveri catchment area has decreased by 35% between 1977 and 1997.[36]

4. **Krishna's** observed runoff to the ocean fell from a pre-irrigation development average of 57 billion cubic meters a year (bcm/yr) in 1901-1960, to less than 21 bcm/yr in 1990-2000 and even more strikingly to 0.75 bcm in 2001-2004 during an extended period of low rainfall[37].

5. **Rivers of Uttarakhand:** In the last fifty years, more than half the rivers of Kumaon region have dried up and have now become rain-fed rivers. 50 years ago, Almora district had a river length of 1639 km which has now been decreased 50% to just 810 km. Scientists believe that without remedial steps, rivers like Gagas, Kosi, Ramganga, Panar, etc. will completely dry up in the next fifteen years.[38]

6. **Godavari,** the second largest river in the country that waters three states – Maharashtra, Telangana and Andhra Pradesh – ran dry at Nashik in 2016 for the first time in 139 years.[39]

One who sincerely wants to work towards resolving this situation feels confused about where to start. How do we go about revitalizing our rivers?

THE KNOTTED-UP RIVER MANAGEMENT PARADIGM IN INDIA

If one were to work on improving the plight of our rivers, it will be useful to know when and how we charted the path to their deterioration. This reminds one of the story of a knotted up handkerchief that Lord Buddha brought into one of his *satsangs*. The story goes like this – in one of the monk assemblies Buddha brought along a handkerchief, knotted it, and asked if the knotted handkerchief is the same as the old one? The monks responded that in a way it is the same, but it has many knots in it. That is, in a way it is the same cloth, but the form has changed.

And then Buddha asked what he should do to bring the handkerchief back to its original state. Should he stretch the ends? The monks responded that to get the handkerchief back to its original form, the knots need to be removed. And the monks added, to remove them we need to closely examine how the knots were formed.

This story summarizes what has happened with most of the natural resources that we humans have been bestowed with on this planet. They are all knotted up. All this has happened in less than five or six decades. The case of our freshwater resources is similar to the knotted up handkerchief. And right now, we as a nation, instead of unknotting them, have only been pulling the knots further apart through our interventions of building more dams and diverting more water to cities from the rivers.

In this section we look at how the knots were formed and what are the knots that we have to untie to revitalize our rivers.

FIRST KNOT - BRITISH LEGACY OF INDIA'S RIVER MANAGEMENT

The worship of the rivers in India has been reduced to a ritualistic process that people follow only because they are told that it will benefit them. The ethos and the fundamental consciousness that gave rise to this reverential worship of rivers has been corroded. A man who conducts a ritual or a ceremony on the *ghats* of Ganga in Varanasi will not fret to spit on the same *ghat* after finishing the ritual.

If we understand how this knot of a complicated "worship and disrespect" behavior is practiced towards an entity at the same time, we may be able to get a better perspective of what needs to be done.

The introduction of property rights by the British colonial regime did the most irreversible damage to the ethos and the consciousness of the Indian people. The property rights of land introduced by the British have triggered a set of consequences to agriculture, the brunt of which is still palpable and borne by the small and marginalized farmers. The agriculture practices that farmers follow today are to facilitate trade of goods rather than to meet their subsistence needs first.

In the case of water, the regime made all the water bodies the state's property. That is the rivers, lakes and ponds which were common property before now no more belonged to the village or its people who inhabited their banks. When rivers, lakes and ponds were common property, the villages used to maintain these assets by coming together as a community and taking turns to maintain them. This community effort established an intrinsic connection between a river and its people. But once their rights on these water bodies were snatched, the connection was severed, and hence the efforts to maintain the rivers were also forgotten. Even today, post-independence, the rivers still belong to the state. The states carry the legacy of the British perception that rivers are physical resources that have to be exploited for human use alone.

The second damage inflicted on the rivers by the British was the technical approach adopted to manage our rivers, which was a direct transplant from Europe. The idea to build barrages to control floods and canals to divert water was structuralist in tradition and reductionist in nature[40]. This direct transplantation of European knowledge of water engineering based on European rivers was inappropriate for Indian rivers. The hydrographs of most European rivers are flat, with very little seasonal flows seen. The flow of Indian rivers changed seasonally, submerging the floodplains in the monsoon and draining off in the summers. This was no aberration to us, but it was to the British. They did not have an understanding of sediment or how to manage it, nor did they consider the flooding and draining of rivers as a natural process. Most of the interventions were to divert the water for irrigation or to generate hydro-power. There was little consideration about the ecology of the river systems or ecological flows of the river.

We still carry this legacy of a narrow understanding of rivers as an exploitable resource. This idea is instilled in engineers in this country. Even now rivers are considered to be a subject meant only for engineers. The roles of other professionals like ecologists, hydrogeologists and others are deemed irrelevant. In the Western countries, though, the paradigm of river management and utilization has shifted to Integrated Water Resource Management (IWRM). The new IWRM paradigm takes into consideration demand management and provides for ecological needs of water too. The ancient Indian ethos to revere our rivers and worship them as goddesses took these two considerations into account as well as the needs of all other living beings dependent on the river. However, the current reductionist approach adopted towards rivers in India has given rise to an unsustainable number of dams, irrigation canals and hydro-power projects.

SECOND KNOT - DEFORESTATION IN RIVER CATCHMENT AREAS

The shrinking of glaciers is largely perceived as the cause for the reduction of water in the rivers, especially the Himalayan rivers. Glaciers are important to rivers, no doubt, but the extent of glaciation that contributes to the river is only 10% on an average. To elaborate on this further, the case of Ganga is represented in Table 1, which indicates the catchment area from glaciers in comparison to the catchment area covered by mountains. Similar is the case for other Himalayan rivers too.

It may, therefore, be concluded that majority of water in the rivers come from the runoff from the catchment area rather than glaciers. If the contribution of runoff from catchment areas is so high in the case of Himalayan rivers fed by glaciers, then, the central Indian and peninsular rivers must have an even higher dependency on this runoff.[41]

Principal Glacier-Fed River System of Himalayas				
Major River System	**Name of River/ Tributary**	**Catchment Area (sq. km) Covered By**		**Percentage Glaciation**
		Mountains	Glaciers	
Ganga	Yamuna	11,655	125	1.1
	Ganga	23,051	2,312	10
	Ramganga	6,734	3	0.04
	Kali	16,317	997	6.01
	Karnali	53,354	1,543	2.9
	Gandak	37,814	1,845	4.9

This section discusses the causes of of river depletion, including: increasing population, over-exploitation of groundwater resources, increasing rate of deforestation, and reduced rainfall. All these aspects have adversely affected the functioning of the rivers' catchment regions.

The catchment region of rivers, unlike popular belief, is spread all across the stretch of the river and not only in the upper reaches near its origin. The water that flows into the river is fed by the rains through the catchment region and by the trees planted in the region. This again leads to the conclusion that if we need the rivers running and thriving again, we must endeavor to revive their catchments and floodplains all through their course, as well as their tributaries. This is equally valid for the catchments of the streams and tributaries that feed into the river as it is for the main river body itself.

Catchment area treatment can happen through adoption of engineering and non-engineering measures such as watershed management, construction of check-dams, gully traps / silt traps, large-scale afforestation with preferable "soil binding and water holding" native species, treatment of degraded land, etc.

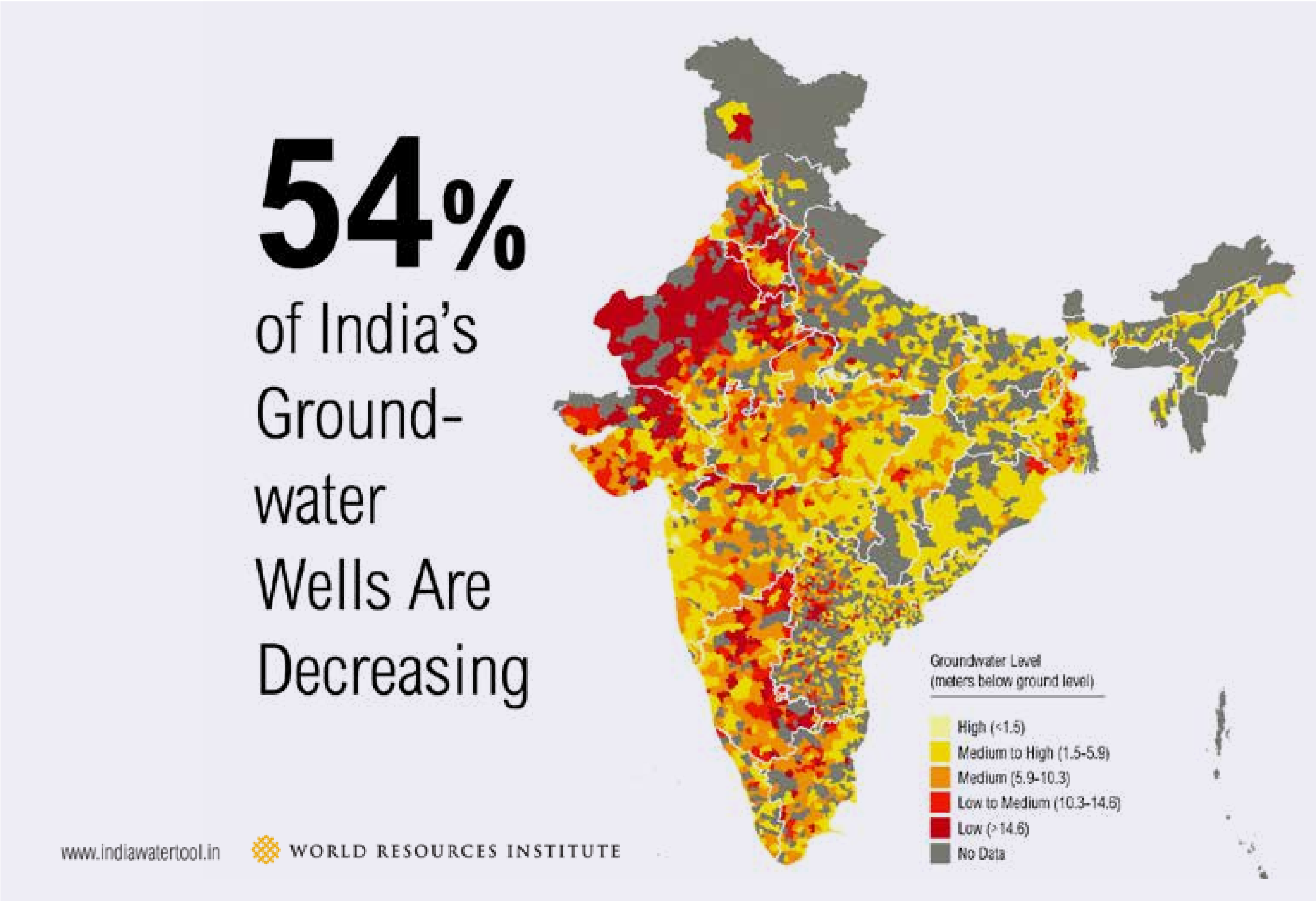


FIGURE 1: DECREASING GROUNDWATER WELLS IN INDIA

Forests created on the river banks with native and endemic species increase the number of rainy days, and increase available runoff by extending the period of surface flow in the river.[42] The maximum flow during floods is reduced and the lowest summer flow is increased.[43] This benefit is lost with deforestation. Over 60-80 million hectares of denuded forest lands and wastelands across the country are unable to retain rainwater, which in turn would have ensured recharging of groundwater and conservation of biodiversity. As a result, the rivers emerging from these mountains are unable to sustain the flow of water throughout the year. Heavy soil erosion has not only been causing floods but also forcing the rivers to change their courses. Such rivers will not be able to support agricultural production in the future.[44]

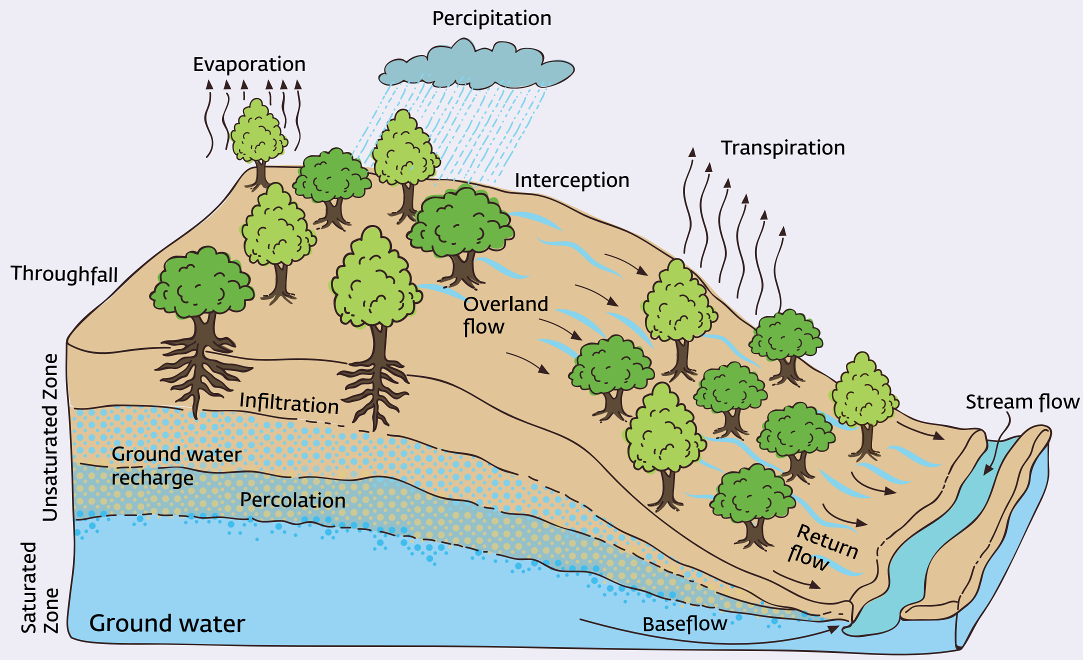


FIGURE 2: THE LINK BETWEEN SURFACE WATER AND GROUNDWATER

THIRD KNOT – OVER-EXPLOITATION OF GROUNDWATER RESOURCES

The water needs of the population have led to an unsustainable over-exploitation of groundwater resources. The advent of high power pumps has further accelerated this trend and groundwater tables are rapidly falling all across the country.

If one looks at the map produced by the World Resources Institute[45] of the groundwater table across the country, a number of red areas dominate the map, indicating an unfavorable exploitation of this water resource (See Figure 1).

It is a well-established fact that surface water bodies and groundwater bodies have a dynamic relationship with each other.[46] In Figure 2, we can see how surface water bodies and groundwater are linked together. When there is a high level of exploitation of groundwater bodies, this leads to drying up of surface water bodies as they end up recharging the groundwater aquifers that are over-exploited. (Refer to Annexure 1)

FOURTH KNOT – FOUR-FOLD INCREASE IN OUR POPULATION

Within 75 years, our population will have increased nearly four-fold from 361 million in 1951 to 1394 million in 2025. That is an enormous increase in water demand in a very short span of time. Although India occupies an area of only 3.29 million km^2, forming 2.4% of the world's land area, it supports over 15% of the world's population.[47] In other words, India supports about 1/6th of the world population while comprising of 1/50th of the world's land and 1/25th of the world's water resources.[48] Narayan Hegde in his paper describes this cycle of exponential increase in water demand:

"The most serious concern is the growing population which is likely to increase to 1.66 billion by 2050. With the increasing population, the annual food requirement in the country will exceed 250 million tons. The total demand for grains will increase to 375 million tons including grain for feeding livestock. With the growth in the National GDP, at 6.8% per annum, during the period from 2000 to 2025 and 6.0% per annum, during the years 2025 to 2050, the per capita income is bound to increase by 5.5% per annum. This will increase the demand for food. While the per capita consumption of cereals will decrease by 9%, 47% and 60%, with respect to rice, coarse cereals and maize, the per capita consumption of sugar, fruits and vegetables will increase by 32%, 65% and 78% respectively, during the period from 2000 to 2050. The requirement of water for livestock will rise from 2.3 billion m^3 in 2000 to 2.8 billion m^3 in 2025 and 3.2 billion m^3 in 2050."[49]

All the points mentioned by Narayan Hegde in his paper about population also account for the drastic changes in India's land use pattern. From 1950 to 2000, the total area under agriculture has increased, whereas the wasteland, other uncultivated land and non-cultivated land and barren lands have reduced. Wastelands have reduced from 8% to 4.5%, other uncultivated land has reduced from 17% to 9.2%, barren land has reduced from 13.4% to 6.2%; and gross cropped area has increased from

46% to 62% and the area sown more than once has increased from 4.6% to 16%.[50] Wastelands, uncultivated land and barren land are actually useful land masses that have been helping maintain ecosystem balance.

The distressing state of the rivers in our country is part of the growing overall shortage of water in India. According to the Falkenmark Indicator[51] (Refer Table 2), which is one of the most widely used water stress indicators, India has moved from being a water surplus (stress free) country to being a water stressed country within just seventy years since independence.

TABLE 2: FALKENMARK WATER SCARCITY INDICATOR

Index (m^3 per capita)	Category/Condition
>1,700	No stress
1,000–1,700	Stress
500–1,000	Scarcity
<500	Absolute Scarcity

Per capita availability of water in India has declined by 70% in the period 1951-2011 to a level of 1545 cubic meters in 2011. This is expected to decline another 15% in the period 2011-2025 to a level of just 1341 cubic meters. At this rate, we are heading for a change from being a water-stressed country to being a water-scarce country (Refer Table 3 for details).

TABLE 3: PER CAPITA AVAILABILITY OF WATER IN INDIA SINCE 1951[52]

Year	Population (Million)	Per capita water availability (m^3/year)
1951	361	5177
1955	395	4732
1991	846	2209
2001	1027	1820
2011	1210	1545
2025	1394	1341
2050	1640	1140

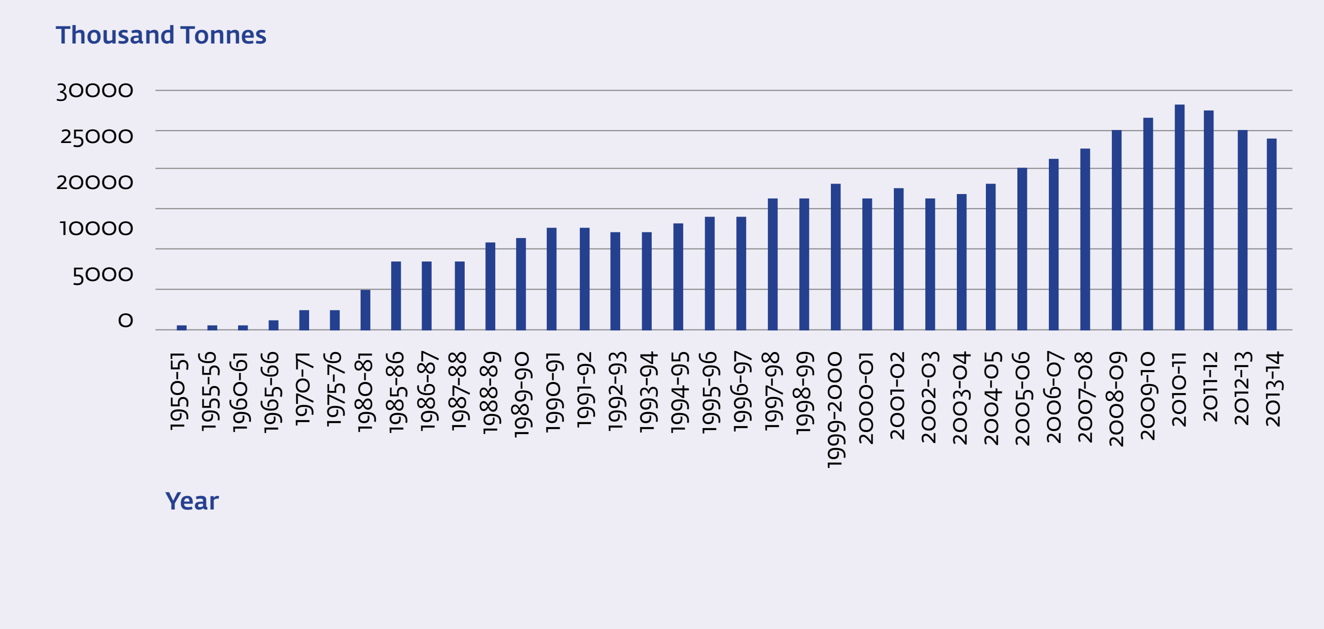
What is desirable at the national level is a holistic policy framework, focusing on river basin management that combines not only abatement of pollution and conservation but also ensures sustainable livelihoods for the riverine communities. Dying rivers are only going to aggravate the water security issues this explosion of population will cause.

FIFTH KNOT – POLLUTION AND OTHER FORMS OF RIVER EXPLOITATION

When one talks about river revitalization, most people focus on the pollution of rivers. It is true that pollution is one the major reasons why life in and around rivers are perishing. Based on the long term assessment of water quality data, 275 rivers out of 445 rivers monitored under National Water Monitoring Programme are identified as polluted.[53]

The sources of pollution to a river are: domestic sewage from urban and rural areas, non-sewage drainages, wastewater from agricultural facilities, and industrial wastewater / effluents. Wastewater generation is proportional to the amount of water consumed. Out of the total freshwater used in India, irrigation accounts for nearly 78%, followed

FIGURE 3: USE OF INORGANIC FERTILIZER OVER THE YEARS



by domestic use 6%, industries 5%, power development 3%, and other activities including evaporation losses, environment and navigational requirements around 8%.[54]

Agricultural runoff: Only 0.3% (528,171 hectares out of 159.7 million hectares) of agricultural land in India is under organic farming. The remaining land is mostly under inorganic farming. The consumption of inorganic fertilizers has only increased over these years from 65,000 tons in 1950 to 24,485 thousand tons in 2014.[55] There is no quantification of what happens to the runoff of the residual fertilizers from the land into the water bodies – rivers or other surface or groundwater bodies. Also the use of pesticides has become ubiquitous, and the pollution from runoff of pesticide will only add to the pollutant load in the water. The agricultural runoff water, though not technically wastewater, has large proportions of agro-chemicals, adding to the toxic load in water.

Urban Sewage: Domestic sewage is one of the most obvious and visible forms of pollution to rivers. Urban settlements in India contribute 61,754 MLD of which 38,791 MLD goes untreated, while the cumulative sewage treatment capacity of the nation is 22,963 MLD. According to Central Pollution Control Board, the untreated 38,791 MLD goes directly into water bodies - rivers or ponds or lakes. The five states viz Maharashtra, Tamil Nadu, Uttar Pradesh, Delhi and Gujarat account for approximately 50% of the total sewage generated in the country. Maharashtra alone accounts for 13% of the total sewage generation in the country.[56] (Refer Annexure 2)

Industrial effluents: With respect to industrial pollution, according to CPCB's 2009 data, only 60% of industrial wastewater, from mostly large-scale industries, is treated. This also runs off into freshwater bodies like rivers, lakes and ponds.

Typically, the constituents of wastewater are organic and inorganic chemicals, bacteria and other microorganisms (some of which may be pathogenic), fats, oils and grease, etc. The organic and inorganic materials may be in suspended or dissolved form. Some of these components are nutrients that are useful for plant growth, but cannot be used or harnessed in their present form when they are mixed in wastewater. Industrial effluents and domestic sewage contaminated by mixing with such effluents can carry various other, often toxic, chemicals such as pesticides, heavy metals, etc.

Many of the chemicals in the above two categories are found to disrupt endocrine systems in humans (and therefore, obviously in other life forms), and are now categorized as "Endocrine Disrupters". Many of the chemicals also do not readily degrade over time and are categorized as Persistent Organic Pollutants (POPs).

Sand mining and riverbed dredging: River beds are the most sensitive part of the riverine ecosystems. The bed is formed by the river flowing on it for millennia. The river beds are today being disturbed either to mine sand or to dredge and deepen the river floor for waterways. In the recent floods that devastated Bihar, sand mining is observed to be one of reasons that made the impact of the floods worse.[57] Sand was always harvested from the rivers as a practice to meet construction needs. The present scenario is problematic due to the unsustainable and unregulated form of mining done on riverbeds.

SIXTH KNOT – CLIMATE CHANGE

Climate change is perhaps emerging as one of the greatest environmental challenges of the twenty-first century, which is further intensified due to population growth, economic development and increased demand on natural resources for food and energy needs. As scientific evidence and information on global warming emerges, the role of forests and associated ecosystems assume greater relevance in this context.

In recent decades, the impacts of climate change have indicated the sensitivity of natural and human systems towards it. Changing precipitation patterns, changing seasons and changes in cropping season, ocean acidification, migration of species due to fluctuations in temperature are some of the visible changes recorded. Pollution (air, water and soil), soil degradation, desertification and deforestation are some of the ramifications that have aggravated poverty, and impacted health and food security. Climatic variations or extreme weather conditions are leading to periodic droughts and floods, affecting a large population, among which the poor and the marginalized are affected the most.

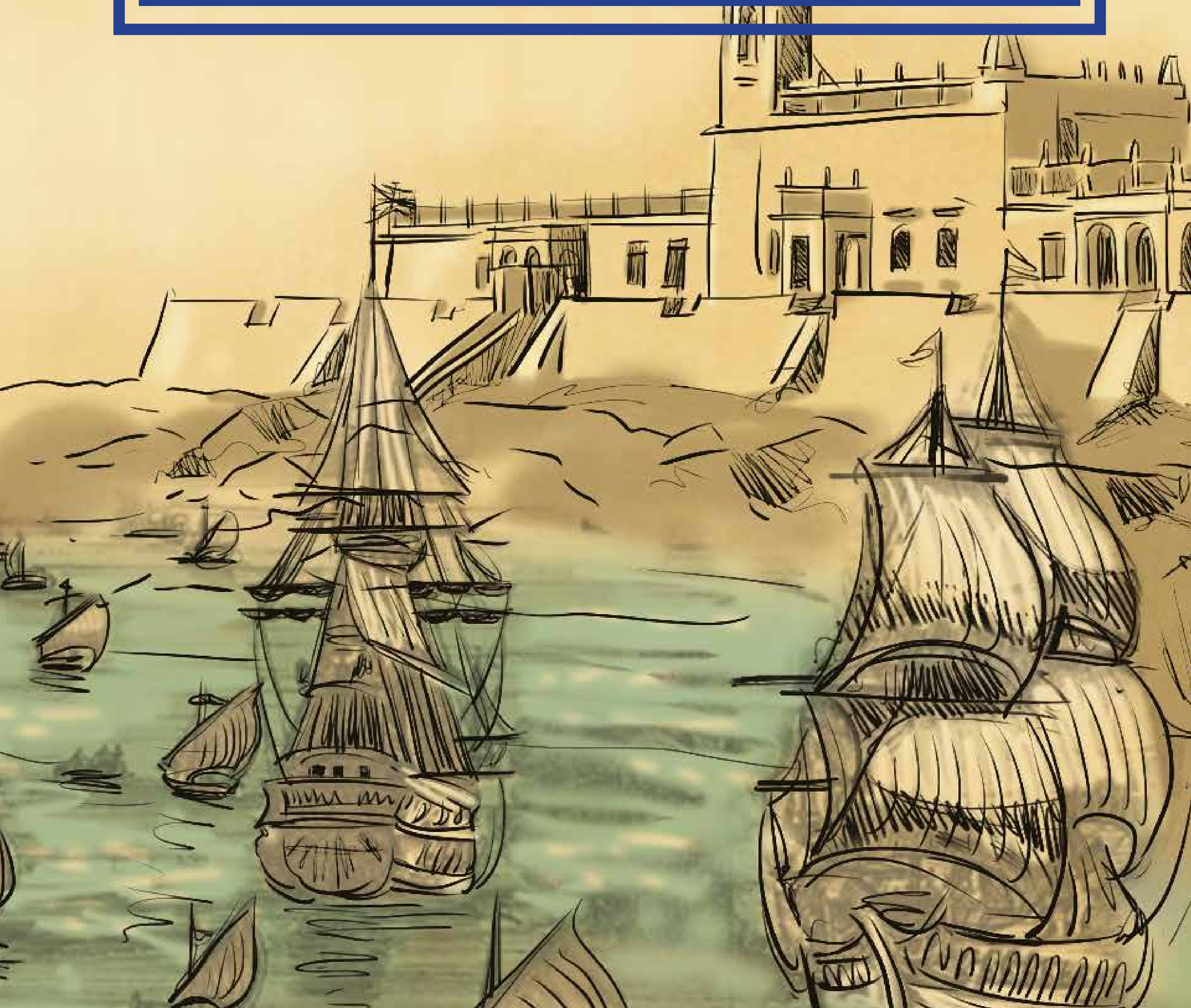
As the climate regulation capacity of many ecosystems deteriorates and/or experiences abrupt and non-linear changes, plant and animal populations will experience negative impacts at local and regional scales. These impacts may include all of the climate change effects already predicted or chronicled – changes in the timing and distribution of water (e.g. droughts, floods, snowpack availability); increases in insects, invasive species, and disease; habitat and biodiversity loss; and species range shifts. In addition, ecosystem services degradation often leads to declines in human well-being.[58]

The most dominant climate drivers for water availability are precipitation, temperature and evaporative demand (determined by net radiation at the ground, atmospheric humidity and wind speed, and temperature). Temperature is particularly important in snow-dominated basins and in coastal areas, the latter due to the impact of temperature on sea level (steric sea-level rise due to thermal expansion of water). In short, the total annual river runoff over the whole land surface is projected to increase, even though there are regions with a significant increase and significant decrease in runoff. However, increased runoff cannot be fully utilized unless there is adequate infrastructure to capture and store the extra water. Over the oceans, a net increase in the term "evaporation minus precipitation" is projected.[59]

River ecosystems have been severely impacted by a multitude of human uses over decades. Water abstraction, damming, pollution and habitat modification have dramatically diminished the functionality of these systems. Small mountainous streams that are usually less inhabited remained nevertheless relatively undisturbed, whereas the rivulets and smaller tributaries in the plains and in the southern peninsula face greater challenges from human interface. Physical alterations in catchments affect most rivers, disrupt their continuum and the interactions between the stream and its terrestrial surroundings, thereby, affecting biodiversity at large (Refer Annexure 3).

Chapter 02

PRINCIPLES OF REVITALIZING RIVERS



“Kaveri is like a graveyard. The sand burns my feet when I walk on it. There is no water – it makes me want to cry.”

~ A 10-year-old boy on the banks of Kaveri, Thanjavur (2017)

In Kerala, 700 villagers came together and brought Kuttemperoor river in Alappuzha district back to life in 70 days. This river was in a bad state for almost 2 decades.[1] Another people's movement from Kerala is revitalizing a part of the Varattar river.[2] The famous revitalization of the Arvari river of Rajasthan is the product of community effort driven by the village water parliament.[3] In all these cases, ordinary villagers with meager monetary means came together and made it happen. Many more rivers in our country, like Ganga, Yamuna and Kaveri, can be revitalized if only people contribute and participate. Every citizen will need to take a *sankalpa* or determined pledge for this cause. Because of the severity of damage that our rivers have suffered, 15-20 years may go by before they can come alive again. Revitalizing them is very much possible, but it demands a certain sense of urgency, sincerity and concerted effort in this direction. We need to take inspiration from our Independence movement when men and women across all strata of society – peasants, the middle class, the elite and the intelligentsia – rallied together. It is time we rally once more to free our rivers from destructive human activities.

The approach to water resource management in the last two decades has been to manage demand efficiently – a major shift from the older discourse of increasing the supply of water while assuming water in nature is inexhaustible. The current paradigm of demand management is a more sensitive approach to working on water resources compared to the previous supply management paradigm. Technological innovations of recent times have been focused on reducing the water consumption for any specific activity.

But with respect to rivers, the discourses and efforts have been solely focused on exploiting the existing quantum of available river water. This includes building of dams, check-dams, canals or linking rivers. A large number of dams are being built on rivers in northeast India to tap hydroelectric power. If the actual quantum of water flowing through the river reduces, all these engineering projects will become meaningless. Therefore, the conservation and revitalization of rivers must take center stage, to ensure augmentation of water flow in rivers with low to zero flow.

The previous chapter discussed the fundamental reasons for the current plight of our rivers, as understanding the cause is the first step towards finding the solution. In this chapter we try to understand in principle how to untie four out of the six knots described in Chapter 1. The other two knots – created by population explosion and by colonial and post-colonial management paradigm interventions – cannot be unknotted. Thus, we will look in-depth as to how to mitigate the consequences of these two knots.

As we map out solutions for untying the knots, we must keep in mind that carelessly unraveling certain knots may end up tearing the fabric of the river-human relationship. That is, if we demand dismantling of dams, or displacement of millions of people from floodplains, or shutting down of polluting industries which were set up over 5 decades ago, people will only cast rivers as their enemies. So while the knots related to human lands cannot be easily untied, we can certainly reduce the stress that such land us has brought upon river systems by adopting eco-friendly methods and technologies. Other knots like the loss of our cultural ethos and emotional connection to rivers, can be untied by working on our mindsets.

The solutions proposed to address each knot are charted out in Table 1.

TABLE 1: PROBLEM- SOLUTION MAP

	Knots	Approaches to Unknot or Alleviate Effect of Knot
1	Current River Management Paradigm	Convergence of institutions with various responsibilities to manage the sustainability of rivers
2	Deforestation	Afforestation
3	Over-exploitation of groundwater	Afforestation & efficient water use
4	Population	Efficient water use

	Knots	Approaches to Unknot or Alleviate Effect of Knot
5	Pollution	Organic or NPM agriculture practice; regulatory norms with incentives and disincentives for various types of action on the city and industrial level
6	Climate Change	Afforestation

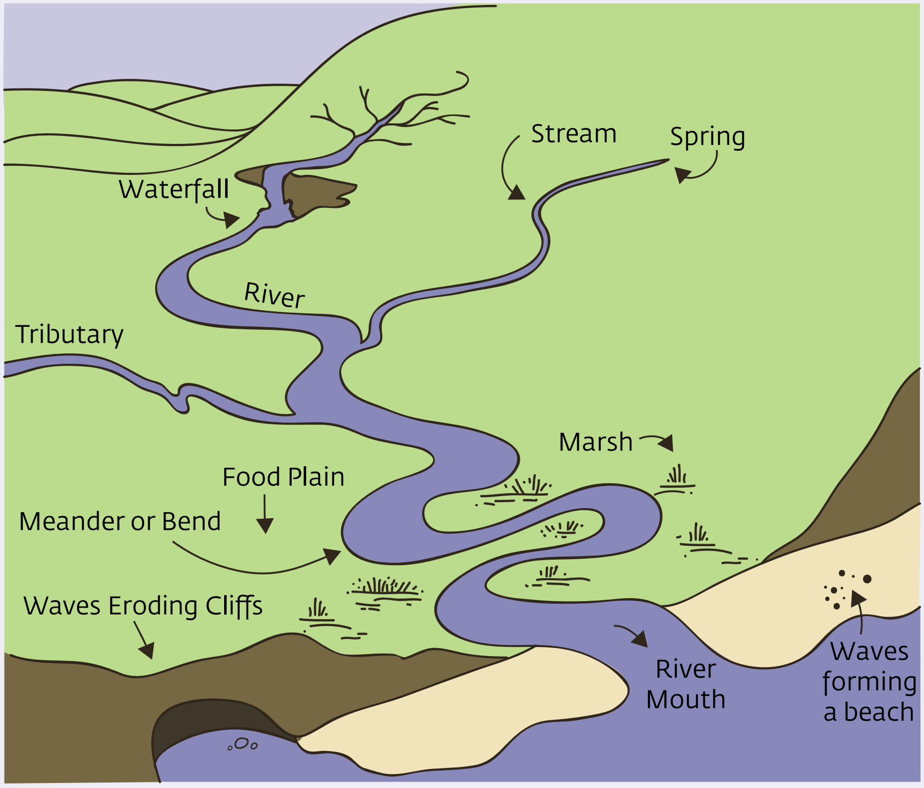
As water is a State subject under the Constitution, the protection of rivers is under the purview of State governments. However, The River Boards Act of 1956 deals with interstate rivers and empowers the Center for: the conservation, control and optimum utilization of water resources; promotion and operation of schemes for irrigation, water supply or drainage; promotion and operation of schemes for the development of hydro-electric power; promotion and operation of schemes for flood control; promotion and control of navigation; promotion of afforestation and control of soil erosion; and prevention of pollution of waters.[4] Yet the Act has never been used. One reason could be the complex and delicate nature of Center-State relations, with the Central Government hesitating to get into a confrontation with a State. Both at the Center and at the State levels, various aspects of exploitation and conservation of rivers are divided among Ministries. For example, hydro-electric power falls under the Ministry of Power; irrigation falls under the Ministry of Water Resources or Ministry of Irrigation; conservation of rivers falls under the Ministry of Environment and Forests. To be able to manage rivers sustainably, coordination between these Ministries is of paramount importance. This aspect of the solution will be dealt with in detail in Chapter 4, as it is dependent on the implementation framework of the proposed solution that we cover in Chapters 2 and 3.

The second solution of afforestation is an answer to deforestation, as well as over-exploitation of groundwater and climate change. Afforestation is a solution proposed from the source augmentation of rivers perspective, but the impact of afforestation on water bodies is not very apparent. We will discuss in this chapter how forests impact the hydrological cycle to benefit rivers and soil. In the context of climate change, forests become a huge carbon sink, absorbing the carbon in the atmosphere and reducing temperatures. Forests also impede high volume runoff during monsoons or floods and recharge aquifers around rivers, which eventually feed rivers during the lean season. Thus groundwater exploitation is taken care of through source augmentation and efficient demand management.

Our population has increased almost four-fold since independence, accompanied by an increase in industrial activity and urbanization. Our water demand has accordingly multiplied manifold, with irrigation accounting for almost 80% of the total water consumed in our country.[5] The flood irrigation practice followed by our farmers is 1000 years old. This needs to change. Micro-irrigation technologies are proven to substantially reduce the water demand of crops, and on a conservative estimate, improve the efficiency of water use by 50%. That is, the quantum of water required in micro-irrigation is half of that required in flood irrigation (See Annexure 9 on micro-irrigation). The efficiency of water use for domestic and industrial needs is not addressed in detail here, because the focus is on land on either sides of the river bed, which is mostly a composite of farm lands and forests, for river revitalization.

The issue of pollution is addressed in a two-pronged manner. Agricultural pollution from runoff of fertilizer and pesticides is addressed by promoting organic and NPM practices on the riverside farms. The issues of sewage from urban settlements and industrial effluents are dealt with in Chapter 4.

HISTORICAL APPROACHES TO REVITALIZING RIVERS



Source: http://thebritishgeographer.weebly.com/river-landforms.html

FIGURE 1: A RIVER AND ITS CATCHMENT AREA

Rivers gather their water from their tributaries, which in turn gather water from streams and other rivulets that are fed by water from forests and springs of the catchment region of the basin. The water that flows from the catchment region into streams and rivulets is called runoff. For a river or stream to flow, the catchment area, which is many times the size of the river, should remain as undisturbed as possible. It is very important that drainage channels especially are uninterrupted by any structure.

Figure 1 shows the way water is collected from various sources into rivers. This phenomenon of draining into the river happens through the entire stretch of the river basin from its origin to the point it meets the sea.

The catchment area of a river does not just comprise springs, streams, rivulets and tributaries. It is a composite of a much larger landmass around these water sources. The water that runs off from the land, and underground water currents, also contribute to the river as much as these surface water flows, if not more. The catchment area of a river is depicted in Figure 2.

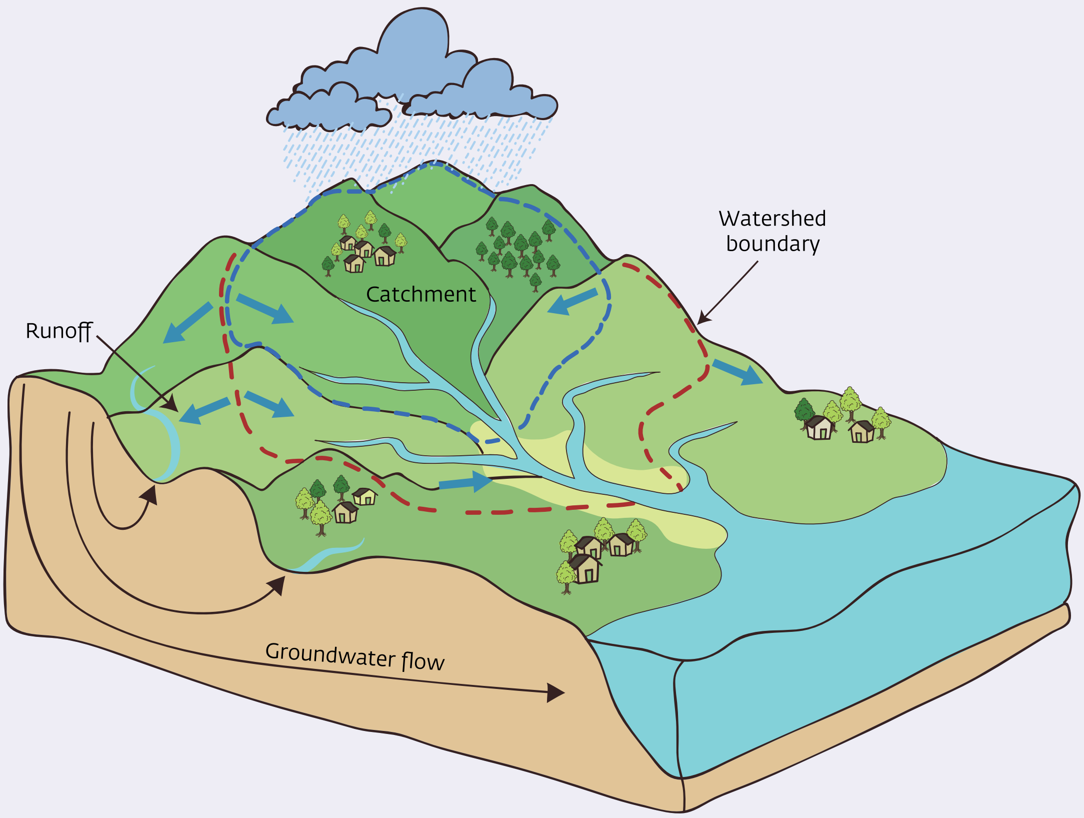


FIGURE 2: CATCHMENT AREA FOR ANY RIVER OR OTHER SURFACE WATER BODY

A river's catchment area encompasses hundreds of square kilometers. The entire catchment may be a composite of smaller catchment zones called watersheds. A watershed is an area of land that contains a common set of streams and rivers that all drain into a single larger body of water, such as a larger river, a lake or an ocean.[6]

A watershed is usually the unit of operation when any sustainable work to revitalize rivers and underground aquifers is envisioned. The revitalization of a river or any other water body is a byproduct of a revived watershed. Integrated watershed management (IWM) is a continuous and adaptive process of managing human activities in an ecosystem, within a defined watershed. It involves the integration of environmental, social and economic decisions and activities through an inclusive decision making process to manage the protection, conservation, restoration and enhancement of aquatic and terrestrial ecosystem features, functions and linkages.[7] This approach involves working on the land, soil fertility and augmentation of fresh water sources.

Integrated Watershed Management (IWM) is a holistic approach which theoretically and technically is the soundest means to revitalize rivers.

The watershed management approach has been followed in India since the 1970s. Till the early 1990s watershed development had been implemented in a fragmented manner by various departments without any planning on watershed basis by involving communities. In 1994, the Technical Committee on Drought-Prone Areas (Hanumantha Rao Committee) formulated a set of guidelines that brought the Desert Development Programme (DDP), Drought Prone Areas Programme (DPAP) and Integrated Wastelands Management Programme under one umbrella. Then in 2009, Government of India initiated an Integrated Watershed Management Programme, integrating DPAP, DDP and Integrated Wastelands Management Program.[8] The Integrated Watershed Management Programme is implemented across most rain-fed areas to help revive the water resources that were otherwise being depleted due to unsustainable practices. Despite a long spell of watershed management, it is unclear how successful the approaches are.[9]

All the evaluations of watershed management are done to assess the technical strength of the solution. A solution this holistic which together addresses the crisis of land, ecological diversity and water will anyway be environmentally sound and sustainable. The reason why many technical solutions to development problems in India or other countries have not taken off is because they did not take into consideration the political and administrative realities of the day.

The challenges with the watershed management approach can be widely classified into two categories – political and administrative boundaries and inequity. Watershed boundaries do not coincide with political and administrative boundaries. A watershed is often spread across two different villages, blocks, districts, sometimes even two different states. A watershed often encompasses land under the administrative control of various departments - for example, a revenue department, forest department and Gram Panchayat. The equity challenge has to do with the outcome of any watershed effort. That is, there is no mechanism to address the upstream-downstream inequity, inter-village inequity, and sometimes in the process of revitalization, while some groundwater sources get recharged others dip.[10] The watershed approach when implemented on the ground was seen by communities as a means to develop the resource rather than manage it. Therefore, there is an uncertainty about water availability to the stakeholders midstream and downstream, making stakeholder consensus difficult.[11] Blomquist *et al.* put the politics of watershed management succinctly, here:

"This gap between prescription and practice (of watershed management) is sometimes attributed to politics, as a sort of nuisance to be overcome or avoided through rational, comprehensive, consensus-based decision making. Fundamental political considerations are inherent in water resources management, however, and are unavoidable even if the desire for watershed-scale decision-making bodies were realized. Boundary definition, choices about decision-making arrangements, and issues of accountability will arise in any watershed... "[12]

SOURCE AUGMENTATION OF RIVERS
A TREE PLANTATION APPROACH

The benefits of forests are intrinsic to the cultures that have had a deep relationship with nature. Charles C. Mann in *1491: New Revelations of the Americas Before Columbus*, describes how evolved the native American way of living was before the invasion of the Europeans. Their system of cultivations was based on tree farming, also known as forest gardening, and was quite advanced compared to what is practiced as agriculture today. Across India, traditionally there are certain patches of forest in and around a village that are kept untouched. These are called the sacred groves, or temple forests. People are educated on the types of trees which are worshipped and which they are not permitted to cut. Two trees that are worshipped unanimously all across the country are *Ficus bengalensis* (banyan) and *Ficus religiosa* (bodhi / peepal). Certain trees are linked to specific kinds of worship. For example, a festival is celebrated in winter to worship *Amla,* i.e. *Phyllanthus emblica*. Lord Shiva had to be worshiped with leaves of *Balanites aegyptiaca* and *Datura stramonium* fruits, and *Calotropis procera* flowers besides others.[13]

Forests are important in the context of precipitation. India gets its rain from monsoon rainfall. These rains have seasonally changing patterns, unlike convection rains. With various hill ranges, there are regions that fall on the leeward side or the rain shadow regions of the mountain ranges. In the rain shadow regions, the forest's ability to cause inland rain by seeding the water laden clouds becomes very critical especially during the drought years.

It is interesting to observe that in current times we understand the benefits of forests only when they are lost and not when they were thriving. Our ancestors did not know reductionist science, but they were sensitive to observe empirically what role nature played and how the wellbeing of human society is linked to the environment around us. Nature would remind us of the precariousness of our lives in quite a number of ways. While the advancements in science and technology have shielded us from the risks associated with many natural phenomena, the cost has been the loss of our relationship with nature. However, recently people are rediscovering this connection and have begun a number of initiatives to restore forests.

CASE STUDIES

Next we look at various case studies that used tree plantation as an approach for source augmentation of rivers. In the case of the Gagas river of Uttarakhand, people from 70 communities came together to revitalize the river and saw it flow. A detailed story of this success is available in Annexure 4.

CASE STUDY FROM INDIA

REVIVAL OF SPRINGS IN THE WATERSHED OF GAGAS RIVER IN UTTARAKHAND

The Gagas river originates in the sacred forests of Pandukholi in Almora district, of Kumaon Himalayas in the state of Uttarakhand. The river is largely defined through the flow of over fourteen major streams or *gadheras* on both banks, and flows for about 50 km prior to merging with Ramganga (West) river. The river basin is spread over 500 sq. km., supporting a population of over 120,000 in 370 villages.

Springs, or *naulas* as they are traditionally called, are the main sources of water in the hills for the people. Overflow from these springs also contributes to small streams which in turn join to form rivulets and rivers. About 15 years ago, the ecological situation had worsened in many parts of the Gagas river's catchment, to the extent that the majority of springs had either dried up completely or their flow was restricted flow to only certain months of the year. It was then that the Ranikhet based Pan Himalaya Grassroots Development Foundation forged a coalition of interest between communities of 70 villages to form a "Gadhera Bachao Samiti". This body decided to plant native trees in their catchment – approximately 1000 hectares. They raised over 1 million saplings of over twenty native species of trees and shrubs in small village nurseries and planted them in the catchment. Simultaneously, they undertook locally appropriate soil conservation measures by digging small trenches or ponds across the gradient of the slope. These are locally called *nals* and *khals.* This improved the moisture regime in the plantation areas as well as infiltration. As the trees started to come up, many springs started to flow around the year, and the overall water situation in the Gadhera improved tremendously.

CASE STUDIES FROM AROUND THE WORLD

We will look now at a few cases across the world to illustrate the relationship between trees and rainfall.

CASE STUDIES FROM EUROPE

DANUBE RIVER

The central component of a European project to revitalize the Danube river, is restoring natural ecosystems affected by human activity. This is done by establishing a continuous ecological corridor called the River Greenway adjacent to the Danube river.[14] More details of the project are available in Annexure 5.

CASE STUDIES FROM NORTH AMERICA

VIRGINIA

The state of Virginia in the US has sponsored a riparian reforestation project in Fairfax county. They aim to create forest buffers – trees, shrubs and other plants that grow alongside streams and rivers. Forest buffers are critical to the health of the Chesapeake Bay. Forest buffers prevent pollution from entering waterways, stabilize stream banks, provide food and habitat to wildlife, and keep streams cool during hot weather. Chesapeake Bay Program partners are working to restore 900 miles of forest buffers per year until 70% of all stream banks and shorelines in the watershed are buffered. 8000 miles of 35-150 feet wide strips of trees have been planted. Plans include planting 15,000 more miles of streamside buffers.[15]

USDA

The US Department of Agriculture (USDA) Conservation Reserve Program and Conservation Reserve Enhancement Program provide incentives for farmers to create streamside buffers. Financial benefits for participants of Conservation Practice 22 (CP-22) (Riparian buffer) are guaranteed as given below.[16]

- 10-15 years of annual rental payments with an additional 20% Rental Rate Incentive
- Payments covering up to 90% of the eligible costs of establishing the practice – 50% from a Cost-Share Payment and 40% from a Practice Incentive Payment (PIP)
- Sign-up Incentive Payment (SIP) up to $100/acre
- Maintenance Rate Incentive
- Mid-Contract Management Cost Share

NEBRASKA, USA[17]

Nebraska has a buffer strip program wherein the government pays the farmer a "rental rate" of $20 to $250 per acre to plant streamside buffer strips. Rates depend on the soil type, whether land is irrigated and whether farmers are enrolled in other programs. Streamside buffers are generally seen as extremely important by all US state forestry services. Cropland adjacent to perennial and seasonal streams, ponds, and wetlands can be enrolled in buffer strips, which are designed to filter agrichemicals such as fertilizers and pesticides. Two kinds of buffer strips are eligible – filter strips, which are narrow strips of grass, and riparian forest buffer strips containing trees and grass. The minimum widths are 20 and 55 feet, respectively; the maximum widths are 120 and 180 feet, respectively.

COON VALLEY, WISCONSIN, USA[18]

Starting from 1935, the US government worked with farmers to restore the Coon valley. After a few years, they found better dry season flows, reduced flood peaks, and healthier soil. Forest cover went up from 37% in 1939 to 50% in 1993.

CASE STUDIES FROM AROUND THE WORLD

CASE STUDIES FROM LATIN AMERICA

SAO PAULO, BRAZIL[19]

Brazil is pursuing an ecosystem restoration of riparian forests in Cerrado. The development objective of the Ecosystem Restoration of Riparian Forests in Sao Paulo Project is to support long-term, large-scale restoration of the riparian forests at Cerrado, and the Atlantic Forest biomes. This is to be done through the development and harmonization of policy, regulatory, economic, and technological tools and mechanisms, while providing opportunities for improved livelihoods, and economic wellbeing of rural communities.

THE PROPOSED SOLUTION

Afforestation of a minimum of 1 kilometer width for the entire stretch on either side of large rivers is the solution proposed to augment the source of water and revive the flow in the rivers. The fundamental reason behind this solution is the role forests play in closing the hydrology cycle, the effect they have on groundwater aquifers, soil and in stabilizing the climate. In this section we take a scientific look at how trees can perform all these functions.

EFFECT OF AFFORESTATION ON RAINFALL

Trees as permanent green cover have a significant impact on stabilizing precipitation patterns.[20] This is achieved by the evapo-transpiration of trees that seed the passing rain clouds, thereby making it rain in and around the tree cover itself. This adds to the flow of the river too. This phenomenon is described below.

Increased rainfall[21] – Trees attract water-laden clouds to precipitate. As forests disappear, precipitation will also reduce in the area, in and around the river floodplains. River flows over time reflect an increase in deluges and scanty flow. Rainfall is increasingly sporadic in nature. [22, 23] If the trees were present, especially around the river, the rainfall pattern would be different.

The effect of trees on the river banks is described in the following scientific explanation by Bill Mollison in *Trees and their Energy Transactions*:

"*A point which is often overlooked is the effect of trees in increasing total precipitation considerably beyond what is recorded by rain gauges.* **The intermittent presence of trees that grow up to a height of 40 feet in forest land and private lands with the wind blowing across these lands create the Ekman spirals[24] thereby causing repeated rainfall in the local region.**

The upward spirals of humid air coming up from the woodlands carry insects, pollen and bacteria aloft thereby seeding the cloud, creating nuclei for rain. The formation of nuclei is a governing factor for local rainfall.[25]

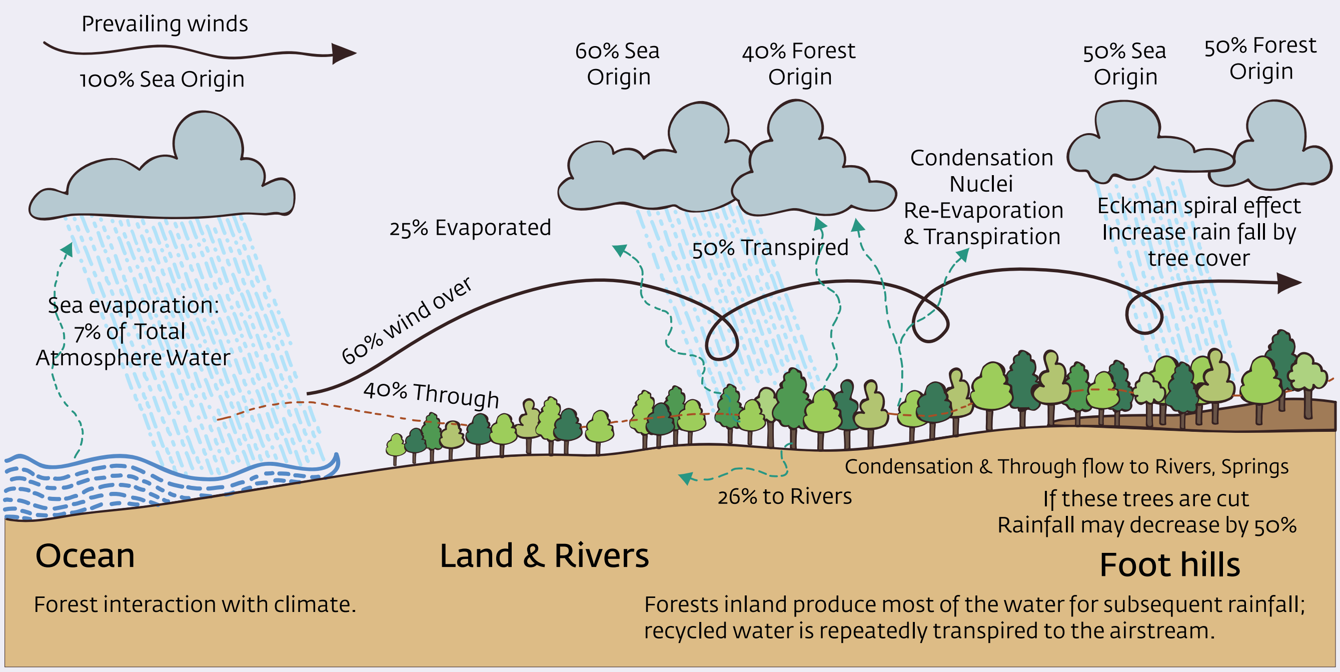


FIGURE 3: FOREST INTERACTION WITH CLIMATE

The impact of forest derived evapotranspiration can be seen in satellite observations of rainfall: over most of the tropics, air that passes over forests for ten days typically produces at least twice as much rain as air that passes over sparse vegetation. Higher relative humidity has likewise been found to raise the likelihood of precipitation. A 10% rise in relative humidity can lead to two-to-three times the amount of precipitation.[26]

Trees and forests contribute to the intensification of rainfall through the biological particles they release into the atmosphere, which include fungal spores, pollen, bacterial cells and biological debris. Atmospheric moisture condenses when air becomes sufficiently saturated with water and much more readily when suitable surfaces, provided by aerosol particles, are present.[27] In the Amazon forests, potassium-salt rich particles with clear biological origins also appear to be directly linked to cloud formation and precipitation.[28] A synthesis of many scientific papers discussing the relationship between trees and rainfall is presented in Annexure 6.

Harvesting environmental humidity: There is another phenomenon where trees harvest water from the atmosphere. A lesser known but significant impact of the tree cover is its condensation effect. This condensation effect created by the tree foliage also adds to substantial amount of water harvested from the humidity of the environment. On average, at least 40% of rainfall over land originates from evapotranspiration (ET), with greater contributions in some regions such as the Rio de Plata river basin, where ET from the Amazon forest contributes more than 70% of rainfall.[29] Transpiration contributes the dominant part of terrestrial ET,[30] thereby producing a part of the water vapor available for rainfall.

In all, forests help in increasing the number of rainy days thus helping have more surface runoff (during rainy days) and subsurface runoff (in non-rainy days) by recharging subsurface aquifers.

EFFECT OF AFFORESTATION ON GROUNDWATER AND SUBSURFACE RUNOFF TO RIVERS

Developing tree cover by tree plantation in the runoff and floodplain area of rivers is a very simple and effective solution to ensure prolonged surface and subsurface flows, and enhance overall water supply.
Trees through their roots enhance the percolation of the water from condensation and percolation into the soil. This will lead to an increased quantum of water in groundwater aquifers that feeds into the flows of the river. Trees help the soil to feed water flow into the rivers in a consistent manner over a long period, drop by drop through its groundwater.

Where does the water in a river come from when it has not rained recently? Base flow is the technical name for flow in a stream or river. River base flow results from groundwater seeping into riverbanks or the riverbed. Base flow is the sole or primary source of streamflow during the annual dry season when rainfall is insufficient to generate substantive runoff. The groundwater flow has a much larger scale and is controlled by vegetative cover, rainfall, land-surface slope, geology and other factors.[31] Hydro-geologists have recognized the importance of the interconnected nature of groundwater and surface water. The surface water is almost always connected to groundwater, which has a critical impact on river water flow.

In general the base flow can be significant enough to allow the stream to flow around the year (i.e. perennial or permanent stream). Recharge from groundwater through base flow is the major source for sustained flow in the river except during storms. For example, on average, 40 percent of all flow in United States rivers and streams originates from the groundwater. Groundwater flowing into a stream is called a “gaining stream”, the most common occurrence of water inflow to streams. Contrariwise, when a river level gets a rise, for example in response to a storm, water can flow from the river into the channel banks, as the water level in the channel rises above the pre-storm groundwater level. This is known as "losing stream". If the stream overtops its banks, to spread over a floodplain, flood water infiltrates to the groundwater under the floodplain. This seepage and infiltration can help reduce the impacts of flooding in downstream areas, and after the storm, the slow release of water from the surrounding saturated area maintains the base flow in the channel. Infiltration through the floodplain to the underlying groundwater table is one of the reasons why maintaining floodplains in an undeveloped (pervious) condition must be an important consideration for planning development.[32]

A stream may switch back and forth between losing and gaining on a seasonal basis during the year and/or during the course of its flow downstream from its headwaters. Conditions may change from gaining to losing at the upstream end of a meander or at the top of an abrupt change in the gradient of the channel. Excessive pumping from a well in the vicinity of a stream may induce a "losing" condition when the zone of drawdown around the well intersects the surface water body. Since groundwater and surface water are not separate resources, when our activities use one of these resources, it often affects the other in a relatively short time frame in terms of quantity and quality.[33]

An important question in hydrogeology is how much base flow occurs in a river in response to a given amount of rainfall. To answer this question, we need to know where water goes when it rains, how long water resides in a watershed, and what pathway water takes to the stream channel. Answering the question of how much runoff is generated from surface water requires partitioning water inputs at the earth's surface into: components that infiltrate and components that flow overland and directly enter into streams. The pathways followed by infiltrated water need to be understood. Infiltrated water that enters into the subsurface, that takes it to the stream relatively quickly, is called interflow. Infiltrated water can also percolate to deeper levels and connect to groundwater, which sustains the steady flow in streams over much longer time scales; this is called base flow. The figure below illustrates schematically many of the processes involved in the generation of groundwater and stream flow.

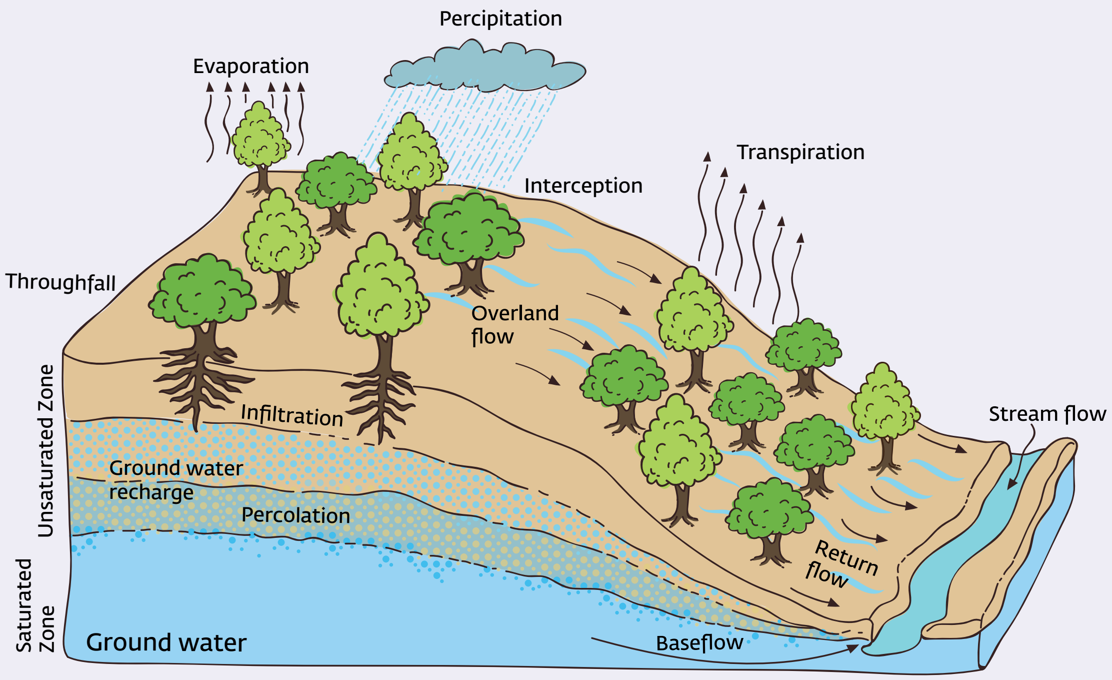


FIGURE 4: PHYSICAL PROCESSES INVOLVED IN RUNOFF AND BASE FLOW

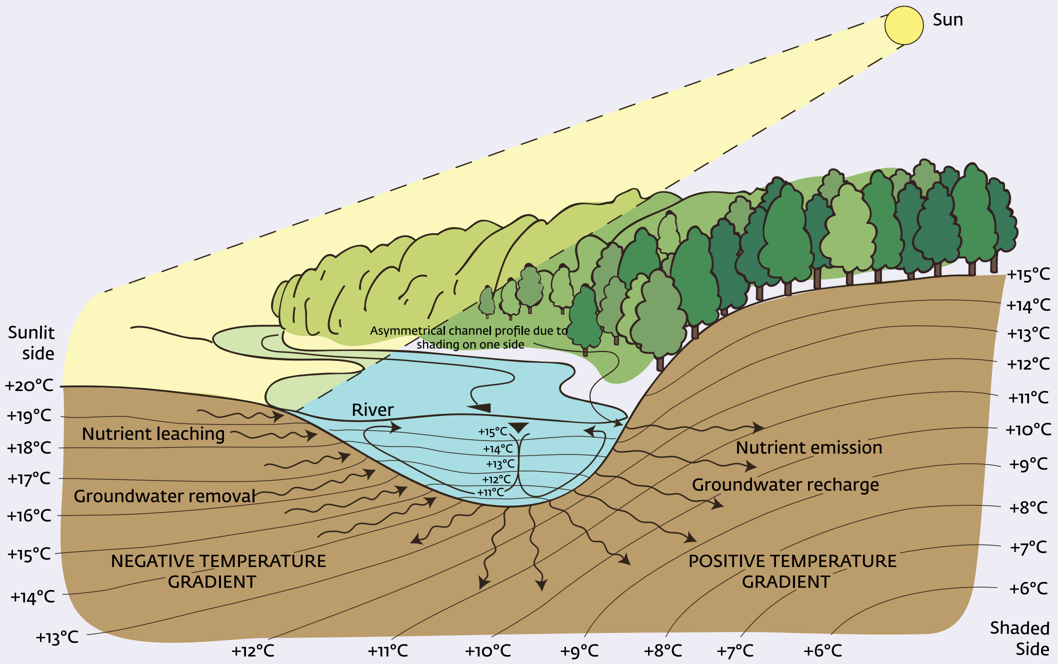


FIGURE 5: TEMPERATURE GRADIENT, GROUNDWATER RECHARGE DONE BY FOREST

(SOURCE: CALLUM COATS; LIVING ENERGIES)

The effect of the loss of forestlands is the establishment of an adverse temperature gradient. This leads to loss of groundwater and soil nutrient leaching. On the other hand, if there are trees on the river banks, then the temperature gradient reverses – leading to a recharge of groundwater and no soil nutrient leaching.[34] Afforestation changes temperature gradients that lead to groundwater and soil nutrient loss.

How can a tree increase infiltration rate? Living and decaying roots create a network of well-connected channels in the soil called macro-pores. Water flow through these macro-pores can be up to several hundred times faster than flow through the soil matrix.[35] In addition, organic matter from leaf litter and tree roots improves soil structure, which can increase infiltration rates. Soil structure is improved as soil particles are cemented together by humus, by organic glues created by fungi and bacteria decomposing organic matter, and by polymers and sugars excreted from roots. Not surprisingly, several studies have documented that vegetation maintains adequate saturated hydraulic conductivity over time in bio retention areas.[36] Breen and Denman specifically compared unsaturated infiltration rates of model soil profiles in above ground containers with trees to containers without trees and found that those with trees had higher infiltration rates.[37] This tells us that even at a very young age, the trees were already having a positive effect on the hydraulic conductivity. Bartens *et al.* (2009) also found that tree roots affected soil hydraulic conductivity even at a young age, and concluded that "woody roots can increase infiltration relatively quickly before there is opportunity for very large diameter roots to form and when root turnover is likely minimal and that therefore it seems probable that water travelled around root channels along existing live roots".[38] In addition, studies examined the role of stem flow (that is, the flow of intercepted water conveyed down the trunk or stem of a plant) as a major source of infiltration into the soil[39, 40] (Koichiro, 2001; Johnson and Lehmann, 2006). The infiltration mechanism is presented in Figure 6 a&b.

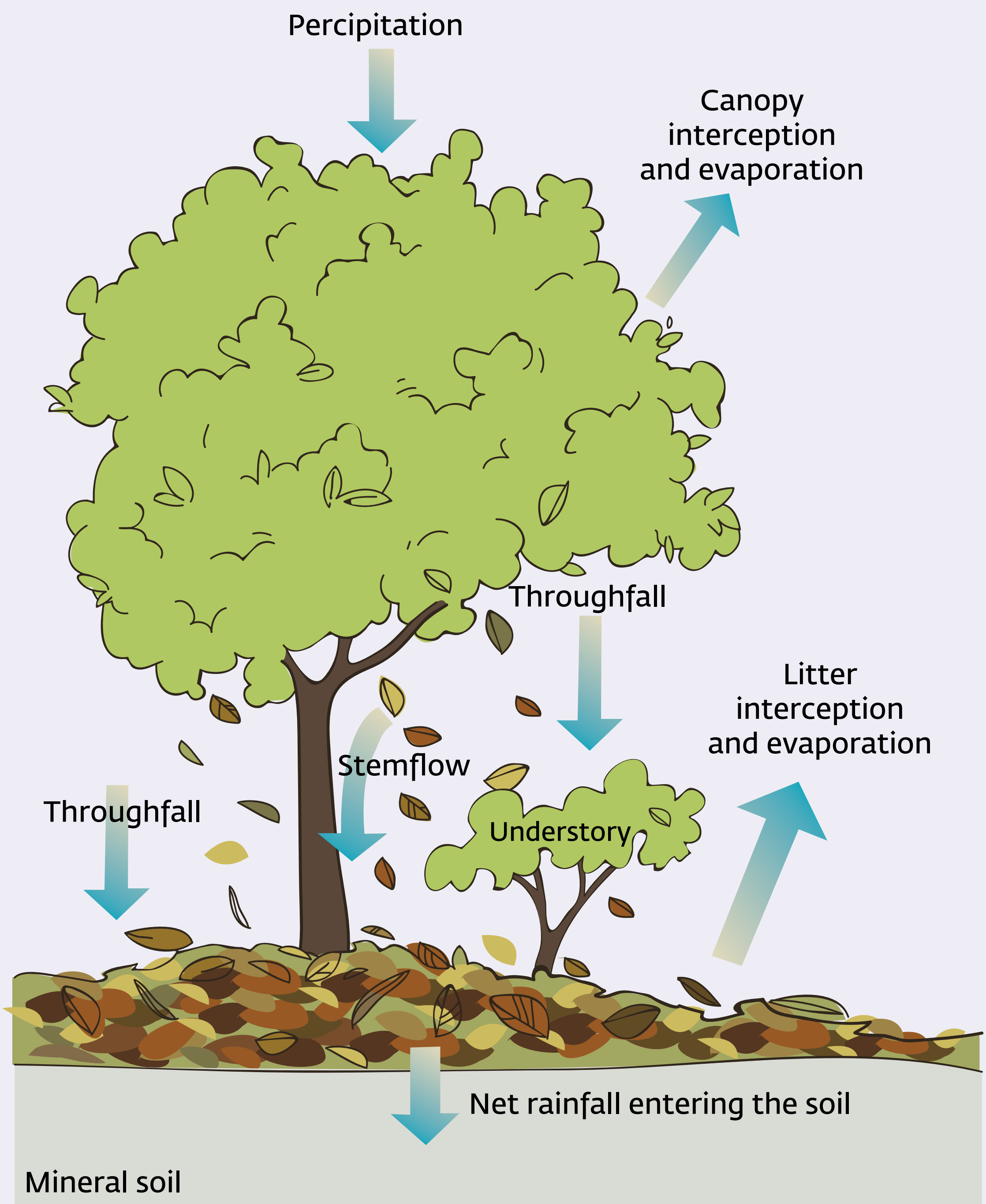


FIGURE 6(A): INFILTRATION MECHANISM IN TREE COVERED AREA

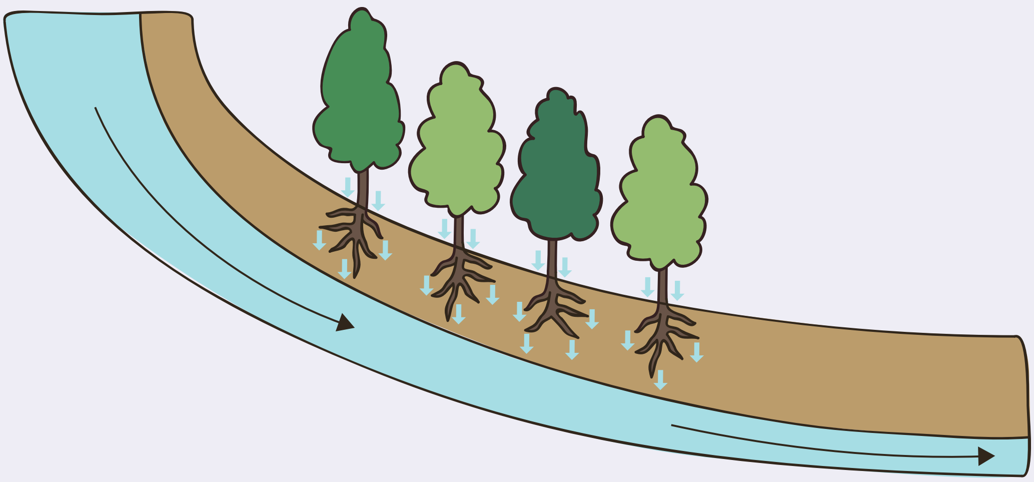


FIGURE 6(B): SCHEMATIC DIAGRAM OF HIGH INFILTRATION IN FOREST AREA

Johnson and Lehmann (2006) determined that infiltration of stem flow, which results from the partition of rainfall by the tree canopy, is enhanced by root-induced preferential flow. The amount of precipitation accounted for as stem flow ranged from less than 1 to as much as 22 percent of incident rainfall above the forest canopy where the rainfall averaged 24 to 200 inches per year. The hydrological role of stem flow is as a water source to the soil beneath the forest. Although the ratio of stem flow to precipitation is small in a forested basin, the effect of stem flow on groundwater recharge might be relatively large.[41]

Not only will the overall quantum of river water stabilize by afforestation but the quality of water will also improve. This is because the major source of pollutant in our rivers is the agro-chemicals used in agriculture. Having green cover will ensure that the rhizosphere of the tree filters out these agro-chemicals from the soil and runoff water before it seeps into the river itself.[42] A detailed reasoning on the effect of tree plantation on the ground water and the hydrological cycle is presented in Annexure 1.

EFFECT ON SOIL

Afforestation ensures increase in soil biodiversity and reduces soil erosion. Soil bio-diversity is improved due to multiple rhizospheres of different fruit crops, and the presence of a variety of microorganisms associated with the rhizosphere. The role of afforestation in the change of soil organic matter, after establishing new forest on former agricultural lands, is scientifically proven. It is observed that afforestation considerably increases the organic matter in erstwhile agricultural land.[43] It was also observed that there was a substantial amount of increase in the soil's ability to sequester carbon, improved soil quality and ecosystem services provided by the soil.[44]

Soil erosion is totally avoided by the non-tillage, multi-tier, multi-crop, and mulching model that has been proposed, resulting in better runoff, leading to increased surface flow. The runoff water is also pollutant free. A soil scientist writes about the poor state of the Indian soil, in relationship to rivers and farmers, and how tree plantation can be part of the solution in Annexure 7.

EFFECTS ON CLIMATE CHANGE

Most of us understand that burning fossil fuels releases carbon that was once buried deep beneath the earth into the atmosphere, turning the planet into one big greenhouse in the process. But in addition to petroleum underground, the soil on the surface of the earth contains a sizable store of carbon in the form of organic matter. Plants add organic matter to the soil when they decompose, and photosynthesis, by definition, removes carbon dioxide from the air and pumps it through the roots of plants and into the soil.

India has set ambitious targets to reduce our carbon footprint. By 2030, our Prime Minister has committed that India will reduce emissions by 33 to 35% per cent of 2005 levels. A key way in which this will be done is by enlarging our forest cover to absorb at least 2.5 billion tonnes worth of carbon dioxide.

In the context of that national objective, it is useful to note that one fruit tree approximately absorbs 4.22 gm of carbon per hour. One square kilometer of tree cover has the potential of sequestering 3,500 tonnes of CO_2 per year at 400 trees per acre. So 2000 square kilometers of tree cover has the potential of absorbing 7 million tonnes of CO_2 per year. Across the 20,000 km of river length in the country, that represents a reduction of 140 million tonnes of CO_2 per year. That makes a significant 6% contribution to the national carbon footprint reduction goal via forest covers. This 6% is a conservative estimate – it is likely to be higher because we haven't accounted for two factors: the relatively higher carbon sequestering ability of a multipurpose tree versus a fruit tree; and the fact that we would save methane emission from annual crops like paddy by flood irrigation which has much higher global warming ability.

Carbon farming[45] is agriculture's answer to climate change. Simply put, the goal is to take excess carbon out of the atmosphere, where the element causes global warming, and store it in the soil, where carbon aids the growth of plants. The principle is pretty straightforward—the practice, not so much.[46] The reduction of temperature in the riverine ecosystem results in reduction in riverbank temperature relative to the river water temperature. This will lead to recharge of groundwater, and will also prevent loss of nutrients in soil into the river.

Non-destructively harvested perennial (NDHP) crops is a categorization of plants/trees that can meet human needs of oil, carbohydrates, proteins and energy, by not destroying them after they yield their produce. Replacing perennial crops that are destroyed every year after the yielding of the produce with NDHP crops, we ensure that the soil is not tilled and therefore the organic carbon is intact. No tillage also saves energy that is spent by machinery used for this purpose.[47] An excerpt from the book on Carbon Farming, that looks at trees and tree-based farming as a solution to the climate change conditions that perennial crops suffer is presented in Annexure 8.

EFFICIENT DEMAND MANAGEMENT

Agricultural water demand amounts to almost 80% of the total fresh water demand in our country. In this section we discuss the technical solution to address this demand. The demand management of industrial and domestic water is not dealt with in detail here, as it requires regulatory mechanisms to address it. These will be discussed in Chapter 4 in detail as a part of the implementation framework for revitalizing rivers. In this section we try to **improve agricultural water use efficiency through appropriate micro-irrigation technologies thus reducing the demand substantially.**

The quantum of water used for irrigation in the last century was of the order of 300 km^3 of surface water and 128 km^3 of groundwater – a total of 428 km^3. The estimates indicate that by the year 2025, the water requirement for irrigation would be 561 km^3 for a low-demand scenario and 611 km^3 for a high-demand scenario. These requirements are likely to further increase to 628 km^3 for low-demand scenarios and 807 km^3 for high-demand scenarios by 2050. As the world population is increasing at a very fast rate, to meet the food requirement it becomes essential to increase the food production at the same rate. To enhance food production, more land should be brought under cultivation and irrigation And so efficient use of available water resources is becoming unavoidable. To tackle this issue, adoption of a micro-irrigation drip system is the best solution.[48]

Drip irrigation is an advanced method of irrigation wherein water is delivered directly at the root zone of crops at frequent intervals in a controlled manner through a closed conduit pipe network. In drip irrigation, generally irrigation is given on a daily basis to fulfil the day-to-day crop water requirement. As water is conveyed through a network of pipes and delivered precisely only at the root zone of crops, the conveyance losses or in-field application losses are almost nil, enabling overall application efficiency as high as 90-95%. In conventional flood irrigation, water is allowed to flow through open canals and field channels and spread in the entire area of irrigation irrespective of cropped and uncropped areas / root zones. As this is uncontrolled water application through porous soil media, most of the water gets lost due to evaporation, runoff, deep percolation, etc., resulting in overall irrigation efficiency as low as 40-60%.[49]

In the conventional flood irrigation method, it is a general practice to apply water to soil once in a week or so. In such irrigation, soil moisture content reaches saturation upon irrigation and recedes to wilting point till the next irrigation. In these situations, most of the time plant roots suffer either due to saturation or moisture stress which results in monotonous plant growth and yield. On the other hand, the daily water application to the root zone of the crop in drip irrigation is an attempt to maintain the soil moisture nearly at field capacity. Due to frequent application and optimum moisture levels in the root zone, i.e. all the time favorable moisture conditions, the plant grows well and yields good produce with excellent quality.

Along with reduction in water use, there are many other advantages to drip irrigation. These include improved crop yield and quality as compared to the conventional irrigation method; minimized fertilizer/ nutrient loss due to localized application, reduced leaching, and reduced weed growth. Water application efficiency is high and it is not necessary to level fields. Drip irrigation can irrigate irregular shaped fields. It avoids soil erosion, and soil type plays a less important role in the frequency of irrigation. The distribution of water is very uniform, labour cost is low and variation in supply is possible by regulating the valves and drippers. Fertigation is possible with minimum wastage of fertilizers, and the foliage remains dry, thus reducing the risk of disease. More details about the effect of drip irrigation are presented in Annexure 9.

THE KNOTS UNTIED

The first chapter looked at the state of rivers and the reasons for it. In this chapter we proposed afforestation and efficient demand management as the technical solutions to revitalizing rivers. None of the proposed solutions are new or path breaking. Anyone who has an understanding of the problem will be able to perceive the logic behind the solutions proposed.

But the challenge regarding afforestation on either side of a river as a solution is with respect to its implementability. Land on the floodplains, especially beside the river, happens to be one the most fertile land patches of the basin with active farming practiced on it. The solution cannot be relocating farmers or removing urban encroachment or shutting down polluting industries. The solution has to be developed in the context of the present conditions on the river side.

The generic technical plan of how much afforestation, and what kind of afforestation around the riverside, will be discussed in Chapter 3. Implementation of the technical solution proposed is also covered in Chapter 3, while mitigating the knots formed by the current river management paradigm and pollution control will be dealt with in Chapter 4.

INTERLINKING OF RIVERS

Interlinking of rivers as a concept was first proposed over a hundred years ago and has been revived several times since. The concept gained new momentum in the early 2000s, was legally challenged, and the Supreme Court finally gave it a go-ahead in 2006. The first phase of the Ken-Betwa link and the Damaganga-Pinjal link are now being expedited. Is this going to be yet another knot that we have to undo? We will briefly examine the basic concept, and the arguments for and against it.

INTERLINKING RIVERS – THE CONCEPT[50]

In 1980, the then Ministry of Irrigation and Central Water Commission formulated the National Perspective Plan (NPP) for Water Resources Development envisaging Inter-Basin Water Transfer comprising of the following two components.

HIMALAYAN RIVERS DEVELOPMENT - 14 LINKS

Himalayan Rivers Development envisages construction of storage reservoirs on the main Ganga, the Brahmaputra, and their principal tributaries in India and Nepal. Additionally planned are an interlinking canal system to transfer surplus flows from the eastern tributaries of the Ganga to the west, and the linking of the main Brahmaputra with the Ganga.

Apart from providing irrigation to an additional area of about 22 million hectares, and the generation of about 30 million kilowatts of hydro-power, it will provide substantial flood control in the Ganga-Brahmaputra basin. It would provide 40,000 cusecs to Calcutta Port and would provide navigation facilities across the country. The scheme will benefit not only the states in the Ganga-Brahmaputra Basin, but also Nepal and Bangladesh as well as the northern and western states of India.

PENINSULAR RIVERS DEVELOPMENT - 16 LINKS

This consists of four parts described below.

Interlinking of Mahanadi-Godavari-Krishna-Pennar-Kaveri

It is assumed that the Mahanadi and the Godavari are likely to have sizable surpluses. Therefore, it is possible to divert the surplus of the Mahanadi and the Godavari to the rivers that are facing water-shortage: Krishna, Pennar and Kaveri. Essentially, this proposal considers the diversion of 15 million acre-feet of Mahanadi flows to the Godavari and a transfer of 30 million acre-feet from the Godavari and its tributaries to the Krishna Basin.

Interlinking of West Flowing Rivers, North of Mumbai and South of Tapi

A number of short-length rivers flow into the west coast north of Mumbai and south of Tapi. Construction of as many optimal storages as possible on these streams and interlinking them can allow an appreciable quantum of water to be transferred to areas severely in need of additional water. Two link-canals are envisaged. The first canal will run northwards from Damanganga and connect it with the Tapi and Narmada rivers. A southern link canal starting from the Damanganga can run along a suitable alignment at the appropriate elevation to Mumbai.

Interlinking of Ken with Chambal

The Ken, Dhasan, Betwa, Sindh and Chambal rivers are southern tributaries of the Yamuna draining about 2.4 lakh square kilometers including the Malwa plateau, Bundelkhand and Baghelkhand, which are amongst the most backward regions in the country and prone to frequent droughts. In order to provide a water grid for Madhya Pradesh and Uttar Pradesh in this region, an interlinking canal could be identified backed by as much storage as feasible.

Diversion of West Flowing Rivers

The narrow coastal plains of India along the west coast, stretching from Kanyakumari in the south to the Tapi in the north, have distinct features both in topography and water resources. The bulk of the rainfall is contributed by the southwest monsoon and a good part of it precipitates on the western side of the Western Ghats because of the high mountains in this region. The narrow coastal belt has numerous rivers and streams which empty into the Arabian Sea. The west flowing rivers in Kerala alone carry an average annual flow of 62 million acre-feet, and those in Karnataka, 50 million acre-feet. The proposal in Kerala is to store and convey water from one river basin to another and transfer the surplus portion of it from west to east for irrigation in an economical manner.

BENEFITS ENVISAGED

Through the program of interlinking rivers, the National Perspective Plan projected additional irrigation potential of 35 mha and hydro-power generation of 34,000 MW. Other benefits would include domestic and industrial water supply, mitigation of droughts, flood management, navigational facilities, fisheries, salinity control, pollution control, infrastructure development, employment generation and socio-economic development.[51]

An economic impact assessment by the National Council of Applied Economic Research (NCAER)[52] states that the short-term impact of the link canal is in the form of increased employment opportunities and the growth of the services sector. Sectors supplying crucial inputs to the construction sector, such as cement and iron and steel, will also grow. In the medium to long term, the major impact of link canals is through increased and assured irrigation. Although the major and direct gainers of the ILR program will be agriculture and agriculture-dependent households, the entire economy will benefit because of increased agriculture production.

NCAER estimated the cost of the program as Rs. 4,34,657.13 crore or Rs. 4,44,331.20 crore at 2003-04 prices. In the short-run, the direct impact of increased investment in the construction sector by Rs. 10,000 crore would result in increased value-added of the construction sector by 3.80 percent. However, due to its forward and backward linkages, the value-added of cement would increase by 2.46 percent, structural clay products by 2.37 percent and basic metal and metal products by 0.65 percent. The increased income in the economy would demand more goods and services and thus all sectors of economy would experience growth in their value-added. It is estimated that the incremental value-added generated in the economy would be Rs. 17,424 crore (0.91 percent) by Rs. 10,000 crore of additional investment in construction. Direct employment in the construction sector would grow by 22.74 percent. Sectors such as coal tar products, cement, electricity, gas and water supply would experience a higher growth of employment than the construction sector. Total employment in economy would increase nearly by 4 percent. Household income would increase by Rs. 16,267 crore. All household categories would augment their income. Aggregate private income would grow by 0.76 percent.

THE CASE FOR A CAUTIONARY APPROACH

Against the economic rationale proposed for the project; there are strong economic arguments, bio-physical and climate science arguments, and ecological arguments [53] that advise us to exercise abundant caution when considering such a large-scale engineering of our water resources.

ECONOMIC ARGUMENTS

The interlinking of rivers idea is based on the fact that there are parts of India which have surplus water and parts that are deficit, and so water must be transferred from surplus to deficit regions so every region has the amount of water needed to support its population. However, the concept of “surplus” and “deficit” has been questioned, since it does not relate to consumption but economic activity. The transfer of water across geographies is mainly supposed to stimulate economic activity of agriculture, industry and services. But natural endowments have always been different and so have the economic activities around them. In an increasingly connected world, we are no longer dependent on food or industrial products produced locally. If all food is grown in a few “agricultural breadbaskets”, an urban region, which uses water mostly for domestic purposes, does not need the same amount of water as a rice-growing belt that feeds the whole nation. The counter-argument therefore is that the economy has to grow within the parameters of locally available resource endowments.

Also, it is estimated that there are around 10 to 13 million fishermen alone earning their livelihood from the Gangetic Basin.[54] In the peninsular states of Odisha, Andhra Pradesh, Tamil Nadu and Pondicherry, around 0.6 million, 0.6 million, 0.8 million and 50,000 fishermen, respectively, are dependent on the river and its ecosystem.[55] The livelihood impact assessment for these fishermen, as well as other livelihoods dependent on river ecosystems, needs to be conducted as part of feasibility studies for interlinking projects.

BIO-PHYSICAL AND CLIMATE ARGUMENTS

The concept of a "surplus" basin is based on a narrow focus on water for certain human needs in parts of these basins, rather than the comprehensive assessment of the functions and services provided by the so-called "surplus" from head-waters to downstream tributaries, and ultimately the estuaries and deltas. The "surplus" water in a basin is often the driver of sediment movement through our river systems – and maintaining sediment dynamics in these rivers is crucial for the ecological and water-quality integrity of these rivers.

The paradigm of "surplus" and "deficit" basins is based on the premise of "stationarity": an unvarying climate and its associated river flow in both so-called "surplus" and "deficit" basins. However many parts of India are undergoing complex changes in the monsoon regime and are expected to undergo even more changes in rainfall regimes in the coming decades due to complex effects of warming atmosphere and oceans, impacts of aerosols and land-cover change. Since the 1950s the monsoon has been weakening in regions such as the Western Ghats and in parts of central and northern India. Furthermore the temporal and spatial distribution of rainfall has become more variable. Rainfall in parts of the country is now happening for fewer days and often in very intense spells. The so-called "surplus" basins may in fact face severe water stress due to shifts in the nature of rainfall.

There is now an increasing recognition of the role of fresh-water inflow in the Bay of Bengal from rivers, the fresh-water "river" that flows down the east coast of India and into the Arabian Sea, and the reversal of flows in the post-monsoon period that controls the salt balance levels in between the Bay of Bengal and the Arabian Sea. This transfer of fresh-water, sediments and nutrients from the land to the sea, and the changes through the seasons, underpins the productivity of our marine ecosystems and sustains marine fisheries. Furthermore the impact of this phenomenon on climate and the monsoon is still largely unknown. The idea of a "surplus" in many river basins overlooks the role that this "surplus" plays in the productivity of our floodplains, estuaries, deltas and coastal and marine fisheries.

ECOLOGICAL ARGUMENTS

Many river basins in India have distinct geology and biogeography. In addition, they carry different pollution loads. Inter-basin transfer could severely disrupt the ecology of both contributing and receiving rivers, with potential loss of river fisheries, aquatic biodiversity and proliferation of invasive and alien species.

The proposed river-links will pass through 1200 km of forests and protected areas throughout the country and disrupt ecological connectivity in many regions, apart from displacing people.

For example, Ken-Betwa, the first of the river links which is being implemented, will result in the loss of two lakh trees in the forests of the Ken basin, which is an irreparable ecological cost. The estimated cost of the link is Rs. 17,700 crore at 2015-16 prices. The benefits of the link in meeting the genuine needs of the water stressed parts of Bundelkhand, its impact on the ecology of the Ken basin and the comparative advantages of alternative water management strategies need to be carefully assessed before going ahead.

"SURPLUS" BASINS AND DYING RIVERS

As we have seen earlier in this chapter, many of our rivers are dying. Rivers that were perennial are becoming seasonal, and many rivers are no longer reaching the sea for a large part of the year. This poses yet another challenge to the concept of "surplus" and "deficit". In our view, the underlying assumption of interlinking of rivers, that the average flow in each river is constant, and inter-basin transfers will yield additional water resources for exploitation, has been weakened. At our present juncture, we need to see our rivers as endangered entities that need to be nursed back to life by augmenting their flows. This is of paramount importance. Shifts in cropping patterns towards less water intensive crops as well as more efficient irrigation practices need to be encouraged with adequate investment and support. Only after that, can small-scale river linking projects (to start with) be scrutinized carefully in terms of bio-physical, climate change, ecological and economic aspects.

CONCLUSION

To sum it up, interlinking of rivers as a solution should be based on scientific reasoning, and politics or emotions should not determine the extent of river linking we do. Interlinking can be considered as a flood mitigation measure. India being a tropical country with high evapotranspiration and over-exploited groundwater resources, interlinking will serve its purpose of irrigation augmentation if water were to be efficiently transported in closed pipes instead of open canals. A few interlinking projects have already rolled out. It is suggested that the economic gains from these projects are weighed against the loss of natural resource capital, before embarking on new projects. In India rivers are mostly forest-fed; therefore bringing back the tree cover on the either sides of the river is the only long-term sustainable solution to address water scarcity and reduce the impact of floods and droughts.

Chapter 03

WATER-EFFICIENT TREE PLANTATION – A SOLUTION FOR REVITALIZING RIVERS

“ Trees are the only living beings that can invite the rains.

Through their body and roots they water the soil and breathe life into the earth, they let the rivers flow.

Setting aside all the economics of what trees can do, the simple services that these trees deliver quietly, which are mostly taken for granted, are the most important and life-giving ones.”

~ G. Nammalvar[1]

Source augmentation and efficient demand management are the approaches proposed to revitalize rivers. Afforestation and tree-based agriculture are proposed as the method to augment the water source of a river. Drip irrigation and other forms of micro-irrigation are proposed as a solution to reduce agricultural water demand and as regulatory mechanisms to improve domestic and industrial water quality and use. Iterating the solution here again:

Afforestation of a minimum of 1 km-width on either side of large rivers for their entire length is the solution proposed to revive the flow in the rivers through augmentation of the source of water. The fundamental reasons behind this solution lie in the role a forest plays in closing the hydrological cycle, and its effect on groundwater aquifers, soil and as a climate stabilizer.

We also propose to improve agricultural water-use efficiency by change in the land use through agro-horti-forestry and appropriate micro-irrigation technologies that substantially reduce the water demand.

The core solution to stabilizing our rivers by creating and maintaining a green cover for a width of a minimum of one kilometer on either side of the river, should happen on a continuous stretch of the river for few hundred kilometers, so as to see visible results of river revitalization. This is possible only when governments lead an initiative of this scale with massive people participation.

LAND USE PATTERNS ON RIVERSIDES

Data and maps of land use along the entire length of the rivers of India are to be made available. To implement any solution on a piece of landmass, it will be essential to know who owns the land. Broadly the land can be classified as public land, or land owned by a private individual – a farmer, or an industry. The percentage of riverside land owned by private farmers is expected to be 60%-75% in the state of Madhya Pradesh.[2] It will be safe to assume that in most states, except the Himalayan states (like Uttarakhand where most of the land of the state is reserve forest, including riverside lands), riverside land held by the governments will be around 25 to 40%.

Therefore, the solution of afforestation should have two different approaches – one for public land (river banks and forest land) and another for the farm land. While the solution proposed for the public land will have the forest as the primary stakeholder, the farm lands will have farmers and their livelihood as the priority. So in the case of public land, raising dense forests with native and endemic trees and shrubs is suggested as the solution and for farm lands, agro-forestry based livelihood is suggested.

Ideally the solution suggested will work best when implemented on the entire length on either side of the river continuously from the origin of the river until it meets the sea (or another river). But the solution proposed here and the means to implement it are novel. Therefore a target of 1 km on either sides of river on a continuous stretch of 100 km or more is suggested. Although the 1 km-width suggested in the solution is scientifically valid,[3] for tributaries and smaller streams this width could be correspondingly smaller (e.g. 500 m or less). The one-kilometer corridor recommendation is also supported by the widely held view amongst forest experts that even one square kilometer of forest is enough to generate rainfall by harvesting passing clouds given the Ekman spiral phenomenon (see Chapter 2).

VILLAGE AS THE UNIT OF OPERATION

When we say that the expanse of the project on the riverside be 1 km in width, it is only a suggestion. It is more important to note that the unit of operation for implementation of the solution should be the village. In the previous chapter we discuss how Integrated Watershed Management Programs were difficult to implement due to the lack of overlap between watershed boundaries and political boundaries. The width of agro-forestry in farm lands could be determined by the num*ber* of villages that fall on a 1 km lateral distance from the river, as a whole. This way, we can work with a village as the unit of operation thus using the 73rd Amendment of the Constitution.

COMMON POLICY ECOSYSTEM CONDITIONS FOR SUCCESSFUL TREE PLANTATION ON PUBLIC AND FARM LANDS

There are many technically sound solutions for developmental or environmental problems. It is not due to lack of solutions that the nature and our rivers are in such perils; it is mostly due to pit falls in the implementation environment.

The solution of planting trees on either sides of the river appears to be quite simple, but it requires a lot of preparation that needs to be done by people in the target areas, as well as setting up of infrastructure for large-scale tree plantation. These conditions discussed here need to be taken into consideration when taking up large-scale projects to revitalize rivers.

BEHAVIOR CHANGE COMMUNICATION TO STAKEHOLDERS

By virtue of being a consumer/water user, every individual inherently is a stakeholder in revitalizing our rivers. It is crucial to launch an awareness campaign, specific to each stakeholder group (farmers, consumers, government departments, industrialists, students, citizens, etc.), for behavior change towards rivers. The Rally for Rivers is one of the first such large scale initiatives to re-ignite the connection we as people of this country have had with our rivers.

Farmers: The most important group of stakeholders who have a major stake in the proposed solution are the farmers. In this chapter's section on farm land, the proposed solution asks farmers to change their cropping pattern with a promise of better income. But in the past, farmers of this country have changed crops in the promise of better returns only to be left worse off. There are many instances where due to the losses incurred many of our farmers have committed suicide. The behavior change communication targeted at farmers should be the most important one. The training and awareness generation for farmers in this belt will have to cover areas of tree-based farming, organic inputs, chemical-free farming, use of micro-irrigation technologies, formation of Farmer Producer companies and dealing with agri-businesses. Farmers in the target area must clearly perceive that there will be support and guidance throughout the program until they realize the economic gains.

Communities Dependent on Forest Produce: For the work that is envisaged on the public land, the communities that have rights on the forest should be made aware of the proposed plan, what it could mean for them, and their role in it. These communities have borne the brunt of restricted access to forests, which their ancestors were able to access freely. This afforestation on public land should ensure to build upon the individual and community rights that the Forest Rights Act, 2006 has bestowed on these communities.

Consumer: The next stakeholder, who is very important in making this whole solution on farm land successful, is the consumer of the farm produce. This includes all of us in this country who eat tree produce like fruits. Creating awareness on consumption of fruits and creating a willingness among consumers to pay a fair price needs to happen in a continual way like the National Egg Co-ordination Committee's *Sunday ho ya Monday Roz khao ande* campaign.

Government: The crucial stakeholders that will make this whole solution take off are the government departments. The various departments involved in different tasks have to come together to put this plan into action. An overall communication to all the government departments about the larger plan and the specific roles of each department will facilitate smooth roll out of the solutions.

Industries: The last but not the least are the industries. The farmers' tree-based produce should be decided based on the industrial demand and the industries' commitment to procure the produce before a farmer engages in production. This approach of guaranteed procurement has been demonstrated by some of the agri-businesses in Tamil Nadu. EID-Parry enters into buy back agreements with farmers from FPOs and that provides security for farmers in more than one way and lessens their anxiety. Such changes in behavior on the part of industries are a convincing nudge for a farmer to convert to tree-based farming.

PEOPLE'S PARTICIPATION AND OWNERSHIP

Participative planning along with Gram Panchayats and Urban Local Bodies: With the Constitutional mandates of the 73rd and 74th Amendments, both Gram Panchayats and Urban Local Bodies are respectively responsible for the overall wellbeing of the people and the environment of their political jurisdiction. It has been observed that any large-scale projects conducted with the participation of local government bodies have been quite successful. PRIs and ULBs should be given the mandate to facilitate community participation during the decision making process regarding agro-forestry in the farm lands of the villagers. This process can be strengthened with the support from agriculture universities, forest departments and NGOs working in the region. A detailed note on PRIs and their role in local self-governance, especially in agriculture and watershed development, is provided in Annexure 10. A similar role can be designated for PRIs in this agro-forestry model on riversides.

Even in the case of forestry in public land which could be reserve forests or protected areas, it would be best to ensure the Individual Forest Rights (IFR), community and Community Forest Resource (CFR) rights of the communities dependent on the forest (prescribed under Forest Right Act, 2006) are respected. These rights, granted for tribals and other traditional communities that have been dependent on forests for generations, are an attempt to renew and strengthen the human-forest relationship that was strained by certain environment and forest protection laws that were mooted by the British to serve their timber requirements. The community forest rights allow these communities to make use of specific kinds of non-timber forest produce. Hence, the decision making about the types of trees to be planted in the public land could happen after discussing the scientifically and economically viable options with these communities. A note on forestry in community forest land and in village common land, as well as relaxation of rules to harvest forest produce in the national agroforestry policy (2014) is discussed in Annexure 11.

SATURATION MODEL

For any work on the river to have the desired effect, it has to be implemented on the entire length of a target area. The stretch could be 100 km or 200 km on the river side. To see the effect of tree plantation on the riverside it is necessary that the entire stretch has trees planted on it. Otherwise, inadequate tree plantation will only serve to increase water levels in depleted aquifers without translating into increased river flow.

QUALITY PLANTING MATERIAL APPROPRIATE FOR THE REGION

Production of Quality Planting Material (QPM) by establishing nurseries is the first step to planting trees on the floodplains. A tree plantation activity of this scale, where trees are planted on both sides of a river at a width of 1 km for hundreds of kilometers, will require millions of saplings. And if the QPM is not of good quality it will not produce economic returns.

Only 10% of QPM reaches the resource-poor remote regions.[4] Quality assurance of genetically improved planting stock, particularly for long-rotation timber species, is crucial for safeguarding the interests of farmers and industries.

The projected annual requirement of planting stock is going to be in millions of seedlings from different tree species. To fulfill this, research institutions, private organizations and forest departments must come together to establish good linkages among farmers for the production of planting material for 20 identified species in the National Agroforestry Policy. National and state-level research institutions, forest departments and universities should enter into a convergence mode to cater to the needs of superior planting stock. There is a challenge to develop a mechanism for certification of nurseries and planting material. A suitable mechanism for laboratory and nursery accreditation must be developed. We can study and learn from agencies involved in certification services in the forestry sector in the country. Well-evolved agroforestry systems can turn out to be self-sustained production systems wherein zero external inputs like fertilizers and pesticides are used. These kinds of agroforestry systems can also be subjected to organic farming certification at the national and international levels to bring in additional income and incentives.[5]

The choice of QPM for either the public or private land should be arrived at after taking into consideration the agro-climatic zone, hydrogeology of the region, tree and shrub species of the native ecosystem and also the knowledge of the community elders and agriculture universities of the region. Although the proposal suggests trees, the tree plantation has to happen without disturbing the existing scrubland, wetland or grassland ecosystems that are native to a particular region. Dr Kumar in his detailed report on agro-forestry models for farm land discusses the importance of QPM for yield and quality of produce. This report is available in Annexure 12.

The Working Group on Horticulture and Plantation Crops for the Eleventh Five Year Plan had projected the total requirement of planting materials of fruits, coconut, cashew, black pepper, tree spices, areca-nut, etc. as 2000 million by the year 2012 at a modest growth rate of 4% per annum. In the segment of fruit crops alone, the projected demand for the planting material was 7,145,851 by the year 2007-08; which was expected to increase to 8,359,632 by the year 2011-12. Supply of such a huge quantity of disease-free, true to type quality planting material is a big challenge and needs to be addressed at the right time at a national level.[6]

The Seeds Act and the Nursery Registration Act have been in operation since December 1966. However, as reported by the said Working Group, the Nursery Registration Act is presently in force in respect to horticulture nurseries only in the States of Punjab, Maharashtra, Himachal Pradesh, Uttar Pradesh, Uttarakhand, Jammu and Kashmir, Orissa and Tamil Nadu. Some system of registering/monitoring exists for horticulture nurseries in the States of Andhra Pradesh, Assam, Bihar, Goa, Haryana, Karnataka, Kerala, while there is no horticulture nursery act in the States of Arunachal Pradesh, Chhattisgarh, Jharkhand, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Tripura and West Bengal. In the absence of any formal system of quality assurance for horticulture planting material, it is not feasible to put any kind of quality control related restrictions on horticulture nurseries which do not have adequate production-related infrastructure and pedigreed mother plants.[7]

Under this situation, the National Horticulture Mission has taken initiative to specify Nursery Standards by specifying infrastructure required for setting up of a Model Horticulture Nursery. With a view to ensure availability of good quality planting material, the National Horticulture Board (NHB) of Ministry of Agriculture (GoI) has started a system of Recognition of Horticulture Nurseries on a voluntary basis since 2009-10. Under this scheme, so far 1413 nurseries have been accredited till 2015-16, and these nurseries are expected to renew their accreditation once in two years. This accreditation system encourages healthy competition between recognized nurseries to retain their accreditation *vis-à-vis* production and supply of QPM. This system would definitely help to ensure the availability of QPM in horticulture crops. Still, farmers are to be suitably educated on the need to procure the QPM from these recognized nurseries only, and the State Governments should also strictly enforce these standards by suitably modifying their State Seed Acts on supplying Quality Planting Materials (QPM).[8]

Local Self-Help Groups (SHGs) can be given the business of setting up nurseries and producing QPM to service the local needs.

Project GreenHands of the Isha Outreach program, through its Green School Movement, has involved school children in planting trees in their villages. Children under this movement can also be involved in cost effective nurseries for QPM required for their village's farm land or forest land.

THE TECHNO-ECONOMIC MODEL: TREE PLANTATION MODEL FOR PUBLIC LAND

DECLARING THE PROGRAM AREA AS A CHEMICAL-FREE ZONE

Declaration of floodplains to be chemical-free zone: According to the definition of what a river is by the Government of India, "*nirmal dhara*", or unpolluted flow is an important characteristic. Therefore, it becomes necessary that the cultivation done on the target area is chemical- free, so that the runoff from the agricultural land to the river does not carry any residual pesticides or chemicals thereby ensuring good water quality in the river. This will also imply that mandatory regulations of industrial effluent standards and effluents from urban sewage treatment plants are detailed.

It will be simpler to implement a solution when the primary landholder is the government. The roll out of forestry on public lands can be quick compared to farm land agro-forestry. The forestry plan and design on government-owned land should be developed taking into consideration the communities that depend on the forest. In the previous section about policy ecosystem precondition of people's participation, we looked at how involvement of tribal and indigenous communities of the forest is necessary to ensure their community forest and forest resource rights are not violated. The trees that are planted should be native or endemic species that suit the agro-climatic zone and hydrological conditions. The implementation and maintenance plan should be in consultation with the communities that are dependent on the land. This ensures that the community owns the protection of the forest. All the ecosystem-preconditions that are listed above are necessary conditions that will help in successful implementation.

The forestry component should be a composite of multi-purpose trees which are native and endemic to the area. It is pertinent to note that we are including here both the government owned forest lands, and the government owned river banks – which constitute roughly 40% of the river length.[9]

The river bank also needs to be protected through non-engineering measures such as through growth of suitable vegetation and grasses that would hold water in soil in their root zone and prevent scouring erosion and sloughing of river bank. Grassland vegetation like vetiver can be used to strengthen the river banks and arrest floods too. For example, Vetiver System (VS) developed by Vetiver Network International, is based on the application of genotypes closely related to only the south Indian variety of vetiver grass (*Chrysopogon zizanioides*) The extraordinary characteristics of vetiver offer many livelihood related options to farmers, and also offer a multitude of practical, inexpensive, low maintenance and very effective bio-engineering techniques for steep slope stabilization, wastewater disposal, phyto-remediation of contaminated land and water, and other environmental protection purposes ranging from soil erosion control, groundwater recharge and water conservation, embankment protection during floods, etc. A note on the various benefits of vetiver as a shrub that can be used to protect banks is available in Annexure 13.

Out of the total riverside land area available, if we take a stretch of 1000 kilometers (2,00,000 hectares) of river length – of single or composite of sections of different rivers – it is assumed that endemic tree species in afforestation areas will cover 40% of the available area, i.e. 80,000 hectares. This includes both government forest land, and government river bank land.

The type of trees to be planted depends on the kind of soil in the concerned area. Recommended species for different soil types are as given in Table 1. This is a non-exhaustive list; there can be more varieties of trees that can be added to the list as needed:

TABLE 1: RECOMMENDED SPECIES FOR VARIOUS SOIL TYPES

Soil Type	Suitable Species
Clay soil	*Azadirachta indica, Pongamia pinnata, Swietenia mahagoni, Pterocarpus marsupium, Terminalia tomentosa, Melia dubia, Dalbergia latifolia, Dalbergia sissoo* (Any 4/5 species)
Red soil with 10ft minimum soil depth	*Swietenia mahagoni, Pterocarpus marsupium, Terminalia tomentosa, Melia dubia, Dalbergia latifolia, Azadirachta indica, Santalum album and Pterocarpus santalinus* (Each 15%)
Red laterite soil with 5ft soil depth	*Tectona grandis, Swietenia mahagoni, Santalum album, Pterocarpus santalinus, Dalbergia latifolia, Azadirachta indica, Melia dubia, Ailanthus excelsa* (Each 20%)
Alluvial soil	*Tectona grandis, Swietenia mahagoni, Pterocarpus santalinus, Terminalia tomentosa, Melia dubia, Dalbergia latifolia, Neolamarckia cadamba* (Teak 60%, others 10%)
Uncultivable soil	*Azadirachta indica, Albezia lebbeck, Dalbergia sissoo, Ailanthus excels, Pterocarpus santalinus* (Each 20%)
Swampy soil	*Terminalia arjuna, Casuarina junghuniana, Pongamia pinnata* (Any one of them 100%)

COSTS INVOLVED IN THE FOREST MODEL FOR ONE ACRE OF FOREST LAND

In one acre of forest land, 250 native and endemic trees can be planted. The cost involved per acre of land is given in Table 2. It is pertinent to note that the condition of the land on which trees are planted is one of the deciding factors of the sapling mortality rate. Therefore, public lands chosen for plantation need to be treated first. Typically, the treatments to degraded land include: contour trenches, pit trenches, gully plugs, gabion dams, check dams, etc. Based on the amount of deterioration of the land, a suitable mechanism should be adopted to treat the land before tree plantation.

TABLE 2: COST PER ACRE OF TREE PLANTATION ON FOREST LAND

No	Operations	Cost per Unit (Rs)	Cost (Rs)
1	Land treatment / preparation works	20,000	20,000
2	Sapling Cost* including gap filling (20%)	10	3000
3	Pitting and planting	40	12,000
4	Manuring and mulching	12	3000
5	Maintenance (soil working, pruning, etc)	5000	5000
6	Drip Irrigation**	25,000	25,000
Total cost per acre of forest (Rs):			68,000

* Varies with species
** Optional

BOX 1: PROJECT GREENHANDS OF ISHA FOUNDATION, ITS JOURNEY AND NURSERIES

In the early 2000s, an agency of the U.N. conducted a survey in the state of Tamil Nadu and predicted that 60% of the state would turn into a desert by 2025. Sadhguru decided to check up on this prediction and travelled around Tamil Nadu. He saw that the state was headed towards desertification much more rapidly than the U.N. prediction. The green cover of Tamil Nadu was only 17% and 11.4 crore trees needed to be planted to increase the green cover to the required green cover of 33%

Realizing the profound ecological problems occurring in the state of Tamil Nadu, Sadhguru applied his unique approach to the problem. He saw that the population of Tamil Nadu was 6 crore If each one planted two trees and tended to them, within 10 years, they would have 11.4 crore and our vision would come true. Even the poorest of the poor are in a position to nurture two saplings, and the rich and the resourceful have the ability to do much more. Therefore the whole effort of PGH is primarily to plant trees in people's minds first.

With this background, Project GreenHands (PGH) was launched in 2005 as an inspiring grassroots ecological initiative. The first project was the rehabilitation of the Tsunami affected coastal area where PGH planted 25,000 trees with the community participation.

In 2006, as a first step, to raise awareness and to establish a public profile, PGH undertook the seemingly insurmountable task of planting seven lakh saplings across the state of Tamil Nadu in just one day. From the very beginning PGH understood that" Awareness generation with action" should be the way to have results A mass tree planting marathon was held on October 17, 2006 where over 200,000 volunteers planted 852,587 saplings in every district of Tamil Nadu in a day resulting in the setting of a Guinness World Record. But unlike other records and record holders, this is one record that PGH will be glad to see broken.

PGH received a wave of public, corporate and government support. PGH has over the years, built on this foundation of support to reach out to communities and people across the country. Starting from the geographical land area of Tamil

Nadu, PGH is reestablishing the power of individual action for large-scale change. Government institutions, NGOs, corporate partners, and individuals have pitched in to grow saplings and plant trees, and to support the effort. Through its activities, PGH aims to inspire people around the world to appreciate the true value of trees and the vital role that they play within human environments.

During the year 2010, Project GreenHands was awarded India's highest environmental award, the Indira Gandhi Pariyavaran Puraskar. On 30 Sep 2010, PGH was declared winner of "Beyond Sports Award 2010" in the Sports for Environment category in the award function at USA. Recently PGH won the "Environmental Award – 2010" from Department of Environment, Government of Tamil Nadu.

PGH has so far successfully enabled the planting of over 30 million saplings in Tamil Nadu with the support and participation of over 2 million people.

Establishing nurseries to raise quality planting material was an important step to be able to facilitate tree plantation at the scales PGH imagined. PGH has been successful in establishing and running 35 nurseries across the state through which on an average 4 million saplings are produced every year. 84 different tree species (combination of fruit, fodder, timber, flowering and avenue trees) endemic to Tamil Nadu are raised in these nurseries. School children, college students, corporate employees, Isha volunteers, nature enthusiasts take part in production activities like filling pockets with soil, transplanting seedlings, watering etc. Earlier if someone wanted to plant trees they had to travel long distances to procure tree saplings. Now with the network of nurseries this definitely has reduced.

These saplings are offered to anyone who pledges to take care of the tree for a minimum of two years. Awareness programs are organized in educational institutions, offices and public functions, where saplings are distributed. These saplings become the dynamic, living hearts of the PGH movement.

A detailed note on the various programs run by PGH in Tamil Nadu is provided as Annexure 14.

CREATING THE NURSERY INFRASTRUCTURE FOR THE REQUIRED NUMBER OF SEEDLINGS

Under forestry plantation, the total number of quality planting material required per stretch of 1000 kilometers of river is estimated to be 8 crores, assuming 250 plants per acre. This will include the multi-purpose trees to be planted in farm land also. To produce the required QPM, roughly 400 acres of land area with water facility will be required. The capacity of nurseries in the state may need to be strengthened. It is important to develop sufficient infrastructure to produce QPM by organic methods. This will be a critical element for successful implementation of the project. Unlike the horticulture nursery which requires a three-year period given sapling grafting, most of the seedlings can be deployed in a year's time.

PLIGHT OF FARMERS IN INDIA

While we as a nation have been clocking decent growth rates, this is hardly reflected in the wellbeing of our farmers. The farmers who have put food on the plates of 1.3 billion people do not have enough to feed their own families. Every year thousands of Indian farmers end their own lives, and shocking as this is, it has become routine, regular news to us. Around 3 lakh farmers have committed suicide in this country in the last 2 decades.[10] Even wars do not result in so many deaths. Have we become so insensitive that we do not care about the people to whom we owe our well-being and our very life?

Farmers in India are classified as marginal, small, semi-medium, medium and large, based on their land holding size. Small and marginal farmers together make 85 per cent of the farming population in India.[11] This set of farmers make up around 70 percent of the total debts incurred by farmers.[12] The amount they borrow ranges from a mere Rs. 23,900 to 35,400. And 72 percent of total farmer suicides are from this group.[13]

The impoverished state of the majority of the farmer community can be attributed to many reasons. The agro-forestry in farm land, although proposed as a solution proposed to river revitalization, attempts to address these reasons which present various livelihood pressures for farmers in the target areas.

In this section we try to articulate the fundamental technical and economic reasons due to which the farming community is in its present state of crisis. Without understanding these issues, there is a high likelihood that this project of revitalizing rivers will not benefit farmers. And so the techno-economic model of agro-forestry based farming needs to address the issues that farmers face.

Let us look at the farming activity as a manufacturing enterprise that produces agro-commodities. There are raw materials that are the input into the farm, which are then worked on by the farmers, resulting in an output (good/ produce) which is then sold. The two major inputs involved in farming are water and soil (which do not have apparent costs). Water crisis is elaborately discussed throughout this entire book, therefore in the next section, the state of soil and major issues surrounding it will be discussed in detail. A farmer uses the seeds, fertilizers, pesticides and his enterprise to produce the output – agri-produce which then comes to our plates as food, or is worn by us as clothes, or is otherwise used (e.g. furniture) after different levels of value addition.

The issues facing farmers today can be broadly classified into input-specific issues and output-specific issues. Under the category of inputs, the major input that needs attention, besides water, is soil and its fertility, and seeds. In the output-specific issues we look at why farmers realize such low margins for their produce.

Although the type of seeds used to farm is of utmost importance, the soil health determines what comes of the seed. Here one must note that the native seeds of any crop or tree have better climate and shock resilience (from sudden change in weather, rains, temperature, etc.) given their history of adaptation in their geographies. Thus, these native varieties should be promoted and improved upon for stable farmer incomes.

The expenditure of a farmer with regards to soil is multiple times that which he spends on procuring seeds. We look at the expenditure on land treatment – ploughing and leveling the land, fertilizing the land, and protecting the crops from pests. For any annual crop, land has to be leveled and ploughed for every round of the crop. That is, if the farmer takes three crops a year, he has to spend on ploughing and leveling at least three times. The expenditure on ploughing and preparing the land is around Rs. 4000 for a paddy farmer in Tamil Nadu. This is substantial in comparison to the income of the farmer.[14] He spends on chemical fertilizers, 3-4 times during the entire cropping cycle. He also spends on different types of pesticides to protect his crop from different types of pest attacks at different stages of the crop cycle. A majority of these farmers practice the conventional inorganic farming. Only 0.3 per cent of land in India is presently under organic farming (one of the forms of sustainable farming). A farmer practicing inorganic farming spends up to Rs. 4000 and Rs. 2150 per acre on fertilizers and pesticides, respectively, which make up a substantial portion of the total cost of Rs. 17,500 towards growing paddy on one acre.[15] Such expenditures which are aimed at ensuring crop productivity have had negative consequences on the soil. We will explain this in the next section, and see how the proposed techno-economic agro-forestry based farming model is a solution for soil health.

CRISIS OF SOIL HEALTH

Soil crisis: After water, the second natural resource required to do farming is fertile soil. The plant fetches 95 to 98 percent of its nutrients from air and water – mainly carbon, oxygen, hydrogen and nitrogen. The remaining 2 to 5 percent of its nutrient requirement is supplied by the soil. Although miniscule in proportion, the soil is responsible for some of the plant's vital functions, like fruit bearing. With repeated use of inorganic fertilizers – which are intended to supplement for the deficiency of N, P, K in soil – the microorganisms responsible for the production of micro-nutrients are killed.[16]

Soil is not just a medium for crop growth but a living system. The soil ecosystem is dependent on its biotic diversity for its health, functioning, stability and sustained productivity. Apart from the nutrients required for crop growth, it needs continuous nourishment with food for its biotic component, macro (earth worms, millipedes, mites, etc.) and micro fauna (bacteria, fungi and actinomycetes). To put it very simply, in the words of Nammalvar Ayya (a legend in Tamil Nadu for promoting sustainable farming for many decades), when we eat anything salty, we get thirsty; similarly for the soil, when we feed it N, P, or K salts it needs more water (irrigation). These salts increase the salinity of the soil over the years, making it unfit for agriculture after a period of time. And as salt does to pickles (kills all the microbes and saves the vegetable for our consumption), it does to the soil too (kills microbes). The only difference is that the microbes killed in the soil are the very ones which make the nutrients in the soil available to the plant in a form that it needs. For it to be fertile, 2% of tropical soil should be made up of organic carbon: right now in India most of the soil comprises only 0.05% organic carbon.

Despite significant growth in agriculture during the last four decades in India, most of our important soil-based production systems are showing signs of fatigue. All India consumption of fertilizers ($N + P_2O_5 + K_2O$) over the years has increased from 1.98 million tonnes in 1970 to 26.8 million tonnes during 2015-16 (Fertilizer Association of India). Meanwhile, the partial factor productivity of fertilizers is declining in intensive cropping systems in India. The partial factor productivity of fertilizers during the last three and half decades showed a declining trend from 15 kg food grains/kg NPK fertilizer in 1970 to 5 kg food grains/kg NPK fertilizer in 2005. In the hurry for higher production, no serious attention was given to long-term soil quality and sustained high productivity. As a consequence, the annual compound growth rate of major crops has declined from 3.36% in 1981-85 to 0.11% in 2001-05. Such gloomy trends were also registered in the case of pulses and oilseeds, while cotton even exhibited a negative growth rate.[17]

Even though there are soil test and crop-based fertilizer recommendations available, farmers continue to follow their own ways of applying fertilizers in expectation of higher yields – which contributes to nutrient imbalances in soil and emergence of multi-nutrient deficiencies. Most of the existing fertilizer recommendations are also based on an individual crop's requirements for a particular season only, which fail to address the nutrient budgets for a cropping system. Biological nutrient fixations in inter/mixed crop soil systems (e.g. cereal + legume) are also not considered while calculating the fertilizer nutrient needs.

Unfortunately, most of the research experiments conducted in agricultural universities, including long-term experiments on soil fertility, focus mostly on assessing the soil's nutrient status alone (chemical property), neglecting the impact and interaction of physical and biological properties on sustaining the productivity of the soil. It is to be noted that integrated nutrient management approaches consider only the nutrient content of organic inputs towards nutrient additions in the soil. Thus they may underestimate the role in organics, since they do not consider their contribution towards enhancing soil fauna and micro flora; this consequently improves solubilization of the soil's native nutrient reserves, apart from fulfilling the function of biological nitrogen fixation from the atmosphere.

With more reliance on machineries, fertilizers and other agrochemicals in the post green revolution era, most of the farmers have forgotten the significance of livestock in Indian agriculture. Unlike Western countries wherein a temperate climate favors accumulation of organic matter in soil owing to low decomposition rates, Indian soils need frequent replenishment of organic matter through incorporation of crop residues and cattle manure. The high decomposition rates prevailing under high temperature and intensive tillage necessitate regular addition of animal excreta to maintain soil microbial population. (The interrelationship of soil, its health and forests is provided in Annexure 7.)

Therefore, the main agricultural activities leading to soil degradation in different agro-climatic regions can be summarized as:[18]

- Low and imbalanced fertilization
- Excessive tillage and use of heavy machinery
- Crop residue burning and inadequate organic matter inputs
- Poor irrigation and water management
- Poor crop rotations
- Pesticide overuse and soil pollution

EFFECT OF PROPOSED AGROFORESTRY MODEL ON SOIL FERTILITY CRISIS

Recycling of crop residues and animal excreta is indispensable for maintaining the food supply (i.e. organic matter at various levels of decomposition) for various microbial populations and their activities at different trophic levels. Each one of their roles is essential and interconnected. Only under these circumstances, with improvement in soil biological properties, soil can have ideal physical properties (structure, aeration, retention and movement of water and nutrients) and chemical properties (pH, accumulation of salts and nutrient transformations and availability).

Only an overall improvement in all these properties can sustain soil health and thereby sustain productivity. The solid, liquid, gaseous and biotic spheres of the soil are in such a dynamic equilibrium with changes in one phase affecting another. Hence the soil management strategies should shift towards a holistic approach.

Change cropping systems Hence, cropping systems need to be redesigned from the existing exploitative mode to a conservation mode to preserve soil health. Without understanding and considering the soil's true nature as an ecosystem, continuous mono-cropping on the same soil relying on inorganic fertilizer additions – done in the style and scale of industrial manufacturing – has led to decline in the soil's productive potential. Such practices lead to the emergence of newer and newer nutrient deficiencies in spite of the addition of newer fertilizer materials. The use of nutrients through organic inputs is, therefore, imperative for maintaining the sustainability of the system.[19]

Non-pesticide management and native livestock breeding address the issue of soil pollution caused by chemical fertilizers, as well as enrich the soil's health in a most gentle manner – by using inputs prepared from native cow dung. We must bring back native breeds of livestock to supplement the organic requirement of the soil. Furthermore, in no-tillage farming, tree foliage ensures that the surface organic carbon and beneficial microbes contained in the soil are not exposed to direct sunlight, which would lead to degradation of soil.

LOW PROFIT MARGINS ON PRODUCE

Unlike most other sectors, the farm sector employs 60% of the population but contributes to only to 18% of the GDP.[20] The majority of the farmers fall under the category of small and marginal farmers. Around 70% of the agricultural produce area is used for production of wheat and rice, but it amounts to only 25% of the earnings from the sector.

When such a small pie is shared by a huge number of farmers, the profit margins naturally go down. While the data show that there is a reduction in consumption of wheat and rice by 1-2% in rural and urban areas, there is an increase in the consumption of fruits and vegetables by 2-3%.[21] This is an annually observed trend. It is observed that most farmers across the country only manage to break even by producing the staples of wheat and rice, but they realize higher profit through fruits, vegetables and other produces. Are farmers then not aware of the difference in profit realization? Or are there other reasons why they choose to stick to rice and wheat and realize lesser margins? In fact, there are a set of valid reasons why our farmers do not move into producing any other crop than what they have conventionally produced:

- When a farmer transitions to a new crop, he needs to learn all about this crop and bridge the knowledge gap
- He may not know if the agro-climatic conditions of his farm can produce good yields of the new crop
- As farmers are not an organized group to plan and decide when and what to crop, they get dictated by the market's needs or a middle man asks them to produce what he wants
- A farmer's economic condition makes his ability to handle risks associated with transitioning from one crop to another very low. When farmers produce perishables, their vulnerability to the market is higher than with staple crops, and they have very little control on price volatility.
- Lack of cold storage facilities forces them to sell their produce as quickly as possible without being able to wait to realize decent margins on their produce
- Last but not the least, there is no minimum support price for perishables.

POLICY ECOSYSTEM CONDITIONS FOR SUCCESSFUL TREE PLANTATION ON FARM LAND

The need for specific policy ecosystem conditions for tree plantation on farm land is necessary due to the vulnerable state of farmers, as covered earlier. The farmer's soil is in a poor state and he hardly has any financial ability to take any risk to his livelihood in order to save the rivers. It is unfair and impractical to expect the most vulnerable lot to bear the brunt of saving the rivers all by their volition.

INSTITUTIONALIZATION OF RIVERINE COMMUNITY FARMERS THROUGH FPO

The biggest bane of the farming community in India is its lack of organization. By facilitating organization of farmers through FPOs, the government can provide and implement schemes to these large groups seamlessly. This also gives farmers the strength to participate in markets, as their graded and aggregated produce will now become substantial in quantity. Information about institutional provisions by the Government of India to help set up and form FPOs and facilitate training should be made available to farmers in the riverine floodplains and target areas. Wherever river revitalization work is mooted, formation of FPOs should be facilitated. Small Farmer's Agribusiness Consortium (SFAC), a society promoted under the Department of Agriculture, Government of India is the nodal agency that is responsible for promoting FPOs across the country and linking producer groups to marketing opportunities.[22] While SFAC helps in setting up of the FPO, NABARD funding is available to manage the administrative affairs of the FPO. SFAC gives guidelines on how to set up an FPO, which is designed to train and facilitate farmers who may have no knowledge of FPOs and their benefits.

SFAC through its accredited facilitating agencies, hand-holds the farmer groups from villages from the point of providing them awareness on FPO formation and guiding them through all the later steps involved. The major steps through which SFAC will support, and coordinate between the government, NGOs, resource persons and farmers are:

1. Pre-project implementation: this involves conducting a baseline study on the volume and value of produce the farmer group has

produced, and market analysis for the produce. Product specific clusters are to be identified and a business plan to be made towards creating a Detailed Project Report (DPR). According to a Government of India guideline, the cluster of villages to be brought under the umbrella of FPO should be identified within one or two blocks, where villages are contiguous and within a radius of about 20 km). The detailed mapping indicating the location of the clusters with distances should be made part of the DPR.[23]

2. Enhancing the capacity for surplus farm production: In this, lead

   farmers and farmer organizations are identified. Exposure visits, training needs, group formation and training in specific areas are provided.

3. Implementation of surplus production: In this stage of implementation, handholding towards productivity increase and identification of value pre-processing is facilitated.

4. Pre-formation Stage of FPO/Collective and Stabilize New Surplus Production System: In this stage, market linkages, exposure visits, consultation with FOs for FPO scope, visioning and structuring are facilitated.

5. Formation of FPO/Collective Aggregation for market access: In this stage FPOs are formalized, and internal systems are constituted. Membership and governance and bye-laws are formed. Formation and strengthening of FPOs is facilitated through assistance by SFAC and NABARD towards organizational administration, use of management Information System (MIS), hiring HR, developing a business plan and interfacing with businesses.

FINANCING AND RISK MITIGATION: COMPENSATION OF NOTIONAL LOSS OF FARMER INCOME

The challenge in the economic model proposed is that the earnings of the farmer for the first few years after transition to the new cropping system are below the threshold of their current earning of Rs. 75,000 per annum.[24] The fact is that not many farmers will have the savings to fund this cash outlay upfront. This would slow down the implementation of the program because only a small percentage of the farmers will be able to fund their livelihoods for the initial 3-5 year gestation before income rises above their current earning threshold.

To tackle this, we are recommending that the government compensate the notional loss of livelihood. We have assumed that the farmer must have an annual surplus at least similar to their current average earnings of Rs. 74,988.[25] With this assumption the additional government cost per farmer would be Rs. 75,000 in the first three years of the program.

The ecosystem services that rivers and the trees on river floodplains provide, strongly justifies the compensation for the nominal loss in the farmers' income. Ways in which we could compensate for the loss of farmers' existing livelihood and minimize the risks involved during the transition to tree-based agriculture are:

- Conversion into horticulture crop by the farmer involves loss of income till the start of commercial yield of the fruit trees. Therefore, the notional loss of income for the farmer is to be suitably compensated.
- Financial support/linkages must be provided for farmers through existing government schemes/programs, financial institutions, and banks, so that they can smoothly transition from staple crop to agro-forestry fruit-tree cultivation. Easy loan with zero interest rates, and long-term repayment plans may be provided to the farmers to help stabilize their livelihood.

- Facilitate and incentivize transition from a chemical system of farming to totally organic farming through non-pesticide management
- Bring in training and exposure to improve productivity, harvesting, grading, value addition, and marketing through the FPOs as an organic produce

MANDATORY MICRO-IRRIGATION PRACTICE

Micro-irrigation has been effective with respect to reduced water consumption and increased yields of produce of any crop. Most of the time, with flood irrigation plant roots suffers either due to saturation or moisture stress which results in monotonous plant growth and yield. In drip irrigation with daily water application to root zone of crop, the soil moisture is maintained at nearly field capacity. Due to frequent application and optimum moisture levels in the root zone (i.e. with favorable moisture conditions all the time), the plant grows well and yields good produce with better quality. Comparison of flood irrigation and drip irrigation in Table 3 substantiates these mentioned advantages.

TABLE 3: COMPARISON OF FLOOD AND DRIP IRRIGATION

Particular	Conventional Flood Irrigation	Drip Irrigation
Water Use Efficiency	Less than 40%	Above 80%
Fertilizer Use Efficiency	Very low	Excellent
Labor Requirement	High	Low
Weed Emergence	Very high	Rare
Leaching and Deep Percolation	Very high	Nil
Surface Runoff and Soil Erosion	Liable	Nil

Particular	Conventional Flood Irrigation	Drip Irrigation
Uniform Crop Growth	Rare	Constant
Uniform Yield and Crop Quality	Rare	Constant
Maintenance	Higher and difficult	Very low and easy
Inter-cultivation	Not possible on irrigation	At any time
Land Leveling and Shaping	Essential	Not necessary
Suitability to Soil Type	Not suitable for heavy soils	Suitable to any soil
Automation	Not possible	Possible
Emergence of Pests and Disease	Higher	Less
Soil Moisture at Root Zone	Varying much between saturation and wilting point	Always nearly at field capacity
Irrigation Frequency	Once in a week or so	Daily

In a project where we intend to augment the source of water, this intervention facilitates the process by managing the demand prudently. Towards this, low interest/zero percent bank loans or product subsidies should be provided to make it easier on the farmer's pocket. The Government's 'Per Drop More Crop' micro-irrigation scheme has to be put to use in the target area of river revitalization.

A detailed note on the science of drip irrigation and its benefits in comparison to flood irrigation with respect to water efficiency and yield can be found in Annexure 9.

According to National Committee on Plasticulture Application in Horticulture, it is observed that with micro-irrigation, there is an increase in yield across various crops. Table 4 lists the effect of micro-irrigation on water usage and the yield improvement observed in many crops.

TABLE 4: RESPONSE OF VARIOUS CROPS TO DRIP-IRRIGATION

Crops	Water saving (%)	Increase in yield (%)
Banana	45	52
Cauliflower	68	70
Chilli	68	28
Cucumber	56	48
Grapes	48	23
Groundnut	40	152
Pomegranate	45	45
Sugarcane	50	99
Sweet lime	61	50
Tomato	42	60
Watermelon	66	19

Source: National Committee on Plasticulture Applications in Horticulture (NCPAH)

INSTITUTIONAL SETUP TO PROVIDE ORGANIC FARM AND PRODUCE CERTIFICATION

One of the common preconditions for tree plantation on either side of the rivers is to make these areas chemical-free zones. When we ask for a stretch of villages to transition to tree-based farming, it is important for the government to handhold and facilitate smooth conversion of conventional farmers to organic farming through training and extension programs through Krishi Vigyan Kendras (KVK). Also when it is ready for the market, organic produce needs to be certified. This can be done through group certification of the farm and its produce. Promotion of group certification instead of individual farmer certification will help ensure there is a group support and pressure to transition from conventional agriculture to organic agriculture. Participatory Guarantee System can also be considered at a village level for building trust about the demand for the produce. Alternatively transitioning to organic farming through the Non-Pesticide Management (NPM) route may also be thought about to produce safe food.[26] There are companies working on helping farmers grow food without pesticides.[27] This is an easier switch than transitioning directly from chemical to organic farming. Eventually if the farmers become convinced of the benefits and prospects of organic farming, they can be helped in that certification too. The larger vision is to provide safe food for the country first and then become export ready. Towards promoting chemical-free farming the Sikkim model can be replicated with respect to dis-incentivizing the use of chemicals in the program area.

BRANDING AND MARKETING OF GRADED PRODUCE

It is found that the agri-businesses requires specific types of produce like: *Ramanad Mundu* – a specific type of chilli grown only in Ramanadapuram district in Tamil Nadu; *Virudunagar Malli* – coriander grown in the Virudunagar district in Tamil Nadu; or *Nagori Methi*- fenugreek from the Nagore district of Rajasthan. Branding is a complicated game, but most FPOs are not in a position to participate in anything beyond the pre-processing stage of value addition to a product in their early years.[28]

Across the world, countries and regions pride themselves with some agri-produce or the other that is specific to their geography. Geographical indicators (GI) are certified for such products by the communities that produce them. This is done so that the communities engaged in production of this product can earn a premium on the product by virtue of it being produced in that region.[29] The yoghurt from Greece is the only one that can be called Greek yoghurt; not all yoghurts can be called that. Similarly, only wine prepared in the small region of Champagne, France can be called champagne – and certainly not any other wine that is prepared like champagne. Similarly, Chennapatna toys in a small town near Mysore are again protected by geographical indicators –not all wooden toys painted with natural ink can be called Chennapatna toys. Therefore, the FPOs that specifically generate produce, which are known traditionally for their specific flavors or aroma, can have geographical indicators certified for them. This will certify the authenticity of the produce and also fetch a premium for the produce from a particular geography. The agri-businesses will anyway take advantage of the GI tags and price their value-added products differently. SFAC has a role to play in helping FPOs –business tie up. The government and industry (in PPP mode) should develop clear branding and marketing strategies for the fruits, other tree products and processed products from the riverine floodplains.

STRENGTHENING FPOs' BUSINESS PROSPECTS: INDUSTRIAL TIE-UPS, LOCAL SUPPLY OF PRODUCE AND MEGA FOOD PARKS (HUB AND SPOKE MODEL)

When fruit cultivation on a large- scale along the rivers, across multiple states, the production of fruits will increase manifold. Eighteen percent of India's fruit and vegetable production – valued at INR 133 billion – is wasted annually, according to data from the Central Institute of Post-Harvest Engineering and Technology (CIPHET).[30, 31] According to a Planning Commission study, 5-39% losses are observed for different horticultural produce in Bihar and Uttar Pradesh. According to the same planning commission report there are not many post-harvest scientists trying to quantify or understand post-harvest challenges of horticulture produce.[32] When we introduce fruits suddenly in such high volumes, one can only imagine what can happen to the produce and producer.

Excess production of any produce leads to a slump in its market price. There are plenty of news pieces describing how this produce is simply dumped either in the field or in the market areas.[33] When the price of the produce slumps to such an extent, it does not make economic sense for a farmer to transport it to the market or, in a slightly better scenario, take it back to the farm because the transportation charges only entail more losses for him.

This makes it necessary for farmers to come together as an organized group in the form of a FPO. Under an FPO setup farmers are both shareholders and stakeholders. Farmer Producer Organizations for the target areas will comprise of the riverine horticulture farmers. The activities of pre-processing, grading and segregation can be done by the FPOs. It has been the experience of many FPOs that local markets fetch better prices than industrial tie-ups. It makes sense to have both channels of income strengthened for a farmer. While industrial tie-ups work out to be a safety net, FPOs can cut down wastage of fruits, get better prices and reduce transportation expenditures, by selling the produce in local markets and to local businesses.

Some suggestions towards strengthening the FPOs as viable business entities towards optimizing the income of farmer members are:

1. Fix a price for the fruits to be sold in the area that will not fluctuate with changes in the quantum of production.
2. One of the costly inputs for a farmer – besides soil input – is land treatment, which requires farm machinery. If FPOs can own farm equipment commonly used by all its farmers, it can rent them at a lower rate than the market rate. This is a win-win situation for the FPO and the farmers renting from it. This model of renting farm equipment is successfully functional in one of the FPOs in Covenant Centre for Development (CCD), Madurai.
3. Tie-up with the local *anganwadis*, schools, government hostels, government hospitals and private hospitals to supply the local fruit produce nutritional supplements for children and patients in the area. A state level policy intervention would be needed to mainstream this practice. Gram Panchayat offices, all other government offices, and Ministry of Information and Broadcasting, can create publicity about local produce and markets which provide better profits. This may also cut down on waste that happens to perishables irrespective of cold storage facilities.
4. Sell the produce under a local brand in the local and weekly markets directly to consumers.
5. Invest in local warehouses and cold storage to address the waste of large-scale produce aggregated from farmers of the FPO.

6. Tie-up with agri-processing industries to pick up the produce from the farm gate at an agreed price much before the production begins. Industries may be provided long-duration loans and tax breaks.
7. Direct marketing of produce has been shown to fetch good prices for most produce. FPOs can have app-based sales of their produce. There are apps being developed to aggregate produce from a single farmer or group of farmers, and pick up produce from their farm and offer better prices. Either FPOs can tie up with such farmers to become their franchisees in a different geography or they can develop their own apps and directly deliver to the consumers.
8. Allied livelihoods to stabilize income/ generate local employment: The agro-forestry model we propose suggests that farmers will be better off if they moved to organic farming. If a large number of farmers decide to transition to organic agro-forestry model they will need: organic inputs and QPM. The servicing of organic inputs (*Jeevamrut, Ghanajeevamrut*) and the QPM can become a livelihood in itself. FPOs can engage SHGs to raise QPM by distributing seeds to SHG members and collecting saplings back, following the *lijjat papad* model. Local SHGs can be given the business of setting up nurseries and producing QPM to service the local needs. The area that the SHGs will service can be the same cluster as the FPO formed by farmers in cluster villages.
9. Landless laborers in the villages where the FPO operates can be engaged in production of organic inputs through livestock. Both QPM nurseries and organic input preparation will need training. This has to be facilitated by the FPOs and by KVKs in the region.
10. Hub and spokes model for Mega Food Parks: The processing units are the hub, the pre-processing centers are the spokes at cluster level, while the collection centers are the spokes at the village

level. The village and cluster level operations are envisaged to be managed by FPOs, while the main processing unit is to be managed by the industry. There needs to be a guaranteed buyback arrangement from the industry so that the farmers are not at the mercy of the market for their produce.

Interaction with Shri Muthuvelayutham, a key functionary of The Covenant Centre for Development, Madurai, provided certain insights on the scale at which FPOs can operate. He has an experience of setting up and working with more than 62 FPOs involving more than 25,000 farmers in the last 13 years, and facilitating tie-ups with agri-business like Dabur, Himalaya, Patanjali and other international brands. Some of the FPOs tried to get into value addition of their fruits by setting up pulping units. But they did not have the capabilities and finances to keep pace with improvements in technology and changing market demands.

Before asking the farmers to grow tree-based raw materials, it is suggested that government bodies like SFAC encourage industries who use these materials to first set up their units in the area and guarantee buyback from the farmers. This model is followed by EID-Parry in Tamil Nadu to procure guaranteed buyback of neem seeds from farmers of a particular district of Tamil Nadu for production of Azadirachtin.

COMPULSORY CROP AND LIVESTOCK INSURANCE

To de-risk the farmers from unforeseen scenarios, the farmers in the target region should be encouraged to take up crop and livestock insurance as an important step for transition to tree-based agriculture. Livestock plays an important role during droughts and other difficult times by augmenting the farmers' income. Therefore, integrating livestock management and insurance will provide a safety net for the farmers during the transition period. This de-risking may ease their worries of transition to agro-forestry based farming. The present crop insurance regime does not cover horticulture and multi-purpose trees in entirety. There are ongoing discussions and policy documents about developing an insurance plan for horticulture crops and other trees. Although a horticulture/plantation insurance is in existence, the scope of the same needs to be expanded to cover more trees under it.[34] Provisions under Sub-Mission on Agroforestry (SMAF) under the National Mission on Sustainable Agriculture (NMSA) are a powerful incentive for conversion to tree-based agriculture.

ONLINE PLATFORM

To facilitate loans, access to saplings and all resources towards change in cropping pattern and farmer livelihoods, it is required to facilitate certification of produce, access to government schemes and to obtain crop and livestock insurance. It will be efficient to make it available through online platform as a single window for all the target farmers who join the program. A case in point is the crop insurance given to farmers of Rajasthan state through an online portal, which has seen historic registration within two months of the portal's creation.

THE TECHNO-ECONOMIC MODEL: AGRO-FORESTRY MODEL FOR FARMLAND

This section details the techno-economic plan for riverside farmlands to transition from present cropping patterns to a tree-based farming approach. There are many plans that look perfect on paper but do not pan out quite well when implemented. The farmer community of India comprises of 85% small and marginal farmers who do not have the ability to bear the consequence of the failure of a proposed model. The solution we propose here stems from 13 years of experience with the PGH initiative, which helps farmers plant trees in private farmlands on their own volition. The agro-forestry generic model envisages providing sources of income to a farmer on a daily, weekly, monthly and yearly basis. The proposed model tries to address the low net income of farmers due to poor profit margins from annual crops. The models, when made specific to agro-climatic zones, will make even more precise predictions of the probable economic benefit farmers can reap from tree plantation. The specificities that will change for the model will be: type of trees to be grown, the inter-cropping specifics, and the crop combinations. The model's economics will further improve and become accurate with knowledge of irrigation facilities and the rainfall pattern in the select geography. India has seen farming activity before many other parts of the world woke up to it. The model suggested in this chapter has evolved by leveraging the traditional farming knowledge that has been passed on over generations of farmers for over 12,000 years. The model suggested in this section is strengthened by taking into consideration the following:

- Traditional knowledge of farmers with respect to tree plantation, also known as the "Wadi Model" about which we will talk later.
- Precision high density farming methods honed by Tamil Nadu Agricultural University (TNAU)
- Subash Palekar's Zero Budget Natural Farming Package of Practices

In order to propose this model as an economic alternative to a farmer's present cropping patterns, it will be useful to know the market for horticulture produce.

THE IMPORTANCE OF HORTICULTURE IN INDIAN AGRICULTURE

To address the challenges in agriculture, diversification has emerged as the best option to address nutritional adequacy, employment opportunities, farm income enhancement, and use of natural resources. Among various options for diversification, horticulture has proved, beyond doubt, its potential for gainful diversification.[35, 36] Any developing economy needs to take care of food and nutritional security, sustainable livelihoods, and health care for ensuring inclusive growth. In this scenario, horticulture stands out as one of the most important sub-sectors of agriculture in the country, marking the onset of a 'Golden Revolution'.[37]

The horticulture sector is a promising area for diversification in agriculture on account of its high-income generation per unit area, with low demand on water and other farm inputs, and as an environment-friendly production system. The Government of India has accorded high priority for the development of this sector, particularly since the VIII Plan.[38]

The impact has been visible in terms of increase in production of horticultural crops. The predicted need of horticulture produce by 2050 is 660 tonnes, in view of the growing population. However, the production of only 240 tonnes in 2010-11 and 300 tonnes during 2016-17 (which is 4.8 percent higher as compared to the 2015-16 estimates), poses a great challenge for the horticultural sector[39] – in the background of shrinking land area, water scarcity, erratic and unpredictable rainfall pattern due to climate change, labor scarcity, etc. Yet, the growing demand for horticultural produce coupled with good agri-business opportunities for inputs like seeds, greenhouse design and construction, irrigation, equipment and, above all, marketing of produce and high value addition, hold much promise. This changed scenario in the horticultural sector is expected to become competitive and improve the economy and profitability. Although climate change poses a threat to agriculture in general, horticulture-based cropping systems have the potential to mitigate it. Perennial trees act as carbon sinks by sequestering atmospheric carbon.[40] The government's aim of doubling farmers' income by 2020 also provides a greater role for the horticulture sector as it generates more income than the agriculture sector.

FIGURE 1: PRODUCTION OF FOOD GRAINS AND HORTICULTURE

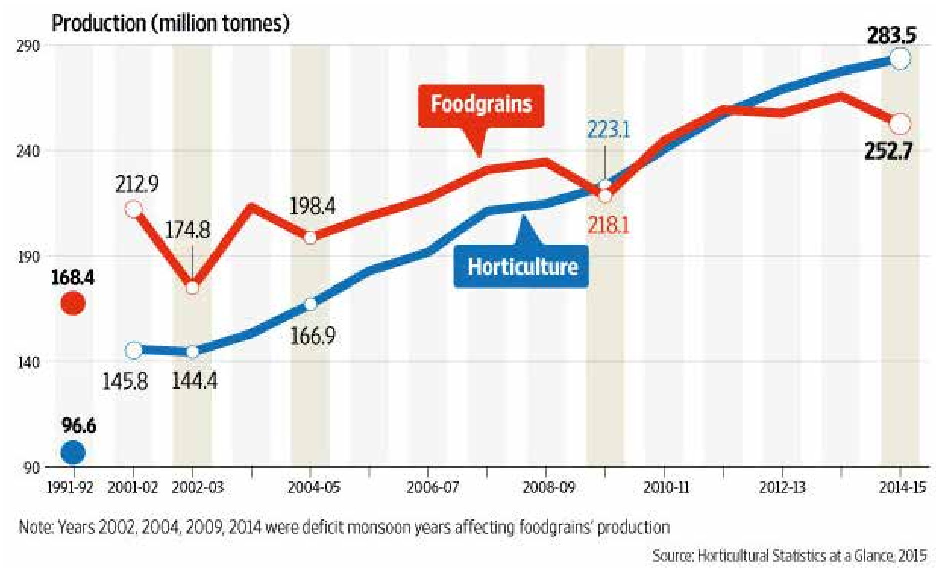
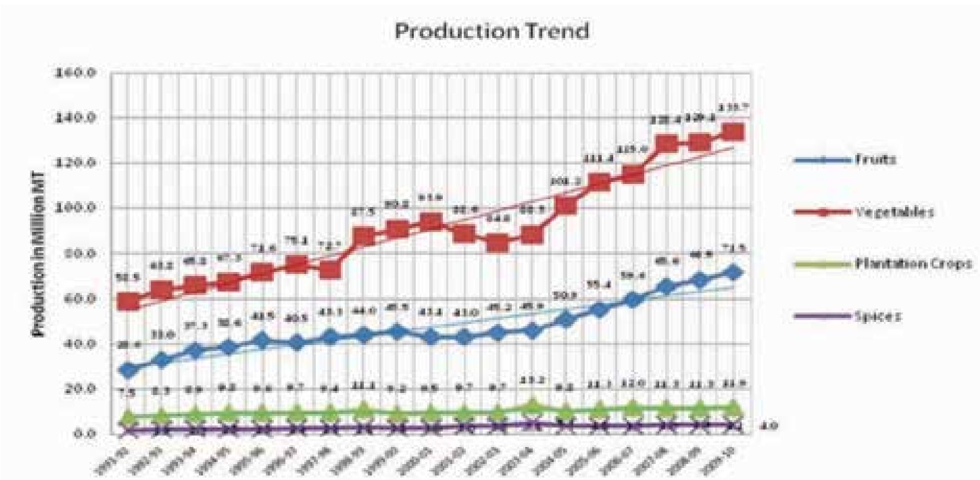


FIGURE 2: PRODUCTION TREND FOR HORTICULTURE



Source: Planning Commission (2012). Report of the Planning Commission Working Group on Horticulture & Plantation Crops for the 12th Five Year Plan. New Delhi

HORTICULTURE SECTOR – GROWTH TRENDS

In 2014-15, production of fruits and vegetables (284 million tonnes) overtook India's food grain production (253 million tonnes) by 31 million tonnes. This was the third straight year when horticulture output outstripped that of food grains. As Figure 1 shows, food grain production dropped in drought years (2002, 2004, 2009, 2014), while horticulture production was either unaffected or stayed on its upward growth trajectory.[41] A detailed note on the horticulture sector and its importance is presented in Annexure 15.

Between 1991-92 and 2009-10, there has been a general increase in production of fruits, vegetables, spices and plantation crops. However, production of vegetables has recorded very high levels of fluctuations.

BOX 2: SUPPLY AND DEMAND PROSPECTS FOR FRUITS

Despite favorable demand and supply side factors, area under cultivation of fruits and vegetables has remained below 10% in the country. Even with one tenth share in area, fruits and vegetables contribute to more than one fourth of the earnings from the crop sector. Fruits and vegetables give 4-10 times the return as compared to other crop groups, namely cereals, pulses and oilseeds. A study on sources of growth indicate that diversification towards horticultural crops is the most powerful factor in raising the growth rate of GDP in agriculture. A 1% shift in area from non-horticultural crops to horticultural crops adds 0.46 percentage points to the growth rate of the agriculture sector. Due to changes in taste, preferences and food habits, the consumption pattern in India has been shifting towards fruits and vegetables. Such changes are also happening globally. Studies on food demand indicate that 1% increase in per capita overall consumption expenditure, results in 1.9% and 1.02% increase in demand for fruits and vegetables, respectively. Thus, per capita intake of fruits and vegetables in the country will keep rising in coming years. Moreover, there is large deficiency of these items in the Indian diet. India's import of fruits is rising by 20% per year. All these indicators suggest that demand-side prospects for fruits and vegetables are very bright.[45]

From 1997-2002, there has been a general increase in the area under cultivation of fruits, vegetables, plantation crops and spices during the initial period, followed by a phase of stagnation for fruits and vegetables. The trend in expansion of area for fruits and vegetables was restored during 2005-2007 and during 2007-2012 the rate of growth increased.[42]

The leading fruit-producing states between 2009-10 and 2014-15 were Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka and Uttar Pradesh. The states leading in production of various fruits in this period are given in Table 5.

TABLE 5: TOP PRODUCERS OF FRUITS BETWEEN 2009 AND 2015

Fruit	Top Producers (Average Annual Production Between 2009 and 2015)
Apple	Jammu & Kashmir, Himachal Pradesh
Banana	Tamilnadu, Maharashtra, Gujarat
Citrus	Telangana, Andhra Pradesh
Grapes	Maharashtra
Guava	Madhya Pradesh, Uttar Pradesh
Litchi	Bihar
Mango	Uttar Pradesh, Andhra Pradesh
Papaya	Andhra Pradesh, Gujarat
Pineapple	West Bengal, Assam
Pomegranate	Maharashtra
Sapota	Karnataka, Gujarat, Tamilnadu
others	Kerala, Maharashtra

Source: Based on data from Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, New Delhi

Trend lines for productivity indicate that the productivity of fruits has not increased as much as vegetables. Productivity of crops like banana, citrus fruits, papaya, pineapple, guava and sapota have recorded sustained increase. However, the productivity of mangoes and litchi are almost stagnant or sagging, whereas, grapes, apples and pineapples have recorded fluctuating productivity due to adverse weather conditions and disease infestation. This may be attributed to lack of linkage between Government-supported area expansion programs, non-availability of QPM, low productivity of old and senile plantations and lack of Government scheme components catering to increasing the productivity of existing orchards.[43]

Fruits and vegetables are mostly grown by marginal and small farmers with land-holding of less than 2 hectares. This means that resource-poor farmers are likely to benefit most from growth in the horticulture sector. This is more so, because the value of the horticulture output grew more than double compared with all other crops put together in the four years between 2008-09 and 2012-13.[44] (See Box 2)

AGROFORESTRY AS A SPECIFIC SOLUTION ON RIVERSIDE FARMLANDS

In this section, a generic techno-economic model for tree plantation in one acre of farmland is provided. The scientific basis of what we are proposing is also mentioned. We will be looking at the precedents of large-scale successful implementation of agri-horti-forestry models for livelihood enhancement. We will also look at the characteristics of the model proposed, the key assumptions in creating it, and the need to enhance farmer livelihood. The subsequent section details the following:

- Suggested package of practices
- A specific example to typically illustrate possible financial benefits
- Comparisons with other cropping options
- Possibility of substantial financial and other benefits of organic production, and issues related to it.

SCIENTIFIC BACKGROUND

Well-documented evidence of a multi-tier system of cropping in coconut based orchards, available at Indian Council of Agricultural Research (ICAR)'s Central Plantation Crops Research Institute (CPCRI), Kasargod, Kerala, is taken as the base model to work out the current mango-based cropping system. CPCRI has developed a coconut-based cropping system aimed at crop diversification and intensive cropping in the interspaces available, which is highly rewarding and sustainable.[46]

Similarly, research by ICAR's Central Institute for Arid Horticulture (CIAR), Bikaner, Rajasthan, has confirmed that in order to mitigate the risk of total crop failure, suitable crop combinations involving perennial fruit crops like *Amla* + Ber or Khejri (a fodder tree) + Cluster bean + fennel / coriander are found sustainable and remunerative under arid conditions.[47] The yield of intercrops was found higher under multiple cropping as compared to mono-cropping. The perennial fruit crops, whose canopies are regularly maintained through pruning, help to maximize the overall productivity, and improve the physical, chemical and biological properties of the soil through leaf litter.

PRECEDENTS EXIST FOR A HORTICULTURE BASED LIVELIHOOD MODEL FOR INDIAN FARMERS

The horticulture based solution proposed here for a private farmer has precedents. One such large-scale tree plantation was done by Bharat Agro-Industries Foundation (BAIF) in Wadi region in Gujarat. This has subsequently been adopted by many horticulture departments of other state governments. It is also pertinent to note that the Wadi Model is recognized by NABARD for improving the livelihoods of marginalized tribal farming communities. They have adopted the one-acre Wadi Model for replication at a national level with the support of the Central Government.

Similarly Project GreenHands of Isha has also been working with farmers in Tamil Nadu and encouraging them to move to agroforestry under its "Trees for Life" program.

Maharashtra Government through its Employment Guarantee Scheme (EGS), has facilitated the shift of a large number of farmers from annual crops to horticulture / fruit-tree crops. This was much before the MNREGA program was initiated by the Central Government.

These Case Studies are discussed below.

CASE 1: WADI MODEL – A LIVELIHOOD PROGRAM

The Wadi program was initiated by BAIF Development Research Foundation in southern Gujarat in the 1980s, and was further expanded to different tribal regions of India. It is an agri-horti-silvi model spread over Maharashtra, Gujarat, Karnataka, Uttar Pradesh, Uttarakhand, Rajasthan, Madhya Pradesh, Chhattisgarh, Bihar, Andhra Pradesh and Jharkhand. An example of this is horticulture crops, such as amla (10 m x 10 m in fertile soil and 8 m x 8 m in degraded soil), mango (10 m x 10 m spacing), and cashew (7 m x 7 m spacing) with intercrops grown in these spaces and trees like *glyricidia and subabul* planted in closer spacing along the farm border in an area of 0.4– 1.0 ha. So far, BAIF has assisted over 1.81 lakh families to establish 68,586 ha based on the Wadi Model. This concept is a comprehensive program for natural resource management, adoption of sustainable farming practices, and upliftment of the rural communities through livelihood security.

Women's Self-Help Groups (SHGs), set up in BAIF-Wadi Model projects, are engaged in a diverse range of income-generation activities, including the following:

- Nurseries for mango grafts and multi-purpose tree species saplings
- Backyard or Wadi plot cultivation of vegetables
- Manufacture of vermi-compost
- Trading in food grains
- Making leaf cups
- Making *papads*
- Manufacture of brooms
- Fisheries
- Group farming by taking land on lease

The main source of funds for these activities is the savings generated by SHG members themselves.

The story of Anita Jadhav of Jadhavwadi in Igatpuri tehsil of Nashik, Maharashtra, illustrates the above. Her family owns four acres of rain-fed land, which is cultivated only in the *kharif* season. The family had no other regular source of income. In 2003-04, she joined the Wadi program and started cultivation of guava in a 1-acre plot. Till the trees reached maturity, she grew *tur, chana*, and other pulses in the spaces between trees. Using improved agriculture practices promoted by the BAIF-MITTRA scheme, she earned an annual net income of around Rs. 5,000.

In 2006-07, the guava trees bore their first fruit, fetching a net income of Rs. 6,000, followed by Rs. 7,000 at second fruiting (generally, guava trees produce fruits twice a year, in the rainy season, and in winter). In 2007-08, the income from first fruiting of the guava trees was Rs. 13,000. Anita used the money to buy a buffalo of `*Mahuda'* breed, which yielded 7 liters of milk a day. From the milk earnings, she bought a crossbred cow. In 2008-09, her net income from sale of milk amounted to Rs. 60,000, which was in addition to Rs. 32,000 earned from the sale of guavas. Thus, in a short span of 6 years, Anita's family rose above the below poverty line to nearly attain `*lakhpati'* status.[48]

CASE 2: PROJECT GREENHANDS' INITIATIVE – TREES FOR LIFE:

PGH, in its own way, has been working with farmers in the last decade to create awareness on farm forestry, and encourage them to plant trees.

With rise in price of farm inputs, delayed rainfall, shortage of labor and increased living, the repercussions for an average farmer is far more disastrous than what meets our eye. Most farmers have abandoned their traditional, sustainable agriculture practices, and now depend on costly loans from banks or money lenders for continuing agriculture.

Through the "Trees for Life" agro-forestry campaign, farmers are encouraged to plant a combination of fruit, fodder and timber trees in the farmland. Through this model that is designed to bring tree-based agriculture back to the heart of Indian farming, farmers are guided to choose and plant the right kind of tree saplings to take care of all issues like crop failure, soil erosion and water inadequacy, thereby creating a self-sustaining movement. Farmers are mobilized through awareness campaigns, advertisement in farmer magazines, etc.

Trees bring biodiversity, soil fertility, a cooler climate, cleaner air and increased rainfall. Their yields reduce agricultural expenditure, while creating the possibility of future income through small-scale forestry enterprises. A process documentation of PGH's activity is given in Annexure 14, and a detailed case study of PGH is given in Annexure 19.

CASE 3: MAHARASHTRA'S HORTICULTURE USING THE EMPLOYMENT GUARANTEE ACT

Maharashtra Government pioneered the famous Employment Guarantee Act in 1977, whereby it guaranteed work to rural unskilled manual laborers needing work. Initially, only public works like roads, irrigation tanks, other water-conserving structures, and works in the Forest Department were taken. But it was noted that there was a scope to increase opportunities for rural employment and open up possibilities in small and marginal farmers' farmlands (which constitute almost 75% of farm holdings) by improving such farms. At that time, about 85% of lands in Maharashtra were rain-fed, and cereal and other crops were becoming slowly unviable with unpredictable outputs due to the vagaries of monsoon.

It was then that Maharashtra Government introduced the horticulture scheme (popularly known as "EGS horticulture") in 1990. It was an instant success from the first year. According to the EGS Scheme, the farmer will be given daily wage to plant horticulture trees in his own farm. The scheme envisaged financial support to the farmer for three years – 50% of the cost of production in the first year, 30% in the second year, and 20% in the third. The critical inputs like good QPM, fertilizers, etc., were provided by the Agriculture Department, and the costs were deducted from the farmer's subsidy. In fact, substantial quantities of the planting material were developed in the nurseries of the four agricultural universities of the State.

The most important feature of the scheme was that the funds were released only in the second and third year on the basis of the survival of the plants. Thus, the second year's release of funds was made only if there was 75% survival, and the third year's, only if there was 90% survival. All payments were made directly to farmer's bank accounts.

The cost norms for each fruit crop were evolved, and it varied from one fruit to another. Slowly, more varieties were added to the previous lists and three-year cost norms were made available. The current list consists of the following:

- Dryland horticulture: Mango, cashew, bher, *sitaphal*, tamarind, awala, jack fruit, *kokam* and few more
- Irrigated horticulture: coconut, orange (both *santhra* and *mosambi*), *chikoo*, pomogrante, grapes, peru, *anjir*, lime, supari and few more
- Other crops: *jojoba,* jatropha, rubber, spice, medicinal, bamboo etc.

Before the start of the program in 1990, about 2.42 lakh hectares were under fruit crop cultivation. Now in 2016-17, about 18.55 lakh hectares are under fruit crop cultivation – an increase of 900%. About 21 lakh farmers have benefitted from the scheme over the years.

The horticulture scheme has helped improve the farm income substantially. It greatly improved the economy of coastal districts of Maharashtra (called *Konkan*) and there was a sudden increase in mango, cashew and *chikoo* production. It reduced migration to Mumbai from Ratnagiri and Sindhudurg districts. It also improved the economy of Western Maharashtra (districts like Nashik, Ahmednagar, Solapur, Pune, Satara, and Sangli). The local political leadership, through cooperatives and entrepreneurs, developed forward linkages for storage and marketing, including exports. Today Maharashtra is the No.1 state in fruit production.

A note on Maharashtra's agro-forestry project through the Employment Guarantee Scheme is available in Annexure 16.

ENSURING FARMER LIVELIHOOD ENHANCEMENT

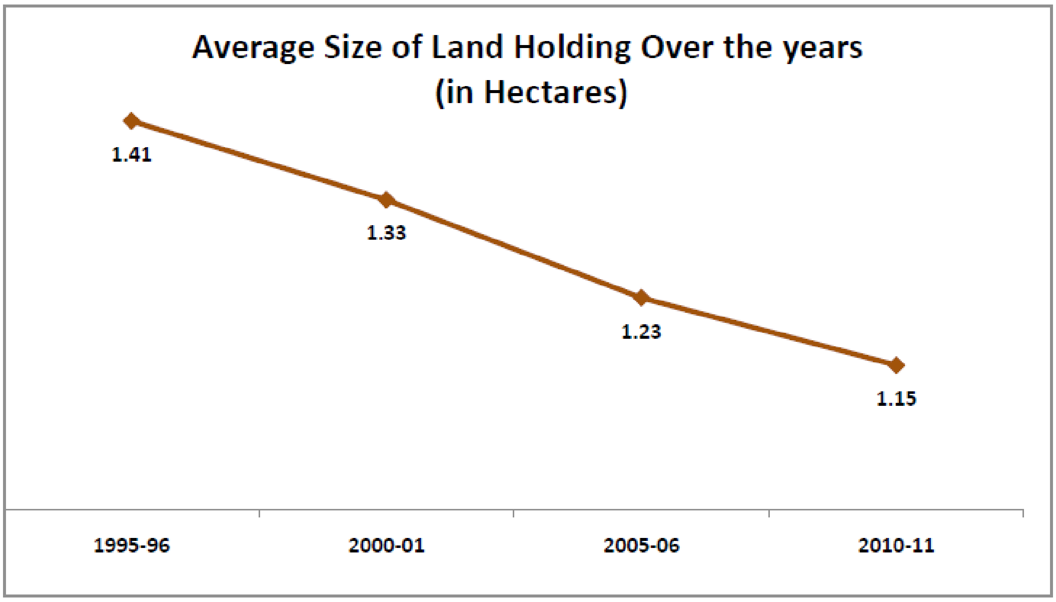
The solution proposed for privately-owned farmland has been conceived of as a rural livelihood project. Successful implementation of this farmer livelihood model, and the consequent rapid adoption of the program by the farmers, would contribute to saving of rivers. This will be effected by the tree cover on river banks augmenting inflows, and use of organic farming practices to prevent pollution by agro-chemicals.

The program's success hinges on ensuring that that the economic benefit for the farmers is achieved. The crux is that this program needs to be definitely and effectively delivered to the farmer – and this must be kept in mind throughout the execution, monitoring and evaluation of the program.

KEY ASSUMPTION IN CREATING A VIABLE LIVELIHOOD MODEL FOR FARMERS: SIZE OF AVERAGE FARMER LAND-HOLDING ASSUMED

The agricultural census data of 2010-11 shows that the average size of holdings has steadily declined over the years since 1970-71, with the 2010-11 figure at 1.15 hectares (i.e. 2.47 acres) (Refer Figure 3). Based on this trend, the model proposed here is for a one-acre parcel of land, which will be occupying roughly half of the land holding of an average farmer

FIGURE 3:



CHARACTERISTICS OF THE PROPOSED ONE ACRE AGRI-HORTICULTURE-FORESTRY MODEL

The Policy Recommendation regarding FPO formation and strengthening business prospects of the FPOs are intended to facilitate organization of farmers as large groups, who will have authority and bargaining capacity to fix the price of the produce. Try as we may, markets are volatile and all the factors of risk cannot be nullified. So the models discussed here incorporate components towards facilitating the farmer becoming self-reliant in his farm inputs. Therefore, native livestock becomes a mandatory requirement for the farm. They provide dung, urine and milk, all of which help the farmer in providing farm inputs and income. In the agro-forestry model, there is adequate organic content in the form of leaves and tree litter. This can be used as soil mulch, fodder for livestock and as an ingredient for preparation of herbal pest repellants. Thus, the majority of farm inputs, like compost, organic growth promoters, organic pest repellents and leaf litter for mulch, are available in the farm itself, through the livestock, trees and no-tillage farming. This reduces the cost of cultivation significantly. So the income that is achieved from the produce of the farm becomes the net income. In addition, if the farmer includes cover-cropping, there will be additional income from cover-crop produce, additional mulch and reduction in de-weeding expenses.

MULTIPLE FRUIT TREE SPECIES

The multi-fruit crop model proposed involves combination of varieties like mango, *sapota*, orange, lemon, guava, pomegranate, *amla*, *ber*, *jamun*, and jackfruit. The combinations have been worked out taking into account the compatibility of the crops, canopy of the crops, root competition aspects, bio-diversity aspects, and economic aspects so as to achieve an early return on investment while concurrently resulting in a significant canopy. Poly-culture fruit species have been chosen not only for complementary reasons, but also to buffer the farmer on account of unexpected losses in any one species. An important aspect of providing income stability to the farmers is to choose crops in a manner that reduce

/minimize labor requirements during peak harvest time, thereby reducing farmer stress. Horticulture-based multi-tier fruit crops have been assumed to be selected in a way that is specific to the concerned agro-climatic region so as to maximize the solar insolation, thus increasing the yield capacity of the proposed model.

MULTI-PURPOSE TREE PLANTATION ON THE EAST-WEST BORDER FOR FRUIT, FODDER, TIMBER AND MULCH NEEDS

The multi-purpose tree plantation on the east-west border acts as a wind break, providing stability to the micro-climate in the fruit crop area, and also enhancing the overall plant diversity. It also provides the farmer income insurance in the long-term through sale of timber. The fodder crop plantation on the boundary will fulfill the fodder requirement for the livestock. Herbal and mulch shrubs/trees on the north-south border, will be used for bio-input preparation and also to provide additional mulch.

INTER-CROPPING OF BANANA, PAPAYA, VEGETABLE, CHILIES FOR GENERATING INCOME IN INITIAL YEARS

The intercrops generate income during the initial few years when the horticulture crops are in gestation, thereby partially offsetting the initial loss of income for farmers. The specific crops used should be selected based on water availability, among other factors.

THE MODEL ASSUMES USE OF DRIP IRRIGATION

Given the shortage of water per se, the model assumes mandatory use of drip irrigation so as to ensure maximum water-use efficiency. More crop per drop through micro-irrigation, and moisture retention through mulching is one of the key features of this model. The drip system ensures increased water-use efficiency in all horticultural crops by maintaining optimum soil moisture, with concurrent improvement in yield and quality of produce across crops. The effect of this is discussed in the mandatory micro-irrigation ecosystem conditions.

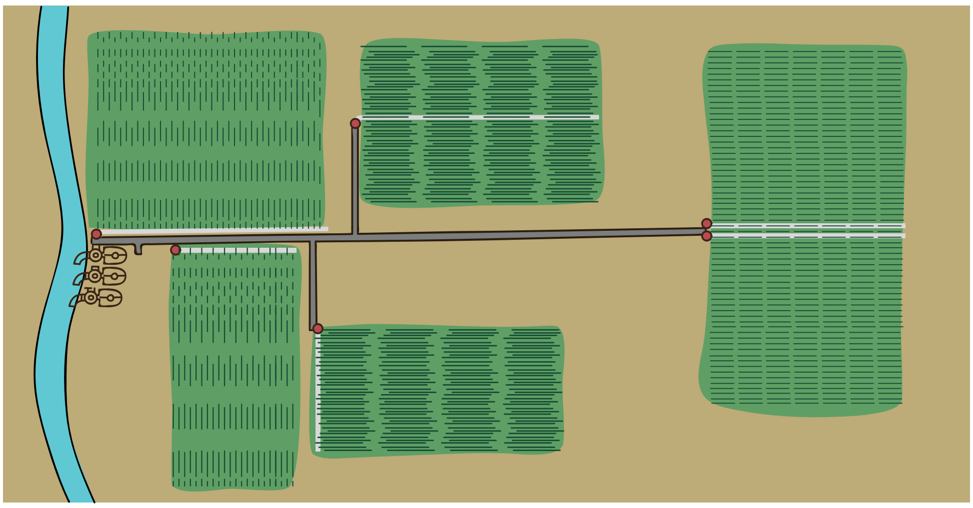
There are different models for drip irrigation possible in the areas adjacent to a river. Considering the land ownership and holdings, types of plantations, available resources like electricity in close vicinity, etc., there could be four major models for adoption of drip irrigation as follows:

- Individual farmers with own Lift Irrigation infrastructure.
- Individual farmers with own water sources (open / bore wells) in adjoining areas.
- Co-operative lift irrigation schemes
- Govt. Lift Irrigation Projects

In a project where such large scale adaptation in a contiguous area is mentioned, the drip irrigation models that can be adopted may be 3 and 4. The third model is already implemented in parts of Maharashtra and northern Karnataka where Farmers' Cooperatives lift water from the rivers to irrigate their land with a shared infrastructure. The old cooperative lift irrigation schemes use conventional flood irrigation methods for infield water applications. But recently active schemes have begun to adopt drip systems for their entire command area. In such schemes, water lifting infrastructure like pump house, distribution network, etc., is common, while for infield the water application system is owned by the farmers.

FIGURE 4:

Co-operative lift irrigation schenes like Bambavade / Gotkhindi LI schemes in Maharashtra.



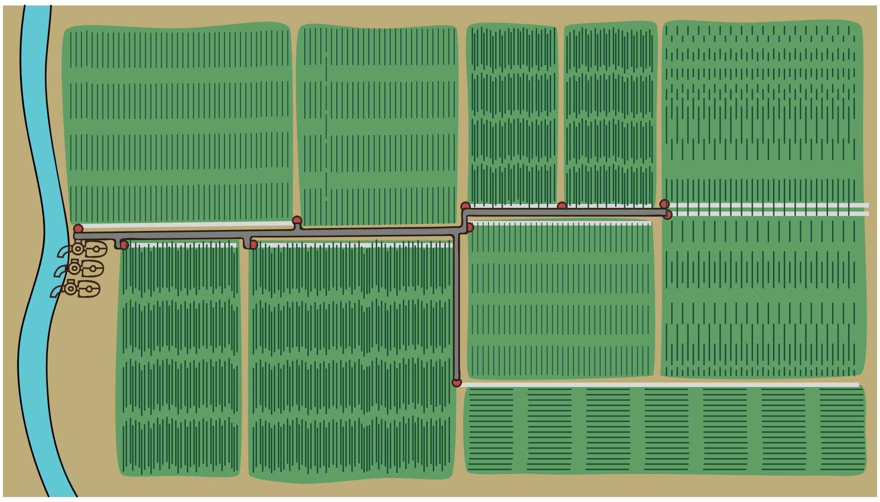
Depending on the interest of farmers / members of the cooperative society, the area covered for irrigation in such schemes may be scattered. In western Maharashtra, there are a few success stories of co-operative drip irrigation schemes, where, on a pilot basis, the government has given special assistance to promote drip irrigation in these areas. The *Gotkhindi* & *Bambavade* farmer's co-operatives are ground breaking schemes that have performed remarkably well in revolutionizing the concept of lift irrigation.

The fourth model involves Government Lift Irrigation Projects, wherein, an advanced Automated Drip Irrigation through a close conduit network is proposed instead of conventional canal networks and flood irrigation. The main objectives of going in for such Lift and Drip Irrigation Projects are:

- Avoid permanent land acquisition, which is becoming increasingly difficult and expensive
- Equitable distribution of water
- Doubling irrigation area with existing limited, available water
- Decrease the gap between Irrigation Potential Created (IPC) and Irrigation Potential Utilized (IPU).

FIGURE 5:

Govt. Lift irrigation Projects like Ramthal Drip Irrigation Project in Karnataka.



Generally, under this type of Government sponsored community irrigation schemes, the area under irrigation will be continuous throughout the proposed command area, irrespective of farmer interest / land holdings. In this segment of Community Micro-Irrigation, Karnataka state is the pioneer and leader. Karnataka has executed a few integrated Lift and Micro-Irrigation Projects like Ramthal Drip Irrigation Project. More details of these models are provided in Annexure 9.

When large-scale micro-irrigation is to be taken up, it would be best to outsource it to experienced organizations as in the two models described above. At present, farmers lose much time waiting for water for flood irrigation. If micro-irrigation is implemented, they can focus on farm operations and also find time to engage in other income-generating activities. This should be done in a way tha it preserves the farmers' right over his land, and preserves the farmers right to make own crop choices. Farmers will no longer have a sense of being stuck on the land waiting for flood irrigation. This will reduce agrarian distress and suicide.

ENSURING SOIL BIODIVERSITY AND REDUCING SOIL EROSION

Soil biodiversity is improved due to multiple rhizosphere of different fruit crops, and the presence of a variety of microorganisms associated with the rhizosphere. Soil erosion is totally avoided by the non-tillage, multi-tier, multi-crop, and mulching model that has been proposed, resulting in better recharge of groundwater, concomitant with pollutant-free quality of runoff water. No tillage with good ground cover ensures increased beneficial soil bio-flora, culminating in sustainable soil fertility. This also reduces a huge cost head for the farmer, who otherwise spends a substantial amount of money in tilling the land for every cropping cycle. The leaf litter and humus formed from the proposed system also adds up to the organic content of the land, and helps revive soil health at a quicker pace.

USE OF NATIVE LIVESTOCK FOR ADDITIONAL INCOME, AND FOR PREPARATION OF BIO-INPUTS

The proposed model involves the use of native livestock for inputs required for cultivation, which serves as an additional source of income to farmer families. Farmyard manure is always required for a farmer to follow any package of practice – be it chemical-free or otherwise. In this model, the bio-inputs prepared, like *Jeevamirtham, Ghanajeevamirtham*, herbal pest repellents, herbal growth promoters, etc., are to be prepared by the farmer using the dung and urine from his livestock and from the biomass from plants in the border area. A farmer need not go out of his farm to prepare any of the inputs required for his farm, if he has just one native cow.

The major reasons for holding native livestock are given below: (Dr. Punniyamoorthy, and expert on livestock, deals with this aspect in detail in Annexure 17)

- Microbial inoculum in a native cow's dung and cow urine is what is multiplied in *Jeevamirtham* and *Ghanajeevamirtham*. These are the inputs that revive soil health and improve the soil organic content.
- The cost of inputs of a cross-bred cow, starting from the cost of the cow, to the day-to-day expenditure, is always high. Consideration of two key issues, sustainability and longevity, results in favoring Indian native breeds (despite their relatively low milk yield). Unfortunately, many rural farmers prefer crossbred livestock (with the promise of short-term productivity) rather than the locally adapted livestock. However, morbidity and mortality is experienced in non-native breeds, because they are poorly adapted to the local climate, and are vulnerable to local diseases. For example, Holstein Friesian crossbred cows are threatened by Foot and Mouth disease that causes wasting and death in up to a million livestock each year. Cows of native breeds carry genetic resistance to the disease.
- Farmers can use Ethno-Veterinary Medicine (EVM), an established science and a practice for prevention and cure of diseases in

livestock. These medicines can be prepared using herbal plants that are grown in the farm, and other ingredients available locally. This significantly reduces the general expenditure a farmer in livestock health maintenance.

PROMOTE INSECT DIVERSITY

Insect diversity is promoted to ensure that a natural and balanced population of insects is present. Unlike in mono-culture, in poly-culture plantations (as proposed in this model), rapid multiplication of pest population, or dissemination of disease causing pathogens is avoided.

It is lack of knowledge of the agro-ecosystems that forces the farmer to use pesticides. The pesticides that have been used in the farm are now found in the food as residue. There are studies that highlight the ill-effects of long-term consumption of food laden with pesticide residues. Repeated, prolonged use of one pesticide make pests resistant it. Consequently, the pesticide is replaced by another, more lethal and stronger pesticide. Understanding of agro-ecology and different roles of different types of pests will help farmers appreciate Integrated Pest Management (IPM) as an approach to pests, and value insect diversity in this farm. Insect and pest attack is a typical problem in high-input mono-crop agriculture practice. The issue of pests becomes insignificant when following the farming system suggested here, especially when farmers come to realize that insects are the farmers' best friends.

Thus, in summary, by adopting the suggested model, the fixed asset value of the land in terms of soil fertility and productivity is ultimately improved, and shifts towards a future of sustainable agriculture.

PACKAGE OF PRACTICES THAT CAN BE FOLLOWED

A scientific package of practices suggested by the ICAR's Research Institutes and State Agricultural Universities (SAU) are available for sustainable farming systems in a way that the farmers will get a good yield, while the soil fertility is also protected for sustaining the land for future generations. The use of drip irrigation systems are also made mandatory in this model in view of its multi-fold benefits. The packages of practices that can be followed for the fruit crops are given in Dr. Kumar's report (Annexure 12).

The Department of Sustainable Organic Agriculture of TNAU has a web portal dedicated to organic farming.[49] The entire portal is in English as well as Tamil and has a Section on 'Organic Farming and Zero Budget Special Technologies'.

SPECIFIC EXAMPLE OF A MULTI-FRUIT CROP MODEL: MANGO + GUAVA + POMEGRANATE CULTIVATION

In this section, we take up a one-acre generic multi-fruit crop model consisting of mango, guava and pomegranate, as these are the most widely grown fruit trees.

In one acre, 32 mango trees, 75 guava trees, and 285 pomegranate plants are used – leading to 392 fruit trees as the main crops. The spacing for each of the three species are as shown in Figure 6.

Along the border, in the east-west direction as alley crops, two rows of trees consisting of 14 *jamun*/jack fruit trees and 70 native and endemic multi-purpose timber trees are planted. Along the border in the north-south direction, herbal and mulch plants are planted and maintained as shrubs for mulch and bio-input needs.

ECONOMICS OF THE ONE ACRE MODEL

If this proposed model were to be implemented, the governments should be willing to bear the short-term cost of livelihood loss for the farmers. Also, scale and the pace of the scale-up required for the project can only be taken up by state machinery. The major bottleneck of the project will be the willingness and ability of cash crop riverine farmers to convert to horticulture. In India, most of the small and marginal farmers do not have the ability to absorb the risk of such a transition.

The challenge in the economic model is that the earnings of the farmer for the first few years of conversion are below the threshold of their current earning of Rs. 74, 988 per annum.[50] The fact is that not many farmers will have the savings to fund this upfront cash outlay. This would slow down the implementation of the program because only a small percentage of the farmers will be able to fund their livelihoods for the initial three year gestation before their income rises above their current earning threshold.

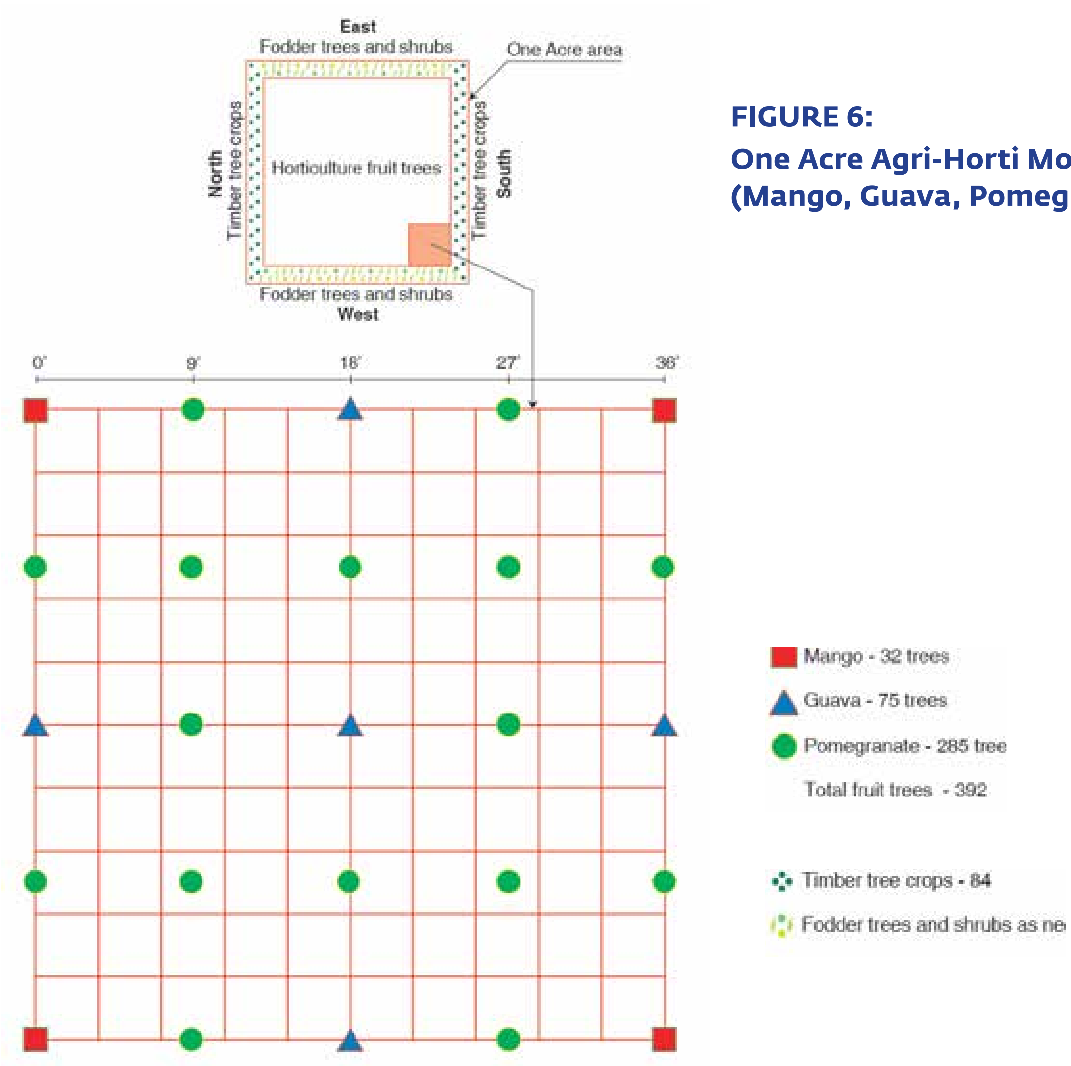


FIGURE 6:
One Acre Agri-Horti Model (Mango, Guava, Pomegranate)

The government, therefore, should be ready to provide a livelihood subsidy or loan to the farmer for the initial years of gestation of the fruit trees. We have assumed that the farmer must have an annual surplus of at least, or similar to, their current average earnings of Rs. 74,988.

We are considering two variants of the mango-guava-pomegranate fruit tree crop model – organically grown and inorganically grown. In the case of the inorganic fruit model, the total quantum of government support required for a farmer will be Rs. 75,000, Rs. 74,000, and Rs. 15,000 over the first three years, respectively.

For the organic fruit model, the total quantum of support required for a farmer will be Rs. 75,000 and Rs. 55,000 in the first and second year, respectively (Refer Table 9 and Table 13). This investment could be made as a subsidy or as a long-term loan to the farmer. Either way, this government investment seems highly desirable given the significant payback in terms of saving our rivers, substantially reducing carbon footprint, ensuring major forest cover gains, large-scale promotion of personal health, and even as a financial investment for society with a strong internal rate of return.

COSTS OF THE MULTI-FRUIT CROP MODEL

The economics of the model is based on incurring a cost of Rs. 1.23 lakh initially in the first year. Subsequently in the second and third years, the maintenance cost would be Rs. 18,000 per annum and this would go up after three years to Rs. 35,000 per annum. Details are shown in Table 6.

It is assumed that in line with the current government practice, all the establishment costs are to be funded by the government. The ongoing maintenance costs can be funded by the farmer himself.

TABLE 6

Break Up of Costs	With Drip
Establishment cost (1st year) Sapling cost, planting material for fodder trees, ploughing, mulch crop, pit making, seed preparation, drip installation, labour cost	1,23,891
Maintenance costs per year (2nd & third year) Weed management through power tiller, *Jeevamirtham*, growth promoter, supplemental mulching	17,901
Maintenance costs per year (after 3 years with increased labor costs) Pruning, *Jeevamirtham*, plant protection spray, harvesting, additional labor, weed management	35,929

The costs indicated above are the actual costs plus interest. For details refer Appendix 5.

FARMER EARNINGS VIA THE MULTI FRUIT-CROP MODEL

In the subsequent sections we examine the earnings from a generic one-acre multi-fruit crop (mango-guava-pomegranate) model. We start with a base model of inorganic cropping. Thereafter, we compare incomes from the following:

- Multi-fruit crop model vs. single-fruit (mango) crop model
- Multi-fruit crop model vs. field crop model
- Organic multi-fruit crop model vs. inorganic multi-fruit crop model

These are only indicative incomes. In practice, there will be variations based on the agro-climatic zone, soil health, land treatment undertaken, irrigation, quality of the produce and the market situation.

We then compare the income from our multi-fruit model with incomes from various single-fruit crops. Further, we examine the additional income in our model from timber and non-timber produce. We also look at the additional income from livestock, as well as the savings in agricultural input costs if livestock is maintained. Similarly, we examine the income from intercropping and the savings in the cost of agricultural production if intercropping is done.

In the base earning model for the farmer, we have assumed that the horticulture produce is of the normal inorganic kind, and not of the organic kind. Given that, the resultant earnings of the farmer would become Rs. 1.8 lakh per annum by year 5, and Rs. 3.2 lakh per annum by year 10 (See Table 7).

TABLE 7: INORGANIC MULTI-FRUIT CROP MODEL

Mango + Guava + Pomegranate: Inorganic farming, without establishment costs, without livelihood subsidy						
Variety	Mango	Guava	Pomegranate			
Trees per Acre	32	75	285			
Years	Return per Crop per Year			Total (Rs)	Expenses per Annum (Rs)	Net Income (Rs)
1	0	0	0	0		0
2	0	6000	12540	18540	17901	639
3	0	27000	51300	78300	17901	60399
4	9600	45000	107160	161760	35929	125831
5	21120	57750	142500	221370	37725	183645
6	34560	72000	188100	294660	39611	255049
7	64000	72000	188100	324100	41592	282508
8	84600	64800	169290	318690	43672	275018
9	128000	58320	152361	338681	45856	292825
10	176000	52488	137125	365613	48149	317464
Total	517880	455358	1148476	2121714	328336	1793378
Note	1. Expenses per acre with drip will go up by 5% each year starting from Year 5					
	2. Internal rate of return (%): Not applicable					

This earning more than doubles the farmer's current income of Rs. 80,000 per annum. In addition, there will be earnings from the following, which have not been factored in the earnings model:

- Sale of timber in the long run after 15 years
- Regular earnings from fodder and the *jamun* fruit tree along the borders
- Possible intercropping earnings in the first few years

COMPARISON OF MULTI-FRUIT CROP MODEL WITH SINGLE-CROP MODEL

It is pertinent to compare the enhanced earnings that result from using a multi-crop model of mango + guava + pomegranate, as compared to, say, mango alone. With just one crop (mango) the earnings in both year 5 and year 10 are Rs. 33,000 and Rs. 275,000, respectively (See Table 8).

TABLE 8: SINGLE FRUIT TREE EARNINGS

Age (year)	Yield (kg/tree)	Yield /acre	*Returns (Rs)
1	0	0	0
2	0	0	0
3	0	0	0
4	10	500	15000
5	20	1000	33000
6	30	1500	54000
7	50	2500	100000
8	60	3000	135000
9	80	4000	200000
10	100	5000	275000

MULTI-FRUIT CROP MODEL WITH FARMER LIVELIHOOD SUBSIDY/LOAN

Table 9 shows earnings from the multi-fruit crop model when livelihood support is provided by the government. The average annual income of the farmer is protected in the first three years before returns start flowing from the fruit crop. As has been covered earlier, the compensation of nominal loss of farmer's income is justified on account of the eco-system services that rivers and the trees on the floodplains provide. It is also a very effective way of redistributing wealth in society in favor of the farmer.

TABLE 9: INORGANIC MULTI-FRUIT CROP MODEL WITH LIVELIHOOD SUBSIDY

Mango + Guava + Pomegranate: Inorganic farming, without establishment costs, with livelihood subsidy								
Variety	Mango	Guava	Pomegranate					
Trees per Acre	65	150	88					
Years	Return per Crop per Year			Total (Rs)	Expenses per Annum (Rs)	Income without Livelihood Subsidy	Livelihood Subsidy (Rs)	Net Income with Livelihood Subsidy (Rs)
1	0	0	0	0		0	74988	74988
2	0	6000	12540	18540	17901	639	74349	74988
3	0	27000	51300	78300	17901	60399	14589	74988
4	9600	45000	107160	161760	35929	125831		125831
5	21120	57750	142500	221370	37725	183645		183645
6	34560	72000	188100	294660	39611	255049		255049
7	64000	72000	188100	324100	41592	282508		282508
8	84600	64800	169290	318690	43672	275018		275018
9	128000	58320	152361	338681	45856	292825		292825
10	176000	52488	137125	365613	48149	317464		317464
Total	517880	455358	1148476	2121714	328336	1793378		
Note	1. Expenses per acre with drip will go up by 5% each year starting from Year 5							
	2. Internal rate of return (%): Not applicable							

From the government's perspective, even if one were to look at the internal rate of return on these costs for society as a whole, then the societal return on this investment is a handsome 41% per annum (see Table 10).

TABLE 10: INORGANIC MULTI-FRUIT CROP MODEL WITH LIVELIHOOD SUBSIDY AND ESTABLISHMENT COST

Mango + Guava + Pomegranate: Inorganic farming, with establishment costs, with livelihood subsidy								
Variety	Mango	Guava	Pomegranate					
Trees per Acre	65	150	88					
Years	Return per crop per Year			Total (Rs)	Expenses per Annum (Rs)	Income without Livelihood Subsidy	Govt Livelihood Subsidy (Rs)	Net System Surplus (Rs)
1	0	0	0	0	123891	- 123891	-74988	-198879
2	0	6000	12540	18540	17901	639	-74349	-73710
3	0	27000	51300	78300	17901	60399	-14589	45810
4	9600	45000	107160	161760	35929	125831		125831
5	21120	57750	142500	221370	37725	183645		183645
6	34560	72000	188100	294660	39611	255049		255049
7	64000	72000	188100	324100	41592	282508		282508
8	84600	64800	169290	318690	43672	275018		275018
9	128000	58320	152361	338681	45856	292825		292825
10	176000	52488	137125	365613	48149	317464		317464
Total	517880	455358	1148476	2121714	452227	1669487		
Note	1.Expenses per acre with drip will go up by 5% each year starting from Year 5							
	2. Internal rate of return: 41%							

As an alternative to providing a livelihood subsidy, a livelihood loan could be considered, which the farmer returns after five years in three annual tranches. This would reduce the effective cost of the program to the government, but would entail significant additional complexity in terms of creating the on-ground capability to recover the funds after five years.

SUBSTANTIAL ADDITIONAL FINANCIAL BENEFIT OF MOVING FROM INORGANIC TO ORGANIC CULTIVATION

There is a substantial additional benefit of having the farmer transition from inorganic to organic cultivation of fruits. This is because the sale price realization of organic crops is about 200% more than the inorganic versions (See Table 11). However, in future, as organic fruit supply increases, we have assumed that prices will drop 30% relative to inorganic fruit – and therefore the sustainable premium over inorganic fruits assumed in the modeling, is much lower, at 120%. There are annual organic certification costs – but these are nominal (about Rs. 2500 per annum) and we have built these into the earnings model.

TABLE 11: PRICES OF ORGANIC VS INORGANIC PRODUCE

Sl.No	Fruits	Organic - Chennai Retail Selling Price (Rs per kg)	In Organic - Chennai Retail Selling Price (Rs per kg)	% Diffference
2	Apple	350	130	169%
4	Guava	100	50	100%
8	Mango Alphonsa	180	100	80%
15	Mosambi	125	45	178%
16	Orange	160	45	256%
19	Pomegranate	280	110	155%
20	Sapota	140	25	460%
Average % increase is				**200%**

Based on this, if one takes the base multi-crop pattern of mango + guava + pomegranate, the net earnings of the farmer in Year 5 rises to Rs. 4.4 lakhs compared to the Rs. 1.8 lakhs per annum for the inorganic fruit crop scenario. Correspondingly, the farmer's earnings in Year 10 rises to Rs. 7.5 lakh for organic production compared to the Rs. 3.2 lakh for the inorganic fruit crop scenario (See Tables 9 and 12). So it is evident that moving to organic fruit crops is hugely beneficial to the farmer in the long-term.

It is also pertinent to note that in the case of organic multi-crops, it is likely that the livelihood subsidy that the government would need to provide would come down in both quantum and duration. We would probably need a subsidy for only two years and not three. The quantum would also come down substantially for the second year – needing about Rs. 75,000 in Year 1 (just as in the inorganic fruit scenario), but much lower in Year 2 – Rs. 55,000 (as compared to Rs. 75,000 in the inorganic fruit scenario). (See Tables 10 and 13)

TABLE 12: ORGANIC MULTI-FRUIT CROP MODEL WITHOUT LIVELIHOOD SUBSIDY

Mango + Guava + Pomegranate: Organic farming, without establishment costs, without livelihood subsidy						
Variety	Mango	Guava	Pomegranate			
Trees per Acre	32	75	285			
Years	Return per Crop per Year			Total (Rs)	Expenses per Annum (Rs)	Net Income
1	0	0	0	0	0	0
2	0	13200	27588	40788	20401	20387
3	0	59400	112860	172260	20401	151859
4	21120	99000	235752	355872	38429	317443
5	46464	127050	313500	487014	40225	446789
6	76032	158400	413820	648252	42111	606141
7	140800	158400	413820	713020	44092	668928
8	186120	142560	372438	701118	46172	654946
9	281600	128304	335194	745098	48356	696742
10	387200	115473.6	301675	804349	50649	753700
Total	1139336	1001788	2526647	4667771	350836	4316935
Note	1. Expenses per acre with drip will go up by 5% each year starting from Year 5; certification Cost: Rs. 2500 pa					
	2. Internal rate of return: 41%					

TABLE 13: ORGANIC MULTI-FRUIT CROP MODEL WITH LIVELIHOOD SUBSIDY

Mango + Guava + Pomegranate: Organic farming, without establishment costs, with livelihood subsidy								
Variety	Mango	Guava	Pomogrenate					
Trees per Acre	65	150	88					
Years	Return per Crop per Year			Total (Rs)	Expenses per Annum (Rs)	Income without Livelihood Subsidy	Livelihood Subsidy (Rs)	Net Income with Livelihood Subsidy (Rs)
1	0	0	0	0		0	74988	74988
2	0	13200	27588	40788	20401	20387	54601	74988
3	0	59400	112860	172260	20401	151859		151859
4	21120	99000	235752	355872	38429	317443		317443
5	46464	127050	313500	487014	40225	446789		446789
6	76032	158400	413820	648752	42111	606141		606141
7	140800	158400	413820	713020	44092	668928		668928
8	186120	142560	372438	701118	46172	654946		654946
9	281600	128304	335194	745098	48356	696742		696742
10	387200	115473.6	301675	804349	50649	753700		753700
Total	1139336	1001788	2526647	4667771	350836	4316935		
Note	1. Expenses per acre with drip will go up by 5% each year starting from Year 5; Certification cost: Rs. 2500 pa							
	2. Internal rate of return (%): Not applicable							

ISSUES RELATED TO ORGANIC CULTIVATION

The sale price realization of organic crops is about 50 percent more than the inorganic versions, mostly in metropolitan cities. Consumer awareness to pay discriminative prices for organic products over inorganic ones is inadequate in many parts of India. This problem requires creating of awareness about the benefit of consumption of organic produce. According to the Organic Farming Policy 2005 of the Ministry of Agriculture, it is very important to rationalize the importance of domestic market development. The procedure needs to be simplified. 'Participatory Guarantee System' (PGS) for domestic certification should be extensively operationalized, where there will be interactive participation of small farmers, enterprises, traders and consumers. Therefore, greater government support is required for creating consumer awareness and promotion of organic certification in order to encourage farmers converting to an organic multi-tier fruit crop model.

Based on this, if one takes the base multi-crop pattern of mango + guava + pomegranate, the cumulative income surpasses cumulative cost in the fourth year itself. On the other hand, under the conventional single-crop model for mango, break-even is reached only in the 7th year (See Appendix 6 for details).

Therefore, it is evident that shifting to organic fruit crops is hugely beneficial to the farmer in the long-term. It is also pertinent to note that in the case of organic multi-crops, it is likely that the livelihood support that the government would need to provide would come down in both quantum and duration.

COMPARISON OF MULTI-FRUIT CROP MODEL WITH FIELD CROPS

According to the Center for Agricultural and Rural Development Studies, TNAU, Coimbatore, in riparian farmlands, crops like paddy, sugarcane and banana are generally grown, but the annual income realized by the farmers per acre is around Rs. 50,000 (two crops/year), Rs. 65,000 and Rs. 85,000, respectively (Annexure 12). However, in the multi-fruit crop model, the average net income in the 5th year is 1.83 lakh per annum (Table 7) which is double that of conventional crops mentioned above. This kind of model thus meets the government's aim of doubling the farmers' income. The benefits of the multi-fruit crop model in sustaining the fertility of the soil are tremendous as compared to conventional crops which are known to greatly mine the mineral nutrients.

CONCLUDING NOTE ON THE ECONOMIC MODELS

We took help from multiple sources to gather information about the income potential of multi-fruit crops for farmers. We commissioned a study by a retired Dean of TNAU, Department of Horticulture, to develop multi-fruit crop models (Annexure 12). We gathered details about establishment cost and income for different fruit trees from officials of Department of Agriculture (Appendix 1). We also gathered economic details for various fruit trees from different agro-forestry farmers that work with PGH (Appendix 2).

A simple model of multi-fruit crops is developed for an inorganic farming practice to illustrate how it changes the income scenario for a farmer. **The income calculation for this model is indicative.** The income from multi-fruit crops for any farmer will vary drastically based on the following choices:

- Health of the soil
- Land treatment
- Agro-climatic zone
- Irrigation
- Choice and quality of produce
- Type of farming practice – inorganic /chemical-free
- Market situation

In general, the agriculture and horticulture produce go through erratic changes in yield and market price realization, due to climate variations, soil conditions, market dynamics, sub-variety yield differences, bottlenecks in supply chain management, etc.

In the following section we mark the possible range of incomes from the above proposed model

Horticulture crops: Farmers growing crops like mango, guava, pomegranate, *amla*, *sapota*, coconut and arecanut make an annual income in the range of Rs. 43,000 to Rs 4.8 lakh (Refer Table 14). In general, the horticulture crops give better incomes from the 5th year onwards.

TABLE 14: RANGE OF INCOME FROM VARIOUS FRUIT CROPS

Crop Name	Farm Gate Price Rs / kg	Average Yield per Acre in Tonnes / Year After Year 5	Per Acre Income Slab After 5 Years (In Rs. lakhs)
Mango	15-30	5.0-15	1.5-2.25
Pomegranate	20-50	4.5-12	2.25-4.8
Guava	11-50	5.0-12	0.90-2.5
Sapota	10-15	3.6-21	0.43-2.1
Amla	15-30	3.6-10	0.58-3.0
Coconut	15-28	4.0-4.8	0.70-1.3
Arecanut	20-45	4.5-12	0.90-3.0

- Multi-purpose timber trees: We have studied the economics of 20 different tree species (Refer Appendix 3).
- These trees, in addition to creating timber as asset in the land, also give produce that is in high demand by industries. While the timber starts maturing for harvest from the 12th year onwards, the by-products can be harvested from the 5th year.
- The by-products include the barks, seeds, flowers, gum, etc., which have a good market demand in pharmaceutical, cosmetic, dyeing and food industries.The regular income in this model is about Rs. 2.8 lakhs per acre per annum after the 5th year.
- The timber as asset when calculated with current market prices, is worth about Rs. 32 lakh to 6.3 crore in 15 to 35 years. The harvest can begin from the 15th year. Valuation of the trees gets better with the age of the tree.

The income from timber and non-timber produce was calculated based on the price rates shared with us by Shri Muthuvelayutham of Covenant Centre for Development. While non-timber forest tree produce, like bark, leaf, flower, seed, etc., can provide periodical annual income, timber itself provides for long-term income. A quick return is possible from pulp trees like *Casuarina* with an income of Rs. 320,000 per acre of trees in a 4-year time maturation period with an initial investment of Rs. 35,000 only. (Appendix 3)

BENEFITS BEYOND RIVERS AND FARMERS

It would be pertinent to point out that this solution of providing a green cover in a corridor along the length of the river not only serves to achieve the objective of revitalizing the river, and providing enhanced livelihood to poor farmers, but also goes a long way in helping achieve two other national priorities, as described below.

4 MILLION HECTARES OF GREEN COVER; 13% OF NATIONAL ASPIRATION[51]

While the national aspiration is to have 33% of the land under permanent green cover, as of 2015 only 21.3% is under tree cover. Therefore, India's deficit in tree cover is currently at 30 million hectares.

In that context, bringing tree cover to either side of a 1000 km river line will increase the green cover by 2 lakh hectares. India has a river-line length of around 20,000 km and therefore has the potential of creating an additional green cover on 4 million hectares of land – thereby making a significant 13% impact on the deficit in the overall green cover enhancement target.[52]

IMPROVED HEALTH STATUS OF POPULATION

Fruits and Vegetables (F&V) will improve the health of the larger society in India. India has a dual burden of non-communicable diseases on one end of the spectrum, and malnutrition-related mortality and morbidity, on the other end.

Non-Communicable Diseases (NCD) accounted for at least 50% of all deaths worldwide in 2005 and were projected to increase to more than 60% by 2015. These NCDs include cardiovascular diseases (CVDs), diabetes, cancers and chronic respiratory diseases, the major brunt of which are being borne by developing countries like India.

Poor consumption of F&Vs is one important factor linked with NCDs, which are considered as the sixth main risk factor for mortality in the world. Overall, it is estimated that low F&V intake is attributable to approximately 2.7 million (4.9%) annual deaths and 26.7 million (1.8%) Disability Adjusted Life Years (DALYs), and causes about 31% of Ischaemic Heart Diseases (IHD), 11% of strokes and 19% of gastro-intestinal cancers.

It is still significantly associated (protective) with lung/pharyngeal/laryngeal/oral cancer, type-2 diabetes mellitus, bone-health, vision/cataracts and micronutrient deficiency state.

A global study reported 74% of adults with low F&V consumption in India. The per capita consumption of F&V is low in a majority (above 70%) of population in developing countries like India. A detailed note on the health benefits from consumption of F&V is provided in Annexure 18.

If the production of fruits on riverine farmlands were to go up, there need to be enough advertisements and campaigns to increase the consumption of fruits. The government can take measures to introduce fruits in schools and *anganwadis*, for children and pregnant mothers to begin with.

FINANCIAL BENEFITS OF GREEN COVER [53]

The United States Department of Agriculture's Forest Service estimates that over a 50-year span, a tree generates $ 162,000 in benefits – $31,250 worth of oxygen, $62,000 worth of air pollution control, recycles $37,500 worth of water, and controls $31,250 worth of soil erosion. Tree roots also remove nutrients harmful to water ecology and quality.

MEETING PROMISES TO THE WORLD ON SDGS

India also stands committed to the United Nations' SDGs 2030, that lay stress on 'leaving no one behind'. Since the SDGs break the silos approach in policy paradigm, the river conservation and revitalization policy will address not only SDG 6 (Clean Water and Sanitation) and Goal 15 (Life on Land), but link effectively to all the SDGs particularly Goal 1 (No Poverty), Goal 2 (Zero Hunger), Goal 3 (Good Health and Wellbeing), Goal 5 (Gender Equality), Goal 8 (Decent Work and Economic Growth), Goal 9 (Industry, Innovation & Infrastructure), Goal 10 (Reduce Inequality), Goal 11 (Sustainable City and Communities), Goal 12 (Sustainable Production and Consumption), and Goal 13 (Climate Action). The outcomes of the proposed policy will meet the above goals, thus delivering on the promises we have made to the world.

Chapter 04

CONSERVE AND USE - AN IMPLEMENTATION FRAMEWORK

The initiative to revitalize rivers has to become a nationwide movement in order to bring about lasting change. Revitalization of rivers is not only the responsibility of the government, it is also that of all those who use water. It requires the coming together of all of us as a nation to realize that a river is no more perceived as a commodity, but as an entity that lives, an entity that breathes life into billions of living beings including human beings.

The paradigm of water management that exists today clearly reflects the lack of a perception of rivers being a single entity. Today, rivers are perceived as a source of drinking water, irrigation, as a resource that can be used to produce energy or as a commodity used as an input into the production of all the goods we use – cars, phones, or books. This perception needs to change.

Having revered our rivers at one point in time, we have forgotten this reverence today. It is high time we realize the wisdom in that consciousness - to not abuse something that is fundamental to life but to conserve and use it. We have come to a point where if we exploit our resources any further, it would signal disaster for humankind. Right now, though we may still be reverential towards water, we have come so far from the fundamental wisdom of conserving water in our daily living that, as a community, we no longer seem to know how to go about it.

In this chapter we attempt to bridge this gap that lies between the *idea* of "conserve and use" of rivers and the *actions* needed to make this conservation a way of living for our society. We do this by outlining how each individual in their own capacity – say, as a consumer, an industrialist, or a farmer – can do their bit in revitalizing rivers. We do not see a conflict between ecology and economy. All stakeholders - rivers, farmers, tribals and other traditional communities dwelling in forests, consumers and industry – need to benefit from a policy aimed at revitalization of rivers. We also seek to outline the institutional setup that would be required to support them. While we have a strong legal framework for prevention of water pollution and sand mining in river beds, the regulatory framework for its operationalization is comparatively weak.

In Chapter 3, we detailed out the policy ecosystem preconditions that are required for effective tree plantation on public land and farmland. We identified the conditions required to make the river revitalization plan technically sound, get participation from majority stakeholders, assist behavior change of all the stakeholders involved, and initiate specific economic interventions to de-risk the villages and communities who are asked to change their livelihood patterns. In contrast, the policy ecosystem preconditions that are described in this chapter are seen as essential to the smooth implementation of the river revitalization program, and to achieve the goal of arresting river pollution.

The details of the policy ecosystem preconditions and the mapping of institutions in this chapter were shaped by a Focus Group Discussion (FGD) that was held at Isha Foundation on 27th August 2017. The group of experts that participated in the FGD was drawn from diverse disciplines - hydrogeology, forestry, water resources management, soil science, horticulture, agroforestry, rural livelihoods, agri-business and agri-marketing, public policy and programs, public administration, management and banking and finance. They included senior civil servants, technocrats, bankers, scientists and social scientists, development professionals, civil society leaders and agri-business leaders. A list of experts consulted is provided in Appendix 4 and a report on the FGD is shared in Annexure 20.

Tamil Nadu Agricultural University signed an MoU with Isha Outreach as a knowledge partner to provide technical and scientific support to the draft policy recommendations and plantation models described in this book. Forest College and Research Institute, Mettupalayam; and Horticulture, Agriculture, Crop Planning, Medicinal Plants and Research Departments of TNAU contributed greatly to the detailed approach for implementation outlined in Chapter 3.

REGULATORY FRAMEWORK TO PREVENT AND COMBAT POLLUTION AND MISUSE OF RIVERS

The main legislations to control pollution of water are:

- Water (Prevention and Control of Pollution) Act, 1974; which prohibits the discharge of pollutants into water bodies beyond a defined limit, and stipulates penalties for non-compliance.
- Water (Prevention and Control of Pollution) Cess Act, 1977; which provided for collection of a cess on water consumed by industries and local authorities. The Rules for the Act (1978) defined standards for the meter that every water consumer has to install.

The regulatory framework for water pollution mainly consists of (i) the Central Pollution Control Board (CPCB) which lays down standards for the prevention and control of water pollution, and (ii) the State Pollution Control Boards (SPCB) which work under the direction of the CPCB and the State Government. Both bodies are set up under the Water (Prevention and Control of Pollution) Act, 1974. The resources for their functioning come from the cess collected according to the Water (Prevention and Control of Pollution) Cess Act, 1977. The CPCB and SPCBs are perceived as weak in their functioning due to infrastructure, manpower and financial constraints.

Sand is a minor mineral under the Mines and Minerals (Regulation and Development) Act, 1957 (MMDR Act). The administration of the mining of minor minerals is within the domain of State Governments. The Act specifically provides for legal and administrative control by State Governments over illegal mining, transport and storage of minor minerals. The MMDR (Amendment) Act 2015 has stringent punitive provisions for combating illegal mining. The Union Ministry of Environment and Forests issued Sustainable Sand Mining Management Guidelines in 2016. These guidelines *inter alia* "ensure conservation of the river equilibrium and its natural environment by protection and restoration of the ecological system", and "ensure rivers are protected from bank and bed erosion beyond their stable profile". Kerala has a law to regulate sand mining on river banks and beds, and other states like Tamil Nadu, Karnataka, Andhra Pradesh and Maharashtra have policies for the same. Despite these, destructive sand mining persists due to insufficient institutional framework and enforcement mechanisms and lack of knowledge of suitable alternatives for sand.

The responsibility of management of pollution of rivers lies with the specific state pollution control boards. Pollution seems to happen in spite of specific norms that exist for all point source pollution into the river. The polluted stretches are already marked and noted by the CPCB. There are specific standards mentioned for the Sewage Treatment Plants, which was also revised recently in 2015 by CPCB. To address the pollution and misuse of the riverbeds the following interventions need to be strictly mandated:

- Identification, delineation, and notification of river land: Revitalization of rivers and associated ecosystems can only be possible if the area is demarcated. Along with this, clear responsibilities need to be delineated for any institutional entity that maintains or manages the river to function effectively. An attempt was made to do this through a draft notification on River Regulation Zones, which was not acceptable to some States. (We look at this in more detail later in this chapter.)
- Data on environmental flows: In order to revitalize the life of the rivers, a minimum environmental flow of water till the sea coast must be mandated for every river under the Environment Protection Act, 1986, enough to sustain the flora and fauna in the ecologically sensitive zone along the river.

  The actual estimation of environmental flows to be maintained in rivers is not a simple process, because of the lack of understanding of the relationships between river flows and various components of river ecology. Environmental flows should not only encompass the amounts of water needed, but also when and how this water should be flowing in the river.[3] The assessment of environmental flows in India is still in its infancy. The major limitations in defining environmental flows are: (a) lack of biological data; (b) lack of river morphological data and sediment transport data; and (c) lack of understanding of ecological impacts of flow alteration.[4] These should now become areas of urgent research focus.

- In 2015, the estimated sewage generation in the country was 61,754 MLD. Data on the installed capacity of Sewage Treatment Plants (STPs) shows that only 32.5% of the sewage generated could potentially be treated. If only operational STPs are considered, this further drops to 30.5%. In 41 cities, untreated sewage is being directly discharged into rivers (see Annexure 1). Sewage Treatment Plants need to be set up for all the cities on river banks.

At present very few cities are levying a service charge on households for sewage treatment though charges are levied for the water supplied. Hyderabad Metropolitan Water Supply & Sewerage Board (HMWSSB) is charging a "Sewerage Cess" of 35% as part of water supply charges. But institutions not drawing water from HMWSSB automatically pay no sewerage cess although they generate sewage and may be discharging it into the public sewer lines.

A realistic sewerage cess should be levied on all domestic and commercial/industrial establishments based on the amount of water consumed. This should apply to those connected to the municipal water supply system as well as those using only groundwater.

Sewage Treatment Plants based on Public Private Participation are being introduced in several cities. The sewage pipeline infrastructure is quite old in many cities. While industries can be invited to set up the STP to treat the sewage collected from the existing sewage network, the government can invest in upgrading the existing old sewage pipeline infrastructure to feed into the STPs. The STPs set up by private entities can be spread across various locations of the city based on the city plan. The location and size of STPs for managing city sewage will be specific to the geography, existing sewage network and spread of the city. **This can**

also be one of the key elements of all the Smart City initiatives. Private participation in sewage treatment can be invited so as to use the output as a product of commercial value. To finance this initiative, a sewage treatment tax can be considered. This will contribute to the financial viability of the enterprise.

The mix of centralized and decentralized STPs can be decided based on the city planning. The Town & Country Planning Department in various states have progressively mandated the requirement of STPs for residential areas, to be set up and maintained by them. **All States should consider a regulation that mandates STPs in all new housing/apartment complexes with more than 50 dwellings. Similar regulation can be mandated for any new commercial infrastructure as well.**

- Data from CPCB in 2009 shows that only 60% of industrial waste water, mostly from large-scale industries, was treated. Many industries directly release untreated effluents into the city sewage system or into rivers and other water bodies (refer Annexure 1). Urgent interventions are needed to penalize the industries that let out effluents that do not follow the standards set up by CPCB.
- The textiles (wet processing), molasses-based distilleries, pulp-and-paper industries and tanneries are among the most water-polluting. In March 2015 the CPCB issued notifications to 9 SPCBs of states along the Ganga basin, following which notices were sent to factories asking them to submit action plans for achieving Zero Liquid Discharge (ZLD) or face severe penalties (including shutdown). In 2008, the Tamil Nadu Government had mandated ZLD for all textile wet processing units in Tirupur. As ZLD involves high capital and operating costs, the Union and State Governments had provided grants of more than 50% towards capital expenditure.[7] Industries utilizing river water should be mandated to adopt a Zero Liquid Discharge model with assistance from the Government. This will prevent extra withdrawal of surface water or groundwater.
- Non-point source pollution from agricultural runoff has largely

been unaccounted for and therefore has become a large contributor to pollution into rivers. The main agricultural water pollutants are nitrates, phosphorus, and pesticides. In September 2016, The Ministry of Agriculture & Farmers Welfare signed a Memorandum of Understanding (MoU) with Ministry of Water Resources, Water Development and Ganga Rejuvenation to promote organic farming on the banks of river Ganga. Under the Namami Gange project, organic farming will be developed under the Paramparagat Krishi Vikas Yojana (PKVY) in clusters in 1657 gram panchayats situated along the course of river Ganga starting from Uttarakhand to West Bengal.[8] Similar programs need to be supported on all riverbank agricultural lands.

- Activities such as housing, religious, commercial and industrial buildings need to be prohibited and regulated to ensure that river banks, river bed and floodplains are not encroached upon from now on.
- To avoid the misuse of riverbeds through unsustainable sand mining, the Sustainable Sand Mining Guidelines issued in 2016 by MoEFCC should be operationalized. The Ministry had tasked the District Environment Impact Assessment Authority with monitoring sand mining. The building and construction regulations can mandate the use of alternatives to sand for construction work on areas larger than a prescribed size. Some of the alternatives that have emerged, and which are being promoted by the Bureau of Indian Standards are fly ash, slag, waste from steel industry/thermal power plants/clay brick and tile industry, and quarry dust. Use of manufactured sand or M-sand should also be promoted. Architects and engineers need to be trained on the use of these alternatives.[9]

Rivers are not bound by political boundaries of states or countries. It is necessary that when any regulation or legislation regarding rivers is made, it is done in consultation with the State Governments. There are many laws and regulations in India that govern water bodies. The most relevant ones to rivers are as follows:

1. State Irrigation and Drainage Acts
2. River Boards Act, 1956
3. Inter-state Water Dispute Tribunal Awards
4. The 73rd and 74th Constitutional Amendments
5. The Panchayats (Extension to the Scheduled Areas) Act, 1996
6. The Environmental Impact Assessment Notification, 2006
7. The Water (Prevention and Control of Pollution) Act, 1974
8. The Wild Life (Protection) Act, 1972
9. The Indian Forest Act, 1927
10. The Forest Conservation Act, 1980
11. The Environment Protection Act, 1986
12. The Electricity Act, 2003
13. Maharashtra Water Resources Regulatory Authority Act (2005)

These laws are focused on how to exploit river water for irrigation or agriculture, industry, drinking water and water for other domestic uses. At the time when these laws were made, the focus was largely on utilization of water and not conservation.

The EIA Notification of 2006 and The Water (Prevention and Control of Pollution) Act, 1974 do deal with river water, but the focus is on pollution and not the quantum of water.

The forest and environment protection laws deal with rivers and other water bodies within the overall biodiversity and ecosystem. There is no exclusive focus on rivers as such.

The river is not seen as an entity which provides for the environment, wild life, and human activity. Madhya Pradesh, in a first legislation of its kind, declared river Narmada as a living entity.[10] This change in perception will influence our relatiosnhip with rivers.

Hitherto, the focus has largely been on the supply side: increasing the availability of water for consumption and productive uses, assuming water to be a plentiful resource. This includes the assumption that rivers will always have water to yield. Lately there has been attention on demand management in order to increase the efficiency of water use through pricing and technology. But demand management efforts have been sporadic, and in practice, the supply-side focus has prevailed. We are now realizing that water will not always be freely available in our rivers. It is time for measures to augment inflows into our rivers.

CASE STUDIES ON REGULATORY REGIMES FOR RIVER MANAGEMENT

In this section, we briefly examine successful river regulation regimes outside India.

Most of the countries have set criteria for identifying their own Wild and Scenic/ Heritage/Wild or National Rivers and have meticulously classified activities that can take place in various stretches of these rivers.

Wild and Scenic Rivers Act (1968): United States

The National Wild and Scenic Rivers System was created by Congress in 1968 (Public Law 90-542; 16 U.S.C. 1271 *et seq.*) to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is notable for safeguarding the special character of these rivers, while also recognizing the potential for their appropriate use and development. It encourages river management that crosses political boundaries and promotes public participation in developing goals for river protection.[11]

Based on their characters, rivers are classified as Wild, Scenic and Recreational, with varying management in each of the categories, allowing for varying degrees of development along the river stretches. Most importantly, the Act prohibits federal support for actions such as the construction of dams or other in-stream activities that would harm the river's free-flowing condition, water quality, or outstanding resource values.[12] On March 30, 2010, the U.S. Congress added 1,100 miles of rivers to this Act. Currently, 252 rivers are protected under the Wild and Scenic Rivers scheme.[13]

Canadian Heritage Rivers System (CHRS) 1984

"Canada's outstanding rivers will be nationally recognized and managed through the support and stewardship of local people and provincial, territorial and federal governments to ensure the long-term conservation of the rivers' natural, cultural and recreational values and integrity."

The Canadian Heritage Rivers System (CHRS), is Canada's national river conservation program, established in 1984 by the federal, provincial and territorial governments to conserve and protect the best examples of Canada's river heritage, to give them national recognition, and to encourage the public to enjoy and appreciate them. It is a cooperative program of the governments of Canada, all 10 provinces, and the three territories. CHRS is a Public Trust and participation in the CHRS is purely voluntary.

Interestingly, CHRS not only works with free-flowing rivers, but also on highly developed rivers like the Grand and Ottawa, to conserve their heritage character. Currently, 38 rivers are designated as Heritage Rivers, while six are nominated. These rivers represent Canada's diverse social, cultural fabric and its ecosystems.

Wild Rivers Project, Australia

Wild rivers, found in a variety of Australian landscapes, are rivers that are relatively undisturbed by the impacts of modern development. Biological and hydrological processes continue without major interference in the catchments of these undammed rivers.

A wild river is defined as "a channel, channel network, or a connected network of waterbodies, of natural origin and exhibiting overland flow (which can be perennial, intermittent or episodic) in which:

- the biological, hydrological and geomorphological processes associated with river flow; and

- the biological, hydrological and geomorphological processes in those parts of the catchment with which the river is intimately linked, have not been significantly altered since European settlement."

The Australian Government recognized the importance of wild rivers across the country in 1992 and launched the Wild Rivers Project. It was undertaken by the Australian Heritage Commission and Environment Australia with the assistance of State and Territory agencies and a broad range of stakeholders. The Project set out to identify rivers, encourage protection, engage in voluntary management of the whole catchment and promote the values of wild rivers. It was guided by water resource management and nature conservation agencies, local government, farmers, conservation groups, indigenous people and the scientific community.

Montana, USA[18]

Montana's 1991 Streamside Management Zone (SMZ) law restricts the following activities:

- Clear cutting (removing all or most trees) within 50 feet of a stream, lake, or water body.
- Allowing slash (tree tops, branches) to enter streams, lakes or other water bodies.
- Constructing roads in the SMZ except when necessary to cross a stream or wetland.
- Side-casting soil or gravel into a stream, wetland or watercourse during road construction, grading, and maintenance.
- Operating wheeled or tracked equipment in the SMZ except on established roads.
- Handling, storing, applying or disposing of hazardous or toxic materials in a manner that pollutes streams lakes, or wetlands or causes damage or injury to humans, lands, animals or plants.
- Broadcasting burn in the SMZ (allowing fire to spread through riparian areas).

TABLE 1: DRAFT RIVER REGULATION ZONE NOTIFICATION

Zones	Definition	Prohibited Activities	Regulated & Restricted/ Permitted Activities
Prohibited Activity Zone (RRZ-PA)	*Rivers flowing at less than 300 m elevation until the formation of delta close to sea level* Extent - • River bank upto 500 m from Highest Flood Level (HFL) without embankments • River bank upto 100 m from HFL with embankments • The entire area available on both sides of the river banks for ecologically sensitive areas, National Parks, Wildlife Sanctuary, etc. *Mountain rivers and hill streams: Rivers flowing at elevation between 300 m and 1000 m* Extent - • If slope of hill towards the river exceeds 30 degrees, RRZ-PA shall extend up to a distance of 5 m from HFL. • If slope of hill towards the river is 10-30 degrees, RRZ-PA shall extend up to a distance of 15 m from HFL. • If slope of hill towards the river is less than 10 degrees, RRZ-PA shall extend upto a distance of 50 m from HFL.	*In plain areas as well as mountain rivers and hill streams:* Permanent constructions, construction of new embankments, land reclamation, dumping of solid wasters/creation of landfills, withdrawal/ diversion of water	*Regulated & Restricted* • Construction of strategic importance • Construction of sewage or effluent treatment plants (<5 MLD) • Temporary constructions in case of emergency • Repair and maintenance of existing road/bridges *Permitted* • Traditional organic farming • Traditional capture fisheries • Traditional grazing • Groundwater withdrawal by hand pumps for local use • Discharge of domestic wastewater from cities or towns only after treatment • Purely temporary structures

Restricted Activity Zone (RRZ-RA-I)	*Rivers flowing at less than 300 m elevation until the formation of delta close to sea level* Extent - • Up to 1 km from outer limits of RRZ-PA. (1.5 km from HFL) without embankments • Up to 1.1 km from existing embankment (1.1 km from HFL) with embankments. *Mountain rivers and hill streams: Rivers flowing at elevation between 300 m and 1000 m* Extent - • Up to a distance of 100 m or the crest of the hill, whichever is less, beyond the boundary of RRZ-PA	*In plain areas* • Hazardous waste producing industries and chemical industries. *In mountain rivers and hill streams* • Permanent constructions and dumping of solid waste.	*Regulated & Restricted* • Construction of residential/ institutional/ commercial buildings; schools, dispensaries, recreational facilities, public toilets
Regulated Activity Zone (RRZ-RA-II)	*Rivers flowing at less than 300 m elevation until the formation of delta close to sea level* Extent - • 3 km from outer limits of RRZ-RA-I	*In plain areas* • Hazardous waste producing industries and chemical industries.	*Regulated & Restricted* • All kinds of industries discharging wastewater with toxic pollutants and heavy metals

DRAFT NOTIFICATION ON RIVER REGULATION ZONE (RRZ)

The protection of rivers calls for regulation and prohibition of certain activities in the river bed and its floodplain by demarcation of necessary zones. Unfortunately, India does not have any legislation to protect the free-flowing status of any of its rivers.

The recent attempt to notify a River Regulation Zone (RRZ) has been the first step in providing the kind of attention that rivers need today. In March 2017, MoEFCC had sent a draft River Regulation Zone notification to State Governments seeking their views. The RRZ, which is modeled on the Coastal Regulation Zone (CRZ), proposes to prohibit and regulate activities on the river front and floodplains. It also seeks to have a National River Conservation Authority headed by the Secretary of MoEFCC. The main characteristics of the proposed RRZ are:[19]

- The proposed River Regulation Zones will be under the ambit of the Environment Protection Act, 1986.
- There are three regulatory zones proposed under RRZ, defined differently for rivers flowing at less than 300 m elevation, and for mountain rivers and hill streams:
    1. Prohibited Activities Zone (RRZ-PA)
    2. Restricted Activities Zone (RRZ-RA-I)
    3. Regulated Activities Zone (RRZ-RA-II)

Within each of these zones, there are prohibited, restricted, regulated and permitted activities (see Table 1).

The mooting of this notification in itself is encouraging, but the zones and the size of the zones seem to be not acceptable to the states. The Maharashtra CM has scrapped this zonation as he did not think it benefited anyone,[20] while CM of Odisha Shri Naveen Patnaik finds that this zonation is impractical in his state where the total length of all the rivers put together is 12,000 km.[21] If the suggested norms were to be implemented in Odisha, of the 1,56,000 km^2 area, around 1,08,000 km^2 will end up in the restricted or prohibited zone leaving very little area for development.

The RRZ as an idea is sound, but the zonation seems to be non-implementable in its present form. If a more pragmatic version is implemented all over India to prevent future encroachments on river beds, banks and floodplains, it will have a beneficial impact on rivers.

The plantation of trees on government land and horticulture trees on private farmlands for augmenting inflows into rivers is a more acceptable solution than strict zoning to protect rivers. Though the change in agricultural land use proposed may be slow initially, in the long run it works in every stakeholder's interest. The proposal does not demand any change in ownership of riverside land, but seeks to change the farming pattern from water intensive annual crops like paddy, wheat, sugarcane, etc., to tree-based farming of multi-purpose trees and fruit trees. In this proposal there are not only strategies to ensure that the farmer's income is not affected, but also ways in which the income can be doubled by transitioning from field crop farming to tree-based farming.

Nevertheless, a policy would be required to protect our rivers from further ecologically destructive activities, while supporting agricultural and forest-based livelihoods. An existing policy that can be examined and adapted is that of Eco-Sensitive Zones. The land use around many Protected Areas in India has undergone drastic changes in the recent past, mainly on account of industrial and infrastructure development. To stem this incursion, the Government decided to notify eco-sensitive zones (ESZs), i.e. areas that act as shock absorbers or transit zones. All activities in ESZs are envisioned as regulatory rather than prohibitive. As a general principle, the width of an ESZ is extendable up to 10 km around Protected Areas.

Eco-sensitive zones are notified the Environment (Protection) Act, 1986.[22] Section 3 of the Environment Protection Act and Section 5(1) of the Environment Protection Rules, 1986, empower the Government to restrict areas in which certain industries, operations and processes cannot be carried out or can be carried out only with adequate safeguards. The areas can be chosen based on their biological diversity, maximum allowable concentration of pollutants, environmentally compatible land use, and proximity to Protected Areas. The MoEFCC guidelines to declare ESZs around Protected Areas list prohibited, restricted and permitted activities. At the same time they tell State Governments to convey a strong message to the public that the ESZ is not meant to restrict day-to-day activities, but only to protect their environment from negative impact.[23]

Building on the concept and guidelines of ESZs around Protected Areas and adapting it to river bed/bank/floodplain, the minimum lateral distance of 1 km from the river should be demarcated and declared as an Ecologically Sensitive Zone under the Environment Protection Act, 1986, with do's and don'ts prescribed to protect it.

NODAL AGENCY TO FACILITATE COORDINATED EFFORT – COOPERATIVE FEDERALISM

The recent introduction of the Goods & Services Tax (GST) was an example of co-operative federalism where both the Center and the States gave up some of their tax powers so as to create a unified national market.

River revitalization is rendered complex due to the Constitutional position on water. According to the Constitution of India, water is the 17th entry in the State list. But the governance of inter-state rivers is the 56th entry in the Union list. In reality, rivers do not adhere to political boundaries – out of 25 major rivers in the country, only seven flow within one state. Many rivers are shared between at least two states.

A simple single-point-focused activity of tree plantation along the entire length of the river, in a country as big as India, will involve many organizations. Water being a State subject, there will be a large number of agencies, across different states, which will work on inter-state rivers.

Secondly, the tree plantation effort has as its stakeholders: the river, the forest, farmers, and the larger society. With so many stakeholders and such an elaborate complex legal background, implementation of a project of this kind would require an effective institutional setup, clear roles and responsibilities of various agencies and a framework that facilitates collaboration.

The River Boards Act (1956) was enacted to manage inter-state rivers. The law was passed to manage inter-state rivers with a sense of urgency in 1956 and the stated objective of the River Boards to be formed was to deal with '*matters of the regulation and development of inter-state rivers and river valleys*'.[24]

The functions of the Board included advising State Governments on co-ordination to achieve maximum results in, *inter alia*,

- Conservation, control and optimum utilization of water resources of the inter-state river
- Promotion of afforestation and control of soil erosion, and
- Prevention of pollution of the waters of the inter-state river

Considering the grave threats to our rivers, it would be desirable to have a single managing entity like a River Board for each inter-state river and rivers that flow within single states. A River Conservation Authority at national level as nodal institution for all river boards would also be desirable.

- **For smooth and unhindered implementation**, considering the diverse actors and activities, and the timebound nature of afforestation/plantation interventions, a single window support system housed in the nodal institution would make the implementation of river revitalization very efficient.
- **Information & Communication Technology support, in the form of a Dashboard** could be instrumental in tracking and informing

stakeholders on the progress of implementation. This is already working well for a number of government schemes.

- **A robust management and monitoring plan** is needed to ensure and oversee the implementation of the provisions of the river policy. The institutional structure for integrated river resources management needs careful design and representation of community institutions, PRIs and ULBs, relevant government departments and elected representatives from the State Assembly and Parliament. State Pollution Control Boards and existing river basin-specific organizations like the Bhagirathi River Valley Development Authority, Irrigation Corporations in Maharashtra, Krishna and Godavari River Management Boards, Water Resources Regulatory Authorities (in Maharashtra, Andhra Pradesh, Arunachal Pradesh) need to be integrated in the institutional structure.
- **Convergence across various government bodies:** In the section discussing the role of each stakeholder and the institutions, we list a number of Ministries and their respective departments that need to be engaged to revitalize the rivers. These departments deal with - agriculture, water resources, environment, fisheries, rural development, pollution control, horticulture and others. The stakeholders along with whom these ministries have to work are - farmer organizations, Gram Sabhas and their forest resource management committees, consumer groups, private sector players, NGOs/Community Based Organizations, elected representatives and PRIs. To establish convergence and coordination of all these institutions and the stakeholders is a crucial task. As has been done for various government schemes in the past, there could be a Mission-model body with personnel drawn from relevant departments, reporting to a committee of Secretaries of the relevant departments, and finally answerable to a Group of Ministers of relevant Ministries, chaired by the Chief Minister. A similar co-ordination mechanism drawing on personnel from various State

Governments would be needed for inter-state rivers.

- The importance of river revitalization would need a high-profile co-ordination and oversight body at the Center, such as a Committee of Secretaries reporting to a Group of Ministers answerable to the Prime Minister.
- **Grassroot planning and implementation:** The cutting edge of the program would be at the sub-district level, the block/taluka, the Gram Panchayat, and individual villages/settlements. Panchayati Raj Institutions could be empowered to play a crucial role in promoting the twin strategy of conservation and livelihoods security. But this also depends on the extent of devolution by the State Government to PRIs of powers, functions, funds and functionaries. In many states parallel institutions set up to implement government programs are more salient than say, Gram Panchayats. In general, the Gram Panchayat could be a nodal agency for oversight of village and settlement level planning. A pragmatic approach would be to spearhead implementation with the strongest community-based institutions existing. These could be the Community Forest Resource management committees under FRA in forest areas, Village Watershed Committees (VWC), FPOs and other farmer organizations, Biodiversity Management Committees (BMC), women's SHGs or traditional community institutions.
- Monitoring, evaluation and learning: A multi-faceted program of this kind needs a robust M&E and learning framework. Monitoring has to be both concurrent and periodic. Independent agencies with this role need to be involved from the very inception of the program, at the stage of preparation of the program logical framework and the implementation plan, and subsequently for baseline studies. Learning from the program requires concurrent research on the validity of its basic premise - the impact of community-led afforestation and agro-forestry on river flows and farmer/forest community incomes. Multi- and inter-disciplinary science research

(drawing on hydro-geology, ecology, silviculture and agriculture) and social science research (economics of community forestry and chemical-free agroforestry; sociological research into gainers and losers from program interventions) would feed back into the program, and enrich the disciplines.

ACTORS

FARMERS & ADIVASIS / OTHER TRADITIONAL FOREST DWELLERS

The most important and vulnerable stakeholder in the tree plantation on farmlands on riverside are farmers. A farmer's decision to agree to plant trees in his farmland by replacing his present cash crop either makes or breaks the case for river revitalization. While all the tasks on the farmland in transitioning to and operationalising the new cropping pattern will be his, he will need active government help to make the transition successfully. While various schemes to support the farmer's transition may be offered by the government, finally it will be the farmer who decides whether to enroll himself in these schemes. The farmers will need to organize themselves through the FPOs.

Tribals and other traditional forest-dwelling communities have lived off the forest for millennia. The Forest Rights Act, 2006 has been one of the strongest legal tools that has provided them community rights to manage the forest resource they depend on. The community forest resource management rights provided by this law is central to the implementation of afforestation in forest lands under this program. The tribals and the communities that depend on the forest should be encouraged to plant trees in their community forest area and to adopt a tree based agroforestry model for their lands where individual forest rights are recognized. Their subsistence needs are usually supplemented with wild fruits and other wild products from the forest. Formalization of their already existing association with forest to benefit them economically will ensure they do advance levels of tree farming on their lands where individual forest rights are recognized as well as on lands where CFR management rights are recognized, for products used in agri-business inputs along with fruits. The species chosen will have to be conforming to the local forest ecology. Income from non-timber produce can be substantial and formation of FPOs will help the tribal communities in this direction.

INDUSTRIES

With growing realization of scarcity of water resources and their pollution, industries consortia have been spearheading efforts to make member industries responsible water consumers. There needs to be an internally agreed upon industrial standard in directing the industrial activities of the preexisting industrial setups on the river floodplain. All industries drawing water from rivers should voluntarily transition towards ZLD, and Governments should assist them with technology and finance. The Agri-SEZs that need to be set up for the riverine farmers' produce would have to be incentivized for safe waste disposal and minimum usage of the water in their premises.

PRIVATE TRADE AND MARKETING ENTITIES

As fruit production begins, its sale and realization of value will be important to keep production cycles going. Private organic produce aggregators will be the key to link producers with markets. Where such aggregators are not yet operating, existing trade channels for non-organic fruits will have to be influenced to buy the produce with a price differential. Private retail market players, from supermarket chains and exclusive organic produce outlets to wholesalers supplying to traditional shopkeepers and pushcart vendors, will need to be linked with. Local consumption is to be encouraged through improving the infrastructure and other supports for local *haats* and provision to supply to schools and *anganwadis*. Local production and local consumption will have the potential to reduce the wastage of fruits and thereby stimulating local circulation of wealth

POLITICAL LEADERSHIP

The political leadership in the districts where this river revitalization project will be initiated need to support the farmers in their districts in the transition to tree based farming models. They can be the effective link in ensuring the schemes, the program's farmer-livelihood support transfers and other support systems are made available to their farmers in their district. An important role would be to facilitate linkages between FPOs and consumer markets, and FPO links with Education and Women & Child Welfare departments for supply of fruits for mid-day meals in schools and *anganwadis*.

CITIZEN CONSUMERS OF FRUITS

The important and most crucial stakeholders, just like farmers, are citizens. The citizens need to consume fruits and increase the quantum of fruits consumption in their diet. While it is suggested that the Information and Broadcasting department will do the job of communication and awareness generation on benefits of consumption of fruits, ideally, all consumers must be willing to pay a price that will be agreeable and reasonably profitable to producers. But realistically, depending on the market segment, there will be varying sensitivity to price, quality and convenience of buying. A pro-sumer (producer–consumer) association has to be developed in the local region to build a self-sustaining fruit production and consumption scenario.

We as people can take interest to learn about and participate in the programs that the government initiates to revitalize rivers, in different capacities. This is the way we unknot the legacy of the strained rivers-human relationship. For the solution of tree plantation proposed and detailed in the previous chapter to work, we need to have a clear map of the ideas - actors – institutions. Usage of rain water harvesting and waste water reuse in homes and business premises and factories, will definitely help in demand management

CONSERVE AND USE

A river as a single entity is the point of view of this chapter. The prelude to ecosystem preconditions is that it should be and it has to be looked at as a single living entity and not as a commodity to be exploited. This will set the tone for the ecosystem preconditions. Then ideas and actors will follow.

The *Idea* in the fundamental solution we propose in case of revitalizing rivers is *tree plantation.*

Actors will be all the stakeholders who have to play an active role in implementation of the framework.

Institutions are the agencies that are responsible towards implementing the overall and different segments of the program.

The effective relationship between actors and the institutions in a larger legal framework is the key to a successful implementation of this program. Actors and institutions do overlap. Actors like farmers and communities protecting forests are themselves to be organized into institutions that play a crucial role in implementation. Industries have their own associations.

Figure 1 illustrates the relationship between the ideas-actors and the institutions.

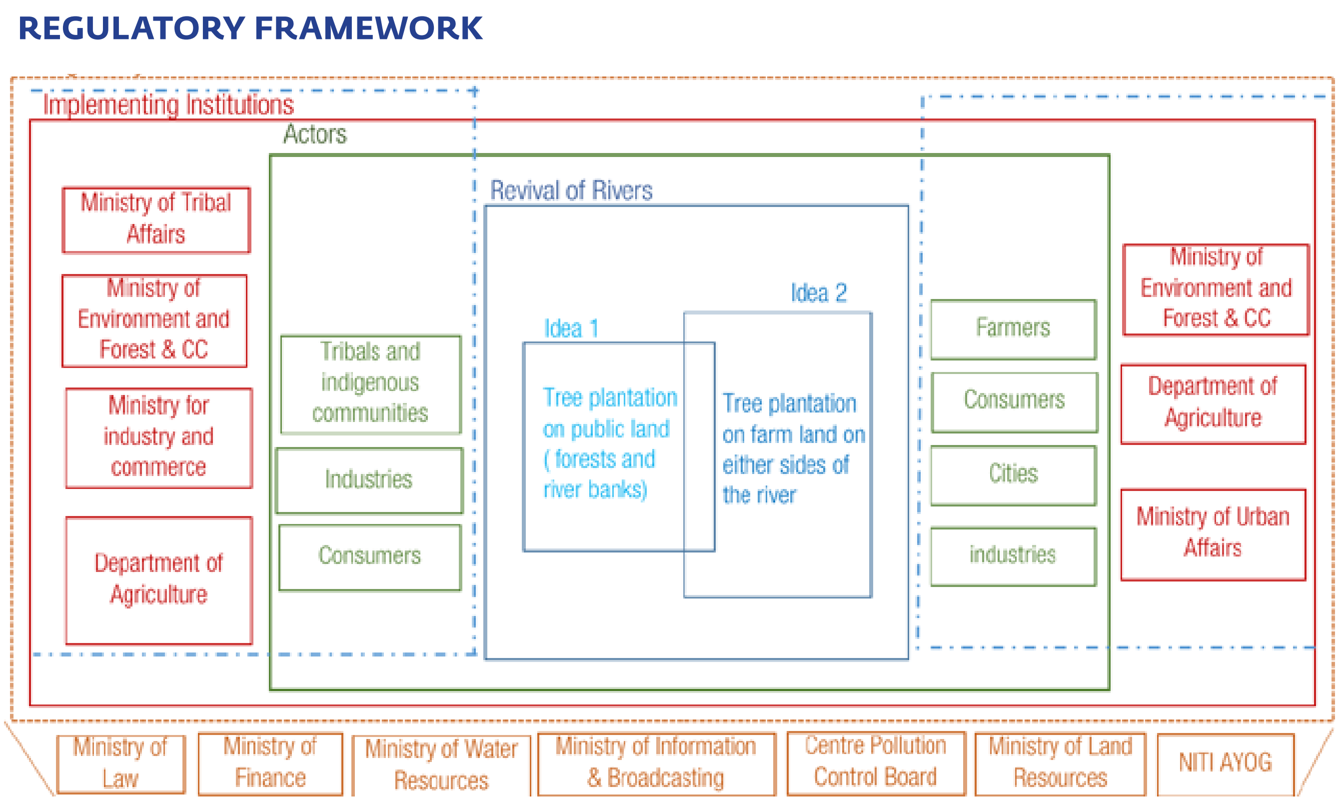


FIGURE 1: MAPPING OF IDEAS - ACTORS - INSTITUTIONS

GOVERNMENT INSTITUTIONS AND THEIR ROLES

The key and most important aspects of the projects lie with the project management and leaders. Bureaucrats are proposed to be the implementation heads of such projects. A primary requirement of an inter-disciplinary project of this kind is coordinated action by bureaucrats in charge of different departments. Tree plantation is a time bound activity and coordination and convergence becomes a mandatory requirement. That is, if the saplings are not planted in the pre-decided time, the money and effort will only be wasted. Once the tree-farming system is set up, on a continuing basis, there has to be co-ordinated action by various institutions to generate products (fruits, timber and NTFP) and market them, and to maintain production systems (soil health, irrigation efficiency, pest control, credit) transport systems (transport infrastructure) and marketing systems (storage and market infrastructure).

FOREST DEPARTMENT

In community forestry on forest land, the Gram Sabha and community forest management institution will be in the forefront of species choice, tree planting and raising, harvesting and trade. Forest departments have to play a crucial facilitative role for QPM, technology, credit, transit, market information and security. The tasks required for plantation across a river's length in the state will involve these tasks:

- Planning the trees for different zones across the length of river.
- Procure seeds of the different set of trees that are planned for both private land and government land.
- Create and develop nurseries with the trees planned for the proposed length of the river.
- Distribute the private land forestry saplings to the agriculture department/ farmers directly.

CREATING INFRASTRUCTURE FOR LARGE-SCALE AVAILABILITY OF SAPLINGS

For 1000 kilometers of river length, assuming 1 kilometer-wide fruit tree belt on 60% of river length (based on the situation in Madhya Pradesh), the total number of fruit saplings (quality planting material - (QPM)) required is estimated to be 12 crore considering 400 plants per acre including allowance for mortality. If fruit tree saplings are raised by grafting, the number of saplings that can be grown in 4 years is roughly 15,000 saplings/acre. About 7500 acres of land will be required merely to raise these saplings. Under forestry plantation, the total number of quality planting material required per stretch of 1000 kilometers of river is estimated to be 8 crore, including multipurpose trees to be planted in farmland. To produce the required QPM, roughly 400 acres of land area with water facility will be required. The capacity of nurseries in the state may need to be strengthened. It is important to develop sufficient infrastructure to produce QPM by organic methods. This will be a critical element for successful implementation of the project. Unlike the horticulture nursery which requires a three-year period for producing sapling by grafting/layering, most of the seedlings of forestry species can be deployed in a year's time.

The actual land required for setting up additional nurseries to produce Quality Planting Material would depend on the existing sapling production capability in the state, and will also depend on the actual scale of riverside plantation achieved on a year on year basis. One would need to identify agro-climatic regions within the state, preferably along the river line, and promote commercially viable nurseries run by village communities as a livelihood initiative for women and women's SHGs. The availability of raw material, at low costs will be a major criterion for selection of these areas.

The production of QPM can be in three phases. In phase 1 right at the beginning of the program, all saplings will have to be purchased from accredited suppliers of QPM. The three years of phase 1 can be used to identify and begin tree nurseries in clusters of villages in the same agro-climatic zone where plantation will take place. In phase 2 and 3, village nurseries can take over sapling production. This will be a livelihood activity for the selected clusters and result in availability of saplings best suited to the agro-climatic zone.

Therefore it is important to develop sufficient infrastructure to produce high quality planting material. This is especially so if we are to make them chemical-free. It is therefore required to evaluate infrastructural capability in this regard in each concerned state. It is also required to strengthen the existing infrastructure of nurseries run by the agriculture, horticulture and forest departments and universities and also accredited private nurseries. There would need to be a focus on supporting community based nurseries to fill the resource gaps in relation to quality planting materials, training of personnel, accreditation and organic certification requirements.

AGRICULTURE DEPARTMENT

In this project, the Forest department and Agriculture department can start the implementation once a detailed Project Report is ready. The Production of the QPM is the most important aspect in the whole program. The respective departments then hold the responsibility to reach out and distribute these saplings to the farmers.

Perhaps the most complex part of the responsibility, involving persistent and sustained engagement, is regarding the behavior and mindset change of the riverine farmers. The required change in mindset is not a simple one as such. We are asking a farmer to move to a completely new system of farming – non-pesticide farming, and also to change the crop to trees that we suggest him or her to grow. This is a huge risk which involves his livelihood. When such a change is proposed the responsibility falls on the agriculture department to de-risk this transition from all quarters, as follows:

- Information and training of riverine farmers on tree plantation through KVKs and other outreach institutions

- Distribution of saplings to the farmer
- Compulsory enrolment of farmers of this program into crop and livestock insurances
- Compulsory micro-irrigation facility to provide to all riverine farmers through PMKSY
- Institutionalization of the farmers through FPOs in the riverine belt
- Setting up of Agri-SEZs to manage the produce from the tree plantations along the length of the river.
- Train FPOs in managing and running the Agri-SEZ units
- Provide financial compensation for the tree plantation farmers in the early years to address the notional loss of income from the transition
- As fruit production begins in large quantity, the State Agriculture Produce Marketing Board will assume importance as it has to maintain all Government markets efficiently.
- In many States, Government civil supplies outlets that stock and sell fruits will have to be linked with FPOs.

ENSURING ADEQUATE SUPPLY OF WATER FOR DRIP IRRIGATION

It is vital for the farmer to have an assured water supply, or an assured source of water to bring up their crops. The need to ensure this has been articulated in the government initiative called the Pradhan Mantri Krishi Sinchayee Yojna (PMKSY) where every farmer's irrigation requirement is addressed as Har Kheth Ko Pani. The PMKSY also promotes drip irrigation practices called 'Per Drop More Crop' ensuring judicious usage of water thereby bringing down the overall demand for water.

FACILITATING MOVEMENT FROM INORGANIC TO ORGANIC HORTICULTURE

Non-point source or diffused sources of pollution that join the river from agricultural run-off, comprising chemical fertilizers and pesticides, have remained largely unaddressed. Not only do these pollutants cause severe river pollution, they also pose significant health and environmental risks. However, an effective mechanism to control/ tackle the same is yet to be devised. While organic farming needs to be encouraged and promoted among the farming community as a short term measure, the use of chemical fertilizers and pesticides needs to be phased out in a time-bound manner for a long term solution in coordination with the Ministry of Agriculture and Ministry of Chemicals and Fertilisers. **Framing of necessary legislation and effective implementation may also be considered necessary in this regard**. If legislation is to be initiated, support for organic farming inputs and livelihood support have to start first, along with widespread dissemination of the plan to bring in a law.

Conversion of organic waste into compost, use of livestock dung and urine and bio fertilizers for use as manure for agriculture purpose are to be promoted so that the agricultural land will become fertile and also reduce non-point source pollution coming through use of fertilizers and pesticides.

This is an imperative given the substantially higher earnings of the farmer. This movement towards chemical-free horticulture will also go a long way in bringing down the pollution in rivers due to agro-chemicals. The key tasks required to make this happen are:

- Training and hand-holding of farmers in relation to chemical-free farming practices would be required especially in the initial few years.In this context the role of livestock and biomass from trees in the farm towards self reliant farming is crucial for increasing the net income from the farm.

- Identification and creation of model farms and farmers in each Panchayat/block is a critical requirement for the farmer to transition to the proposed agri-horti-forestry model.
- Facilitation of organic certification of produce through group certification by third parties or through the Participatory Guarantee System (PGS) is to be considered. This certification will play an important role in securing higher price realization for the farmer. The government will need to build the institutional capability to support certification of organic farm produce.
- In an ideal scenario the government should facilitate the movement from inorganic to organic directly. However, given the ground realities, there may be a need to consider a phased approach of moving from inorganic to non-pesticide management in the first phase, and from there moving to using an organic package of practices.

ORGANIZING SALE OF PRODUCE, SUPPORT WITH BRANDING, AND ENSURING PRICE STABILITY

As a result of this large scale movement to production of fruit crops on river banks there will be a substantial increase in the supply of fruits compared to the current market size in India – and this will be especially so if the movement is towards organic fruit crops as recommended by this proposal. The key tasks required to make this happen are:

- Need institutionalization of the farmers via an appropriate Farmer Producer Organization (FPO). One of the key challenges of the farming community in India is its lack of organization. By facilitating organization of farmers through FPOs, the government can provide and implement schemes to these large groups seamlessly. This also gives farmers the strength to participate in markets, as their graded and aggregated produce will now become substantial in quantity. The FPO with the aggregated produce, as an entity, will be capable of raising capital to invest in ventures that can engage in production of value added products and bargain for better price realization.

- There is another large opportunity to leverage the FPO infrastructure to create a unified 'brand'. There are many potential benefits of building a unified national organic brand:
- Building a brand could be an important way of enhancing price realization for farmers, and ensuring price stability. Creating a brand is a particularly relevant idea in the context of organic produce – because the brand could, over a period of time, come to provide the consumers an assurance in relation to the truly organic nature of the produce.
- The organic produce market in the country is in an early stage of development, so this would be a good time to create such a brand with a relatively good early mover advantage.
- A unified national organic brand would be a relatively cost-effective way of directing marketing expenditure to build a stable consumer franchise.
- A brand would also allow for an easier upgradation to more value-added products in relation to the food-processing industry.
- Lastly, it is quite possible that one would have to develop export markets for the organic produce – given that the organic consumption trends in the more developed parts of the world are well ahead of the trends in India. Again a brand would be vital to tap into these export markets.
- Finally the government has a wonderful precedent with NDDB milk federations and the creation of the Amul brand. Learnings can be taken from here and suitably contextualized and evolved.
- As part of developing the market for organic fruits, the government would have to take purposive steps to encourage the building up of a food processing industry and a cold chain in close proximity to the

major nodes of organic farm production. As an increasing number of farmers take to fruit cultivation and get organized into FPOs, the role of the state in fostering farm-industry linkages will come into sharp political focus. Development of this infrastructure and the linked cold chain would also be a necessary pre-requisite to tap into the large export market for organic produce. Facilitating export sales could play a strong role in ensuring domestic price stability in spite of the rapidly increasing supply of organic farm produce.

- Hub and Spokes Model for Mega Food Parks

  The processing units being the hub, the pre-processing centers being the spokes at cluster level, and the collection centers the spokes at village level, the village level and cluster level operations is envisaged to be managed by FPOs, while the main processing unit is to be managed by industry. There needs to be a guaranteed buyback arrangement from industry so that the farmers are not at the mercy of the market for their produce.

WATER RESOURCE DEPARTMENT/ RIVER MANAGEMENT BOARD

There are river management boards for some major rivers, but otherwise rivers as water bodies are governed by water resource departments across most states. These departments are responsible for allocation of water from the river and the type of activities that happen in and around the rivers. The responsibility of this department will be to ensure that the activities of tree plantation on the riverine floodplain are supported and other activities that undo the efforts of tree plantation are restricted. These include:

- Not permitting any new industrial activity to start on the project area
- Allocating water from the river, based on the flows of the previous year
- Managing and allocating the quantum of water so that environmental flow of the river is addressed

WOMEN AND CHILD HEALTH DEPARTMENT

When the fruits are to be produced all across the private land on the floodplains of rivers, there is going to be a substantial increase in the quantity produced. This newly available quantum of fruits needs to be consumed. If the consumption of these fruits is not ensured, it will add to the already high wastage of fruits in India. Along with this issue there exists the larger scenario of malnourishment of children in this country. There is a scenario where these probable problems can become a solution for each other.

Synergy may be achieved by Riverine Farmer FPOs officially tying up with the respective Women and Child Development Ministry and the Departments of Education, for regular supply of fruits for anganwadi and mid-day meal programs of schools. A policy of serving only organic produce in school and anganwadi mid-day meals may also be considered.

INFORMATION AND BROADCASTING MINISTRY

The project we have proposed is economically viable, environmentally sustainable and technically feasible. But many projects with such vision have failed to achieve their objectives. This is due to the fundamental problem of communication. When a project like this, which aims to revitalize a river, has a byproduct of production of fruits in huge quantities, such voluminous supply needs to be met through consumer demand. This needs public interest advertising, promoting consumption of fruits as a health message, which can be facilitated by the Information and Broadcasting Ministry. Promoting organically produced fruits alone can also be considered both on health grounds and to support organic fruit farming.

This department can also be used to motivate the farmers and help them get information regarding the riverine tree plantation. The department should compile and broadcast program productions to the farmers and consumers through the different mediums available to the department at their disposal – radio, TV, Kisan TV and all others available to them.

Other agroforestry multi-purpose trees grown on farmland have the potential to augment the income of the farmer from the sale of timber and non-timber produce. The necessary farmer-friendly change in transit regulation for cutting and sale of timber will encourage the farmer to go in for planting such multi- purpose trees in his farm. A business model envisaging a tie-up from industry for non-timber produce through FPOs as contract farming, will provide stability of farm income and can be a win-win situation to FPOs and industry.

CONVERGENCE OF GOVERNMENT DEPARTMENTS: NEED FOR A SINGLE WINDOW FOR FARMERS

- The convergence of various state departments and other organizations has to be oriented towards the goal of livelihood enhancement. It is vital to offer the farmer a single window for interacting with the government. It is also imperative to build online platforms for delivery of these benefits and services to farmers in an efficient, transparent, and quick manner.
- This whole initiative therefore has to be developed not as a project but as a program encompassing multiple streams of projects, where different aspects of this model are effectively managed. Therefore, the sub-projects in the program have to be aligned to the different departments and other organizations and monitored centrally by involving an appropriate level of authority. In other words,

the program is to be designed as a convergence model involving different schemes implemented by different implementing agencies/ government departments. The following are the government departments which will need to work in a convergent way at the state level to support fruit tree cultivation on private land and community forest resource management on forest land:

- Animal Husbandry
- Extension
- Animal Health
- Livestock Insurance
- Public Works Department
- Irrigation
- Agriculture
- Horticulture
- Nursery
- Sustainable Organic Agriculture
- Organic Certification
- Agricultural Marketing
- Agriculture Extension – KVK
- Facilitation of FPO Formation
- Forest Department
- Territorial Forestry Division
- Working Plan Division
- Social Forestry and Extension
- Environment Department
- Forest Policy Division
- Forest Management
- Nurseries
- Minor Forest Produce
- State Compensatory Afforestation Fund Management and Planning Authority (State CAMPA) – Steering Committee & Executive Committee

- Fisheries
- Departments of Panchayati Raj and Rural Development
- Watershed Management
- Department of Tribal Affairs/Tribal Welfare & Social Welfare
- Revenue Department
- Department of Financial Services
- National Agricultural Insurance Scheme (NAIS)
- Department of School Education
- Department of Women & Child Development
- Department of Food & Civil Supplies
- Planning, Economics and Statistics Department
- Culture and Tourism
- State Remote Sensing and Environment Center
- State Pollution Control Board
- Small Farmers Agri-Business Consortium (SFAC)
- NABARD
- Nationalized Banks
- Agriculture Universities
- Department of Sustainable Agriculture
- Animal Husbandry
- Department of Animal Husbandry
- Horticulture Department
- NGOs & NGO Networks
- Training and hand-holding farmers in chemical-free farming practices
- Facilitation of FPO formation and establishment
- Guidance for getting community forest resource rights recognized
- Support for community forest resource planning, management & marketing; partnerships & institutional arrangements

Financial support is needed for land use change to agro-horti-forestry by farmers and for community forest resource management. These are from a range of different government departments as enumerated below:

- Drip irrigation - Agriculture Engineering Department – 'More Crop Per Drop' (PMKSY)
- Rainwater harvesting structures – Agriculture Engineering
- Fruit tree crop establishment – National Horticulture Mission
- Crop loans through kisan credit card – Agriculture Department
- Crop insurance – Pradhan Mantri Fasal Bima Yojna
- Livestock insurance – Department of Animal Husbandry, Ministry of Agriculture
- Labor costs which are not covered in the above-mentioned schemes can be covered by NREGS
- Livelihood subsidy/loan from the appropriate Government department
- Loan from Tribal Development/MFP Department/Corporation for initial MFP gathering costs
- Loan from co-operative/nationalized banks for MFP processing & marketing

MAPPING – ACTORS AND INSTITUTIONS

A simple project with a single mandate of tree plantation on parts of the river floodplain along the entire river's length requires substantial amount of work to be done by the stakeholders of the project. This chapter looks at the scope of the actors and their responsibilities towards revitalizing the rivers.

FARMER

Table 2 details the activities that the farmers have to engage in and the support that has to be provided by the owner institution.

Farmer Activities	Owner Institution: Department of Agriculture and Farmer Welfare
Become aware of tree-based agro-forestry proposed for riverside farms	Conduct trainings on agro-forestry models for farmers through KVKs and other extension mechanisms. Identify and create model farms and lead farmers in each Panchayat/block. Arrange exposure visit to successful farmers in the region to change the mindset of the farmer
Learn about Non-Pesticide Management (NPM)	Use National Mission on Sustainable Agriculture and train and build skillset of farmers to move from pesticide to non-pesticide farming.
Transition to tree-based farming	Livelihood support to compensate the notional loss in income during the transition period. Work with local research organizations to identify native and endemic species specific to the agro-climatic zone that will suit the river floodplain and also be economically viable. Provide training on intercropping with trees, fodder and staple crop specific to agro-climatic zone of farmer.
Adopt NPM and eventually no chemical farming	Facilitate training from departments/NGOs to move from chemical to NPM and eventually to organic farming.

Avail crop and livestock insurance	Set up easy to use online platforms for farmers to enroll in river revitalization programs and avail insurance. Enroll all farmers in the target area for mandatory crop and livestock insurance.
Implement Micro-irrigation	Tie up with banks for zero percent loan/subsidy to help farmers access micro-irrigation technology like drip irrigation. Collaborate with Ministry of Water Resources in specific areas when this is rolled out.
Learn about and set up FPOs	SFAC, under the Department of Agriculture is mandated to help identify and set up FPOs based on produce. Local NGOs can be used to support FPOs in the initial years of setting up. Facilitate group certification of farmers who grow produce under NPM or organic methods, based on the farmers' choice. Facilitate industrial tie-up for produce from FPOs.
Initiate grading and pre-processing activities	Facilitate FPOs to set up infrastructure for preliminary value-addition in terms of cleaning, grading and pre-processing. Use NABARD funding to conduct administrative activities of FPOs. Set up cold storages and warehouses to store goods to reduce wastage and get better prices.

TRIBAL AND OTHER TRADITIONAL FOREST-DWELLING COMMUNITIES

The Ministry of Tribal Welfare is the owner institution that will support the activities of tribals and other traditional forest dwellers. But as the land that is being worked on is forest area, the Ministry of Environment, Forest and Climate Change should support the activities.

Activities by Tribal and Indigenous Communities	Owner Institution: Ministry of Tribal Welfare Supporting Institution: Ministry of Environment, Forest and Climate Change
Become aware of the tree-based river revitalization project	Provide detailed information on the tree-based river revitalization intervention
Learn how it will affect the community	A clear role for the community has to be decided with respect to the trees planted in the reserve area.
Participate in the decision making of the species to be planted	The choice of trees in the reserve forest should be indigenous and endemic to the forest. It should be decided in collaboration with local forestry experts and considering the hydrological condition of the aquifer.
Get trained in producing and collecting tree-based raw materials	NGOs help farmers organize into FPOs and tie-up with agri-businesses NGOs support community forest resource planning, management & marketing; partnerships & institutional arrangements
Become aware of tree-based agro-forestry proposed for riverside forest land where individual rights are recognized	Conduct training on agro-forestry models for farmers through KVKs and other extension mechanisms of the Departments of Agriculture and Tribal Welfare Involve and collaborate with the Ministry of Information and Broadcasting Involve local NGOs working with the communities to bring awareness about riverside tree plantation.

Learn about Non-Pesticide Management	Use the National Mission on Organic Farming and train and build the skillsets of farmers to move from pesticide to non-pesticide farming.
Learn about and set up FPOs	SFAC, under the Department of Agriculture is mandated to help identify and set up FPOs based on produce. Accredited NGOs in the region can support FPOs in the initial years of setting up. Facilitate group certification of farmers who grow produce under NPM or organic methods, based on the farmers' choice. Facilitate industrial tie-up for produce from FPOs.
Transition to tree-based farming	Livelihood support to compensate the notional loss in income during the transition period. Work with local research organizations to identify native and endemic species specific to the agro-climatic zone that will suit the river floodplain and also be economically viable. Provide training on intercropping with trees, fodder and staple crop specific to agro-climatic zone of farmer.
Adopt NPM and eventually no chemical farming	Facilitate training from departments/NGOs to move from chemical to NPM and eventually to organic farming.
Processing/value addition and marketing	Facilitate FPOs to set up infrastructure for preliminary value-addition in terms of cleaning, grading and pre-processing. Use NABARD funding to conduct administrative activities of FPOs. Set up warehouses to store MFP to reduce wastages and get better price Provide market information and facilitate price discovery, facilitate fair auction and prevent cartelized/monopsonic buying

CONSUMERS

At present, fruit consumption in the country is woefully low. An individual on an average consumes less than 60 grams of fruit every day. However, the prescribed quantity by WHO is 300 grams. In the proposed agro-forestry model proposed fruit trees are suggested for monthly and seasonal incomes. If the farmers have to move from a water-intensive paddy or wheat to a fruit tree, they have to be able to see profits. For this to happen there needs to be demand for their produce and also a fair price realization. This needs work from the Ministry of Information and Broadcasting, the Department of Food and Civil Supplies and the Department of Agriculture to connect the producer to the consumer. Annexure 18 describes the health benefits of consuming fruits.

Activities by Consumers	Owner Institution: Department of Agriculture Supporting Institution: Ministry of Information and Broadcasting
Become aware of where the food on their plate comes from	Awareness camps in Resident Welfare Associations by Department of Agriculture Create and broadcast ads on health and fruits over different mediums – Radio, TV, WhatsApp groups and other social media platforms Repeatedly telecast ads and other media content about farmers and what they do to get food on our plates. This should evoke respect for farmers in people's hearts.
Become aware of the nutritional value of fruits	Create ads, documentaries and animations on fruits and how important they are for health. Repeatedly telecast ads and other media content promoting eating fruits and their benefits Special focus on organically produced fruits

Know your farmer	Organize weekly farmer markets like weekly haats and broadcast about them on radio and other media that are specific to cities. Encourage people to visit. Organize exposure visits to the farms around a city. Link farmers and consumers by organizing farmer groups to give presentations to city audiences.
Children and pregnant women should consume fruits	Facilitate FPOs to tie up with anganwadi and heath care workers of the villages. Give fruits as part of mid-day meal, preferably organically grown Work with the Department of Education and Department of Women and Child Welfare to facilitate this.
Become willing to pay for fruits	Awareness campaigns about what it takes to produce fruit, value chain of the produce, and why organically grown fruits tend to cost more.
Buy directly from farmers of FPOs	Department of Agriculture can develop an app to aggregate the locations of all farmers and FPOs. This can be used by consumers to locate farmers and directly transact with them.

INDUSTRIES

The relationship of industries with the forest, rivers and the farming community will have a huge impact on the quality of work done to revitalize rivers. Industries play two important roles in the revitalization of rivers:

- As the primary water user and effluent generator.
- As buyers of produce from tree farmers.

INDUSTRY AS A WATER USER

Although the industrial sector uses a lot less water (15%) than agriculture, they still account for a substantial quantum of water (~100 Billion Cubic Meters) usage in the country.

Activities by Industries (as a water consumer)	Owner Institution: Ministry of Industry and Commerce Supporting Institution: Central Pollution Control Board and Ministry of Water Resources
Use water efficient technologies for industrial activity	Efficient water use standards specific to sectors and activities must be developed. All industries must be mandated to adopt water efficient technologies. Incentivize efficient use of water. Disincentivize inefficient use of water. Work with Water Utility Boards, Ministry of Water Resources to evolve a monitoring protocol across the project area.
Harvest rain water in the industrial premises	Mandate Rainwater Harvesting (RWH) in all industrial establishments. Disincentivize industries who do not have RWH on their premises.
Treat effluent to acceptable standards before releasing into rivers or other water bodies	Heavy penalties to be levied by State Pollution Control Boards on industrial units discharging raw effluents into rivers. Facilitate interest-free loans or subsidies to set up effluent treatment plants in the unit. E.g. Tirupur incentivized effluent treatment plants, reducing pollution in the Noyyal River. Incentivize industries that treat effluent. Incentivize industries that reuse the treated effluents within the units. Industrial development boards should collaborate with State Pollution Control Boards to routinely monitor and implement measure to mitigate pollution.

INDUSTRY AS A MARKET FOR AGRO-FORESTRY PRODUCE

The entire premise of enhancing the farmer's livelihood is the transition from producing staples to perishable fruits and other tree-based produce. Getting the farmers to change their crop pattern is possibly the simpler part. All these years, the assumption has been that markets will emerge to buy a commodity that is produced in substantial quantity. But what pans out usually is a market glut, leading to farmers dumping their produce in the farm itself, to avoid even transportation costs. At the same time, the horticulture sector is still not saturated and the food processing industry is growing at a 13% growth rate.[25] In India we process only 4% of fruits and vegetables produced. There is a large potential for futher processing. The activities that need to be done by industries to realize this potential are as follows:

Activities by Agribusiness Industries (as a market to fruits and other tree-based products in target areas)	Owner Institution: Ministry of Industry and Commerce Supporting Institution: Department of Agriculture
Identify and tie-up with specific FPOs that can provide raw materials to industry	Department of Agriculture to maintain a database of FPOs and produce details. SFAC or other local NGOs to facilitate tie-ups with industries Ministry of Industry to help agri-businesses set up 'mega food parks' for aggregation of produce from various FPOs.
Help install farm technologies in the farmer's land	Department of Agriculture to help set up micro-irrigation technologies in the farms in tie-up with ndustries. Provide on farm assistance to monitor and ensure good quality of produce.
Have buy back arrangement and guaranteed price payment on the date of delivery	The companies which express interest in a particular type of produce to FPOs and farmers, should have a buyback arrangements and offer a guaranteed price. Department of Agri-Marketing can take an active role in setting up the Industry-FPO/Industry-Farmer tie-ups. NGOs can play a key role in creating and facilitating the tie-ups.

URBAN SETTLEMENTS

Urban settlements with dense populations in small areas stand second as water polluters. Only less than 30% of the sewage generated gets treated. Stringent actions need to be taken to reduce the discharge of untreated sewage from urban settlements into rivers.

Secondly, urban areas have diverted water from rivers for domestic use, and also over-exploited their groundwater. Urban Local Bodies should mandate measures for water demand management.

Activities by Urban Local Bodies	Owner Institution: Ministry of Urban Affairs Supporting Institution: State Pollution Control Boards
Set up effluent treatment norms for housing complexes. Independent STPs to be mandated in housing complexes based on number of houses	City municipal authorities should develop Sewage Treatment Plant capacities and standards of effluent treatment based on their population density. State Pollution Control Boards must help implement these standards and monitor the households/communities for compliance. Incentives and dis-incentives in the form of reduced property tax and penalties for violators should be followed to ensure STPs are set up. Collect charges for treating sewage generated by households and industrial establishments. Set up independent STPs if the number of households in the housing complex are more than 50 in number. Levy fines on housing complexes that do not set up STPs and link to the existing sewage system of the city.

Rainwater harvesting to be mandated in all households and housing complexes.	To a good extent this has been incorporated in building norms in many cities like Chennai and Bangalore. It needs strengthening in all cities.
Water metering and revision of water billing slabs and sewerage charges	Water bills across most parts of the country are a flat bill given to each household. Water meters need to be installed and water should be billed based on usage rather than flat bills. There is a quantum of water that is designated as lifeline water, which a person will need to meet his basic needs. Water billing should be based on consumption slabs with progressively increasing per liter rates, to curtail the wasteful use of water. Sewage billing of households that are connected to the city network needs to be initiated. The city should mandate paying sewage bills for both domestic and commercial purposes.

GENERIC IMPLEMENTATION PLAN

A river-wise specific revitalization action plan would need to be prepared by conducting detailed surveys, investigations and studies of the individual river, beginning from the origin to the termination point. These studies and investigations would need to be carried out based on a firmed up Terms of Reference document (ToR). Hydrological data for the last 40-50 years, contour maps, inventorization of wetland, catchment area, floodplain, rural and urban settlements, extent of use of fertilizers, agricultural lands and cropping pattern, socio-economic status, etc., would have to be studied and will have to form the basis for a concrete and implementable River Action Plan.

The activities that are enumerated for tree plantation based river revitalization need to be implemented with financial and time implications. It will be prudent to introduce a project of this kind as a Public Private Partnership, taking into account various financing models including gap funding, annuities and design –build-operate (DBO) models. The cost sharing can be done between the Center and State Governments. The Companies Act 2013 mandates companies to allocate 2% of their profit to Corporate Social Responsibility activities. This available CSR funding can be used towards revitalizing rivers too.

To develop an implementation plan for working on any good stretch of rivers, it will be useful to conduct a detailed pre-project baseline study and develop an implementation plan that is specific to a river. A generic list of activities that need to be conducted to develop a detailed implementation plan are:

1. BASELINE STUDIES

a) Water budget

b) Land use – land cover pattern analysis (LULC)

c) Demography

d) Land-holdings and current farming practices

e) Industries and Municipalities

2. IDENTIFICATION OF TECHNICAL INSTITUTIONS AS KNOWLEDGE PARTNERS

3. SOLUTION DESIGNING FOR PRIVATE LAND

a) Develop a tree plantation plan for private land on either side of rivers

b) Identify the government departments that have to support the farmers through the transition from annual crops to tree-based crops

c) Identify agro-forestry and horticulture schemes under the Horticulture Department

d) Identify the subsidies under different schemes to help adopt micro-irrigation in all the farms in the project area

e) Preparing and strengthening farmers

4. SOLUTION DESIGN FOR GOVERNMENT LAND

a) Identification of specific forest species for government land

b) Purchase of Quality Planting Material (QPM)

c) Institutional setup

d) Overall project outlay for the government

5. THE WAY FORWARD

a) Institutionalization of farmers into FPOs along the river segment

b) Crop and livestock insurance

c) Tie-up with industries to establish forward linkages

d) Incentives to ensure sustainability beyond the subsidy period

e) Approximate budget for working on a river

FINANCING RIVER REVITALIZATION PROGRAMS

There is also a need to pool resources from various programs of the Central Ministries of Environment, Forest and Climate Change (MOEFCC), Urban Development, Drinking Water and Sanitation, Agriculture and Farmer Welfare and Ministry of Water Resources, River Development and Ganga Rejuvenation as well as the State Governments, and ensure implementation of afforestation, environmental flow, wetland conservation, promotion of efficiency in agriculture, scientific studies, etc., to revitalize rivers.

Some of the major schemes that can support the implementation of the tree plantation program to revitalize rivers are:

1. IMPORTANT SCHEMES:

(a) Mission on Integrated Development of Horticulture (MIDH)

(b) National Mission on Sustainable Agriculture (NMSA)

(i) Paramparagat Krishi Vikas Yojana (PKVY)

(ii) Sub-Mission on Agro-Forestry (SMAF)

(c) Pradhan Mantri Fasal Bima Yojana (PMFBY)

(d) Pradhan Mantri Krishi Sinchai Yojana (PMKSY)

2. OTHER RELATED SCHEMES OF RELEVANCE:

(a) NMAET - National Mission on Agricultural Extension & Technology

(b) RKVY – Rashtriya Krishi Vikas Yojana

(c) NFSM - National Food Security Mission

(d) SAGY - Saansad Aadarch Gram Yojana

(e) CAMPA Funds – based on Compensatory Afforestation Fund Act, 2016

Annexure 22 provides the objectives and available finances of each scheme mentioned above.

INDICATIVE BUDGET FRAMEWORK

The government, through its ministries and departments, is graduating into outcome-based budgeting. Following from this, we have presented an indicative budget framework in Appendix 6. We have fine-tuned our outcome-based budget framework to the limited level of the program we are proposing. We have divided the program into three sub-programs, which contain all activities that are required to meet the common objective of each, and an indicative budgetary framework is laid out.

These sub-programs are:

Creation of awareness: For any policy to be successful, it is important to generate awareness about three things – 'Situation, Complication and Solution.' The situation in this case is the consistent degradation of rivers in the country; the complication is the impossibility of agriculture and life if the rivers are not revitalized; and the proposed solution is afforestation. Clear communication of policy objectives will not only create an acceptance for the proposed policy intervention but will also help in obtaining the support of the general masses and stakeholders, which is crucial to any successful policy.

Afforestation: The plantation of trees is the crux of the program. This budget lays out the activities that need to be undertaken for achieving afforestation in three different contexts – state-owned land, land owned by farmers, and land owned by forest dwellers. Furthermore, this is a long process and has been divided into a pre-plantation phase, which ideally begins as soon as the government accepts the program. The second phase is the plantation period, which, depending on the tree variety, may take between 1 and 3 years to materialize. Post-plantation, there are some regulatory functions that need to be performed on an on-going basis.

Creation of agro-based industry: The strength of this model is its systems approach. It looks at rivers as a system of biodiversity, and approaches its revitalization through the revitalization of all its facets.

Organic afforestation helps in refilling of aquifers and catchments while causing minimum water pollution. Similarly, the economy of the project is also analyzed through a systems approach. The afforestation drive will lead to high-quality produce of fruits. However, it is equally important for this produce to find its way to the market at fair prices. Only then will the economic loop get closed. For this reason, we have envisaged the creation of a vibrant agro-based industry with significant participation of farmers through Farmer Producer Organizations (FPO). The third budget lays down the activities for this sub-component.

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Appendices

APPENDIX 1

DR. S. MANOHARAN, DEPUTY DIRECTOR, DEPARTMENT OF AGRICULTURE, TAMIL NADU

Crops		Fixed Cost (Rs)			Variable Cost (Rs)		
	Seedling per acre	Seedling	Field preparation	Drip irrigation	Manures	Labour	Plant protection
Guava	300-350 @ Rs, 70 per plant	23,000	5,000	15,000	10,000	50,000	5,000
Mango	300-350 @ Rs, 60 per plant	20,000	5,000	15,000	10,000	50,000	5,000
Sapota	120 @ Rs, 60 per plant	7,800	5,000	10,000	10,000	50,000	5,000
Amla (Gooseberry)	450 @50 per plant	22,500	5,000	15,000	10,000	50,000	5,000
Pomegranate	700@30 per plant	21,000	5,000	17,000	10,000	50,000	5,000
Ber (for Dry lands)	190 @50 per plant	19,500	5,000	10,000	10,000	50,000	5,000

Variable cost given to the maximum and may be reduced depending upon the availability of family labour.

ECONOMICS OF VARIOUS FRUIT CROPS

					Climatic requirement		
Total (Rs)	Standard yield after	Av.yield tons /year	Price/ kg (Rs)	Income (Rs)	Rainfall mm	Soil pH	Water EC
108,000	3	12	25	300,000	600-700	6-8.2	<1.5
105,000	3	15	15	225,000	500-600	6-7.8	<1.0
87,800	4	8	15	120,000	500-600	6-8.8	<2.0
107,500	4	10	30	300,000	400-500	6-8.8	<2.0
108,000	2	12	40	480,000	600-700	6.7.5	<1.0
99,500	4	5	15	75,000	400-500	6-8.0	<1.0

APPENDIX 2

PROJECT GREEN HANDS, COIMBATORE, TAMIL NADU

No	Crops	No of Sapling per Acre	Establishment Cost (Rs)	Maintenance Cost (Rs)	Harvesting Cost (Rs)	Protection Cost (Rs)
1	Mango	80	10,000	20,000	10,000	40,000
2	Guava	160	17,600	20,000	40,000	77,600
4	Lemon	168	26,000	30,000	30,000	86,000
5	Sapota	70	10,000	20,000	30,000	60,000
6	Gooseberry	190	11,400	20,000	40,000	71,400
7	Arecanut	800	24,000	35,000	*	59,000
8	Coconut	75	11,000	20,000	*	31,000
9	Tender coconut	75	26000	25000		51000

Notes: *
Harvesting done by buyer

Crops	Yield per Acre	Protection Cost (Rs)	Income (Rs)	Net Income (Rs)
Paddy/ short	1500 kg	30,000	53,000	23,000
Paddy/ Long	2000 kg	32,000	71,000	39,000
Banana	800 nos	35,000	200,000	165,000
Turmeric	2000 kg outern	125,000	160,000	35,000
Sugarcane	50 tons	130,000	300,000	170,000*
Sugarcane	50 tons	55,000	110,000	55,000**

Notes:
*Sugarcane converted to jaggery in farm
** Sugarcane sold to sugar factory

ECONOMICS OF VARIOUS CROPS OF PROJECT GREEN HANDS FARMERS

First Yield	Income (Rs)	5th Year Yield	Income (Rs)	10th Year Yield	Income (Rs)	Farm Gate Price (Rs)
2,000kg/4th	60,000	5,000 kg	150,000	10,000 kg	300,000	30 / Kg
1,800 kg/ 2rd year	90,000	5,000 kg	250,000	6,000 kg	300,000	50 / Kg
900 kg/3rd year	45,000	6,500 kg	325,000	10,000 kg	500,000	50 / Kg
7,000 kg	70,000	21,000	210,000	28,000	280,000	10 / Kg
10,000 kg	150,000	10,000	150,000	15,000	225,000	15 / Kg
8,000kg /4th year	200,000	16,000	400,000	20,000	500,000	25 / Kg
3750 no	37,500	9000 /no	90,000	10500/no	105,000	10 / nut
7500 no	150000	22500	450000	26000	520000	20

APPENDIX 3

PROJECT GREEN HANDS, COIMBATORE, TAMIL NADU

Crops	Sapling per Acre	Distance	Establishment Cost per Acre (Rs)	Drip Irrigation Cost (Rs)	Maintenance Cost per Year (Rs)	Harvesting Cost per Acre (Rs)
Teak wood	300	12 x 12	20,000	20,000	1,500 x12 =18,000	By merchant
Sandal + support tree 100	300	12 x 12	30,000	20,000	1,500 x12 =18,000	by Govt
Red sandal	300	12 x 12	20,000	20,000	1,500 x12 =18,000	by Govt
Mahogany	300	12 x 12	20,000	20,000	1,500 x12 =18,000	By merchant
Vengai	300	12 x 12	20,000	20,000	1,500 x12 =18,000	By merchant
Rose wood	300	12 x 12	20,000	20,000	1,500 x12 =18,000	By merchant
Malaivembu Timber	300	10 x 10	20,000	20,000	1,500 x12 =18,000	By merchant
Malaivembu Plywood	400	10 x 10	20,000	20,000	1,500 x12 =18,000	By merchant
Malaivembu Pulp	400	10 x 10	20,000	20,000	1,500 x12 =18,000	By merchant
Perumaram	300	12 x 12	10,000	no irrigation	500 x12 =6,000	By merchant
Venkadambu	400	12 x 12	20,000	20,000	1,500 x12 =18,000	By merchant
Acacia mangium	400	10 x 10	10,000	no irrigation	500 x12 =6,000	By merchant
Kumil	300	12 x 12	20,000	20,000	1,500 x12 =18,000	By merchant
Casuarina	3200	3 x 3	35,000	30,000	500 x12 =6,000	By merchant
Karumaruthu	300	12 x 12	20,000	20,000	1,500 x12 =18,000	By merchant
Neem	300	12 x 12	20,000	no irrigation	500 x12 =6,000	By merchant
Poovarasu by cuttings	300	12 x 12	20,000	no irrigation	500 x12 =6,000	By merchant

ECONOMICS OF TIMBER AND NON-TIMBER FOREST PRODUCE

Year of Harvest	Yield per Tree	Yield per Acre	Rate (Rs) per cu. Feet per Kg per Ton	Farm Gate Price per Tree (Rs)	Farm Gate Price per Acre (Rs)
20- 25 years	12 cu feet	3,600 cu feet	per cu. Feet 1,500	18,000	5,400,000
30 - 35 years	20kg heart wood	6,000 kg	per kg 10,500	210,000	63,000,000
25 - 30 years	30kg heart wood	9,000 kg	per kg 3,000	90,000	27,000,000
15 - 20 years	12 cu feet	3,600 cu feet	per cu. Feet 1,500	18,000	5,400,000
20 - 25 years	12 cu feet	3,600 cu feet	per cu. Feet 1,000	12,000	3,600,000
30 - 35 years	12 cu feet	3,600 cu feet	per cu. Feet 2,500	30,000	9,000,000
15 - 20 years	12 cu feet	3,600 cu feet	per cu. Feet 900	10,800	3,240,000
7 - 8 years	500 kg	200 tons	per ton 7,000	3500	1,400,000
4 - 5 years	250 kg	100 tons	per ton 5,500	1375	550,000
5 - 6 years	150 kg	45 tons	per ton 4,500	2250	675,000
5 - 6 years	150 kg	60 tons	per ton 7,000	1050	420,000
5 - 6 years	150 kg	60 tons	per ton 7,000	1050	420,000
10- 12 years	.75 tone	225 tons	per ton 7,000	18,000	5,400,000
4 years	12.5 kg	40 tons	per ton 8,000	-	320,000
20- 25 years	12 cu feet	3,600 cu feet	per cu. Feet 1,500	18,000	5,400,000
20 years	12 cu feet	3,600 cu feet	per cu. Feet 600	7,200	2,160,000
20 years	12 cu feet	3,600 cu feet	per cu. Feet 1,100	13,200	3,960,000

APPENDIX 3

PROJECT GREEN HANDS, COIMBATORE, TAMIL NADU

Establishment Cost Details		
S. No	Item	Cost (Rs)
1	Breakdown of cost per tree	
(a)	Sapling cost	10
(b)	Manure cost	10
(c)	Pit digging labour	15
(d)	Planting cost	10
	Total cost per tree	45
2	Tree Establishment Cost (Rs 45 x 400 trees / acre)	18,000
3	Ploughing Cost	2,000
4	Drip irrigation Cost	20,000
	Total	40,000

ECONOMICS OF NON-TIMBER FOREST PRODUCE

N. MUTHUVELAYUTHAM, THE COVENANT CENTRE FOR DEVELOPMENT, MADURAI, TAMIL NADU

S. No	Crops	Botanical Name	Sapling per Acre	Year of Harvest	Farm Gate Price per Tree (Rs)	Farm Gate Price per Acre (Rs)	Bark Harvest after 5 Years - Yield / Tree in Kg	Income Rs / Kg	Annual Income (Rs)
1	Teak wood	Tectona grandis	30	20- 25 years	18,000	540,000	0	0	0
2	Sandal Wood	Santalum album	30	30 - 35 years	210,000	6,300,000	0	0	0
3	Mahogany	Swietenia mahagoni	30	15 - 20 years	18,000	540,000	20	100	60,000
4	Rose wood	Dalbergia latifolia	30	30 - 35 years	30,000	900,000	0	0	0
5	Malai Vembu	Melia dubia	30	7 - 8 years	3,500	105,000	0	0	0
6	Kumil	Gmelina arborea	30	10- 12 years	18,000	540,000	20	100	60,000
7	Pooarasu	Thespesia populnea	30	15 - 18 years	20,000	600,000	15	10	4,500
8	Neer Marudu	Terminalia arjuna	30	35 - 40 years	50,000	1,500,000	20	100	60,000
9	Neem	Azadirachta indica	30	18 - 20 years	10,000	300,000	6	40	7,200
							15	10	4,500
10	Ashoka	Saraca asoca	30	No felling	0	0	20	150	90,000
11	Fodder Trees		100	No felling	0	0	0	0	0
Total Insurance value created + Annual Income until harvest						11,325,000			286,200

Comparison of Income from Various Crops Suitable in the Flood Plain Areas				
Sl. No	Crop Name	Farm Gate Price Rs / Kg	Avg Yield per Acre in Tons / Year after Year 5	Income Slab per acre after 5 Years (Rs, lakhs)
1	Paddy	Rs 19 to 25	3 tons	0.57 to 0.75 Lakhs
2	Banana	Rs 16	12 tons	2 Lakhs
3	Turmeric	Rs 80	2 tons	1.6 Lakhs
4	Sugarcane	Rs 2.2	50 tons	1.1 Lakhs
	Average Income of regular cash crops commonly grown			
1	Mango	Rs 15 to 30	5.0 to 15 tons	1.5 to 2.25 Lakhs
2	Pomegranate	Rs 20 to 50	4.5 to 12 tons	2.25 to 4.8 Lakhs

APPENDIX 4

PARTICIPANTS AT THE FOCUS GROUP DISCUSSION ON RALLY FOR RIVERS ISHA YOGA CENTRE, 27 AUGUST 2017

No	Experts Name	Institution	Designation
1	Ajay Rastogi	Foundation for Contemplation of Nature, Ranikhet, Uttarakhand	Founder Director
2	Ambrish Kumar IAS	Government of Rajasthan	Settlement Commisioner & Director Land Records
3	Anandi Iyer	Fraunhofer-Gesellschaft India	Director
4	Deepak Srivatsava, IFS	Forest College Research Institue, Mettupalayam	Dean
5	Dr M. Kannan	Tamil Nadu Agricultural University	Head - Dept. of Floriculture
6	Dr Lakshmi Lingam	Tata Institute of Social Sciences, Mumbai	Professor
7	Dr Rajendra Singh	Tarun Bharat Sangh, Alwar, Rajasthan	Director
8	Dr Saravanan		Soil Scientist
9	Dr Sunesh Sharma	Himmotthan- an Associate Organization of Tata Trusts	Project Officer
10	Dr Swayamprabha Das		Development Professional
11	Dr P. Thambidurai	Amrita University, Kollam, Kerala	Assistant Professor
12	Dr R.M. Vijayakumar	Tamil Nadu Agricultural University	Head - Dept. of Fruit Tree Cultivation
13	N Muthuvelayutham	CCD - The Covenant Centre for Development, Madurai	Founder
14	P. Narendra Babu		Freelance Consultant and Natural Resources Governance Expert

PARTICIPATING EXPERTS

No	Experts Name	Institution	Designation
15	Ram Mohan Mishra IAS	Govt of Meghalaya	Principal Secretary
16	S.T. Patil	Water and Land Management Institute (WALMI)	Director (Retd)
17	P.V.S Surya Kumar	NABARD, Mumbai	CGM – Business Initiatives Department
18	S.S Vaseeharan	NABARD	DDM, Coimbatore
19	Vishwanath Giriraj IAS	Government of Maharashtra	Additional Chief Secretary (Expenditure) – Department of Finance
20	Praveena Sridhar		Environmental Engineer and Public Policy Professional
21	Cdr Lakshmanan Iyer (Retd)	Anantha Naturals Pvt. Ltd., Coimbatore	Director
22	Rajesh Ramakrishnan	Isha Foundation	Volunteer, Development Professional
23	R. Ethirajalu	Isha Foundation	Project Advisor – Project Green Hands
24	Anand Ethirajalu	Isha Foundation	Coordinator – Project Green Hands

APPENDIX 5

INTRODUCTION

The economics of a multi-tier multi crop system in horticulture is always more attractive than horticulture mono-cropping. This will be shown in this section through calculations for one such model – Mango-based Multi-fruit Intercrop System.
In the case of the Mango-based Multi-fruit Intercrop System, the top canopy will be mango, followed by guava and then pomegranate. Chapter 3 has the plantation details of this system. As can be seen from the data in succeeding paragraphs, both the payback period and the cumulative income are far more attractive compared to monocrop of any one of the fruit trees.

All the calculations shown are for 1-acre models for organic processes based on the Zero Budget Natural Farming (ZBNF).

MANGO-BASED MULTI-FRUIT INTERCROP SYSTEM

COST DETAILS

Sl. No	Particulars	Details	Cost (Rs)
A	Establishment cost (1st year)		
A1	Sapling cost for border planting	(300 Banana, 14 Jamun,152 timber and fodder slips)	₹ 8,000
A2	Planting material for fodder cum mulch trees (Agathi and Gliricidia) for a length of 230 m along the border for about 152 trees (3mx3m)		₹ 2,000
A3	Ploughing& Rotavator - 2 hours	(2 hrs x ₹ 600 / hr)	₹ 1,200
A4	Soil application of Ganajeevamirtham@400 kg/acre	(1 B type x ₹ 250)	₹ 250
A5	Sowing mulch crop	(50 kg seeds x ₹ 40 / Kg)	₹ 2,000
A6	Incorporation of mulch	(Labour ₹ 600 + Fuel ₹ 300 + Brush cutter ₹ 300)	₹ 1,200
A7	Pit making	(1 cubic feet size) for main field for about 400 pits	₹ 2,500
A8	Drip system instalation		₹ 53,000
A9	Sapling cost for fruit crops	(32 x ₹ 80) + (75 x ₹ 50) + (285 x ₹ 60), Including transportation cost	₹ 23,410
A10	Seedling dipping with Beejamirtham		₹ 1,200
A11	Pit digging for border crops as per lay out	(5hrs JCB @ Rs.700/hr)	₹ 3,500
A12	Labour costs for planting (border + main field) as per lay out		₹ 7,000
	Sub Total		₹ 1,05,260

COST-BENEFIT ANALYSIS OF MANGO-BASED MULTI-FRUIT INTERCROP SYSTEM

Sl. No	Particulars	Details	Cost (Rs)
A13	Overhead expenses (@ 10%)		₹ 10,526
	Total establishment cost		₹ 1,15,786
B	Rainwater Harvesting		
	Total rainwater harvesting costs		**10,000**
C	Maintenance costs (2nd & third year)		
C1	Weed management through power tiller twice /year		₹ 2,400
C2	Jeevamirtham through drip	Labour cost + Maintenance – 12 times	₹ 3,600
C3	Spraying of growth promoters	(6 sprays –@ ₹ 400 / spray)	₹ 2,400
C4	Plant protection sprays	(2 sprays – @ ₹ 400 / spray)	₹ 800
C5	Supplemental mulching, Harvesting pomegranate and guava – labour costs		₹ 7,000
	Total maintenance costs (2nd & 3rd year)		**16,200**
D	Maintenance costs (after three years with increased labour costs)		
D1	Pruning costs	@ ₹ 25 /tree for 400 trees, once in 2 years	₹ 5,000
D2	Weed management through power tiller once /year		₹ 1,500
D3	Jeevamirtham through drip –12 times	Labour cost + Maintenance	₹ 2,000
D4	Spraying of growth poromoters	(8 sprays –@ ₹ 600 / spray)	₹ 4,800
D5	Plant protection sprays	(4 sprays – @ ₹ 600 / spray)	₹ 2,400
D6	Supplemental Mulching (sowing and incorporation)		₹ 2,200
D7	Harvesting (10 A types 20 B types)		₹ 11,000
D8	Additional labour for earthing up, mulching and maintenance		₹ 4,000
	Total maintenance costs (after 3 years)		**32,900**

Notes:
Cost of cultivating annual vegetable intercrops during first two years not included.

APPENDIX 5

LOSS OF INTEREST ON INVESTMENT

Loss of Interest on Investment (Without subsidising cost on drip system)						
Year	Estimated Cost with Drip (Rs)	Interest / Year (Rs)	Cumulative Interest (Rs)	Interest on Cumulative Interest (Rs)	Total Cost (Rs)	Cumulative Cost (Rs)
1	₹ 1,15,786	₹ 8,105	₹ 8,105	₹ 0	₹ 1,23,891	₹ 1,23,891
2	₹ 16,200	₹ 1,134	₹ 9,239	₹ 567	₹ 17,901	₹ 1,41,792
3	₹ 16,200	₹ 1,134	₹ 10,373	₹ 647	₹ 17,981	₹ 1,59,773
4	₹ 32,900	₹ 2,303	₹ 12,676	₹ 726	₹ 35,929	₹ 1,95,702
5	₹ 32,900	₹ 2,303	₹ 14,979	₹ 887	₹ 36,090	₹ 2,31,793

Loss of Interest on Investment (After subsidising cost on drip system)						
Year	Estimated Cost with Subsidy on Drip (Rs)	Interest / Year (Rs)	Cumulative Interest (Rs)	Interest on Cumulative Interest (Rs)	Total Cost (Rs)	Cumulative Cost (Rs)
1	₹ 62,786	₹ 4,395	₹ 4,395	₹ 0	₹ 67,181	₹ 64,071
2	₹ 16,200	₹ 1,134	₹ 5,529	₹ 308	₹ 17,642	₹ 81,713
3	₹ 16,200	₹ 1,134	₹ 6,663	₹ 387	₹ 17,721	₹ 99,434
4	₹ 32,900	₹ 2,303	₹ 8,966	₹ 466	₹ 35,669	₹ 1,35,103
5	₹ 32,900	₹ 2,303	₹ 11,269	₹ 628	₹ 35,831	₹ 1,70,934

RETURNS CALCULATIONS

Returns from ZBNF Mango (Intercropped at 10.8 x10.8 m spacing; 32 trees /acre)					
Age (Years)	Yield / plant (Kg)	Yield / Acre (Kg)	Returns (Rs)	Cumulative Returns (Rs)	Returns / Tree (Rs)
4	10	320	₹ 9,600	₹ 9,600	₹ 300
5	20	640	₹ 21,120	₹ 30,720	₹ 660
6	30	960	₹ 34,560	₹ 65,280	₹ 1,080
7	50	1600	₹ 64,000	₹ 1,29,280	₹ 2,000
8	60	1920	₹ 86,400	₹ 2,15,680	₹ 2,700
9	80	2560	₹ 1,28,000	₹ 3,43,680	₹ 4,000
10	100	3200	₹ 1,76,000	₹ 5,19,680	₹ 5,500

Notes:
1. Sale price estimated as ₹ 30 / Kg in 1st year of yield
2. An increase is assumed in procurement cost every year

COST-BENEFIT ANALYSIS OF MANGO-BASED MULTI-FRUIT INTERCROP SYSTEM

Returns from Guava (Intercropped at 75 plants /acre)					
Age (Years)	Yield / plant (Kg)	Yield / Acre (Kg)	Returns (Rs)	Cumulative Returns (Rs)	Returns / Tree (Rs)
1	5	375	₹ 3,000	₹ 9,600	₹ 40
2	20	1500	₹ 12,000	₹ 21,600	₹ 160
3	40	3000	₹ 27,000	₹ 48,600	₹ 360
4	60	4500	₹ 45,000	₹ 93,600	₹ 600
5	70	5250	₹ 57,750	₹ 1,51,350	₹ 770
6	80	6000	₹ 72,000	₹ 2,23,350	₹ 960

Notes:
1. Sale price estimated as ₹ 8 / Kg in 1st year
2. An increase is assumed in procurement cost every year

Returns from Pomegranate (Intercropped at 285 plants /acre)					
Age (Years)	Yield / plant (Kg)	Yield / Acre (Kg)	Returns (Rs)	Cumulative Returns (Rs)	Returns / Tree (Rs)
1	0	0	₹ 0	₹ 0	₹ 0
2	1	285	₹ 12,540	₹ 12,540	₹ 44
3	4	1140	₹ 51,300	₹ 63,840	₹ 180
4	8	2280	₹ 1,07,160	₹ 1,71,000	₹ 376
5	10	2850	₹ 1,42,500	₹ 3,13,500	₹ 500
6	12	3420	₹ 1,88,100	₹ 5,01,600	₹ 660

Notes:
1. Sale price estimated as ₹ 40 / Kg in 1st year
2. An increase is assumed in procurement cost every year

APPENDIX 5

COST-BENEFIT COMPARISON

Cost-Benefit Analysis from Mango Based Multi Fruit Intercrop System (Rs)							
Year	Mango	Guava	Pomegranate	Total	Cumulative Returns*	Cumulative Costs	
						With Drip	Without Drip
1	₹ 0	₹ 3,000	₹ 0	₹ 3,000	₹ 3,000	₹ 1,23,891	₹ 64,071
2	₹ 0	₹ 12,000	₹ 12,540	₹ 24,540	₹ 27,540	₹ 1,41,792	₹ 81,713
3	₹ 0	₹ 27,000	₹ 51,300	₹ 78,300	₹ 1,05,840	₹ 1,59,773	₹ 99,434
4	₹ 9,600	₹ 45,000	₹ 1,07,160	₹ 1,61,760	₹ 2,67,600	₹ 1,95,702	₹ 1,35,103
5	₹ 21,120	₹ 57,750	₹ 1,42,500	₹ 2,21,370	₹ 4,88,970	₹ 2,31,793	₹ 1,70,934
6	₹ 34,560	₹ 72,000	₹ 1,88,100	₹ 2,94,660	₹ 7,83,630		
7	₹ 64,000	₹ 72,000	₹ 1,88,100	₹ 2,94,660			
8	₹ 86,400						
9	₹ 1,28,000						
10	₹ 1,76,000						
Cumulative returns per crop	₹ 5,19,680 (in 10 years)	₹ 2,88,750 (in 6 years)	₹ 5,01,600 (in 6 years)	₹ 7,83,630 (in 6 years)			

Notes: *
1. Returns from timber and fodder crops are not included
2. Returns of cultivating annual vegetable intercrops during first two years not included
3. Returns from yield from fruit trees along border is also not included
4. Breakeven is obtained in the 4th Year itself. Additional income from Sl. 1, 2, 3 above is not factored here.
5. Cumulative returns obtainable under monoculture of mango crop in 10th year is surpassed in 7th year itself under intercrop system

COST-BENEFIT ANALYSIS OF MANGO-BASED MULTI-FRUIT INTERCROP SYSTEM

(ONLY) MANGO 1-ACRE MODEL CALCULATIONS:

COST DETAILS

S. No	Particulars	Details	Cost(₹Rs)
A	Establishment cost (1st Year)		
A1	Raising fodder (Agathi, Subabul) and mulch trees (Gliricidia) for length of 250 m along the border 100 trees (3mx3m)		₹ 2,000
A2	Ploughing & Rotovator - 2 hours	(2 hrs x ₹ 600 / hr)	₹ 1,200
A3	Soil application of Ganajeevamirtham @ 400 kg/acre	(1 B type x ₹ 250)	₹ 250
A4	Sowing mulch crop	(50 kg seeds x ₹ 40 / Kg)	₹ 2,000
A5	Incorporation of mulch	(Labour ₹ 600 + Fuel ₹ 300 + Brush cutter ₹ 300)	₹ 1,200
A6	Pit making	(1 cubic feet size) @ 10x10m spacing - 50 pits - JCB	₹ 1,200
A7	Drip system instalation		₹ 45,000
A8	Sapling cost	(50 Nos x ₹ 80 per sapling)	₹ 4,000
A9	Seedling dipping in Beejamirtham		₹ 200
	Sub Total		₹ 57,050
A10	Overhead expenses (@ 10%)		₹ 5,705
	Total establishment cost		**62,755**
B	Rainwater Harvesting		
	Total rainwater harvesting costs		**10,000**
C	Maintenance Costs (2nd & 3rd Year)		
C1	Weed management through power tiller twice /year		₹ 2,400
C2	Jeevamirtham through drip	Labour cost + Maintenance - 12 times	₹ 2,400
C3	Spraying of growth poromoters	(6 sprays -@ ₹ 200/ spray)	₹ 1,200
C4	Plant protection sprays	(2 sprays - @ ₹ 300/ spray)	₹ 600
C5	Supplemental Mulching		₹ 2,000
	Total maintenance costs (2nd & 3rd year)		**8,600**

APPENDIX 5

S. No	Particulars	Details	Cost(₹Rs)
D	Maintenance Costs (After three years with increased labour costs)		
D1	Pruning costs	₹ 25/tree for 50 trees/ once in 2 years	₹ 1,250
D2	Weed management through power tiller twice /year		₹ 2,000
D3	Jeevamirtham through drip	Labour cost + maintenance - 12 times	₹ 3,000
D4	Spraying of growth poromoters	(6 sprays -@ ₹ 250/ spray)	₹ 1,500
D5	Plant protection sprays	(2 sprays - @ ₹ 300/ spray)	₹ 800
D6	Supplemental Mulching (sowing and incorporation)		₹ 2,200
D7	Harvesting (2 A type + 3 B types)		₹ 1,900
D8	Additional labour for earthing up, mulching and maintenance		₹ 3,000
	Total maintenance costs (after 3 years)		**15,650**
	Grand total		**97,005**

RETURNS CALCULATIONS

Returns for Monoculture of Mango					
Age (Year)	Yield (Kg/ Tree)	Yield / Acre	Returns (Rs)*	Cumulative Return (Rs)	Annual Returns / Tree (Rs)
4	10	500	₹ 15,000	₹ 15,000	₹ 300
5	20	1,000	₹ 33,000	₹ 48,000	₹ 660
6	30	1,500	₹ 54,000	₹ 1,02,000	₹ 1,080
7	50	2,500	₹ 1,00,000	₹ 2,02,000	₹ 2,000
8	60	3,000	₹ 1,35,000	₹ 3,37,000	₹ 2,700
9	80	4,000	₹ 2,00,000	₹ 5,37,000	₹ 4,000
10	100	5,000	₹ 2,75,000	₹ 8,12,000	₹ 5,500

Notes: *
1. Sale price estimated as ₹30 / Kg
2. 10% increase in procurement price every year assumed

COST-BENEFIT ANALYSIS OF MANGO-BASED MULTI-FRUIT INTERCROP SYSTEM

COST-BENEFIT COMPARISON

Costs-Benefit Comparison (Rs)							
Year	Estimated Cost with Drip (Rs)	Interest / Year (Rs)	Cumulative Interest (Rs)	Interest on Cumulative Interest (Rs)	Total Cost (Rs)	Cumulative Cost (Rs)	Cumulative Returns (Rs)
1	₹ 62,755	₹ 4,393	₹ 4,393	₹ 0	₹ 67,148	₹ 67,148	₹ 0*
2	₹ 8,600	₹ 602	₹ 4,995	₹ 350	₹ 9,552	₹ 76,699	₹ 0*
3	₹ 8,600	₹ 602	₹ 5,597	₹ 392	₹ 9,594	₹ 86,293	₹ 0*
4	₹ 15,650	₹ 1,096	₹ 6,692	₹ 468	₹ 17,214	₹ 1,03,507	₹ 15,000
5	₹ 15,650	₹ 1,096	₹ 7,788	₹ 545	₹ 17,291	₹ 1,20,798	₹ 48,000
6	₹ 17,000	₹ 1,190	₹ 8,978	₹ 628	₹ 18,818	₹ 1,39,616	₹ 1,02,000
7	₹ 17,000	₹ 1,190	₹ 10,168	₹ 712	₹ 18,902	₹ 1,58,518	₹ 2,02,000
8	₹ 17,000	₹ 1,190	₹ 11,358	₹ 795	₹ 18,985	₹ 1,77,503	₹ 3,37,000
9	₹ 18,700	₹ 1,309	₹ 12,667	₹ 887	₹ 20,896	₹ 1,98,399	₹ 5,37,000
10	₹ 18,700	₹ 1,309	₹ 13,976	₹ 978	₹ 20,987	₹ 2,19,386	₹ 8,12,000
Breakeven point: 7th year							

Note:
Returns start after year 4.

APPENDIX 5

YIELD & RETURNS CALCULATIONS FOR OTHER MONOCULTURE PLANTATIONS:

GUAVA MONOCULTURE

Returns from Guava (as pure crop system; 172 plants / acre)				
Year	Yield / Plant (Kg)	Yield / Acre (Kg)	Returns (Rs)	Returns / Tree (Rs)
1	5	860	₹ 6,880	₹ 40
2	20	3440	₹ 27,520	₹ 160
3	40	6880	₹ 61,920	₹ 360
4	60	10320	₹ 1,03,200	₹ 600
5	70	12040	₹ 1,32,440	₹ 770
6	80	13760	₹ 1,65,120	₹ 960
			₹ 4,97,080	

COST-BENEFIT ANALYSIS OF MANGO-BASED MULTI-FRUIT INTERCROP SYSTEM

POMEGRANATE MONOCULTURE

Returns from Pomegranate (as pure crop system; 450 plants / acre)				
Year	Yield / Plant (Kg)	Yield / Acre (Kg)	Returns (Rs)	Returns / Tree (Rs)
1	0	0	₹ 0	₹ 0
2	1.5	675	₹ 29,700	₹ 66
3	4	1800	₹ 81,000	₹ 180
4	8	3600	₹ 1,69,200	₹ 376
5	10	4500	₹ 2,25,000	₹ 500
6	12	5400	₹ 2,97,000	₹ 660
			₹ 8,01,900	

APPENDIX 6

GENERATION OF AWARENESS THROUGH COMMUNICATION AND MOBILISATION

Sr No	Inputs	Cost
Farmers		
1	Farm/ Village level visits by technical experts	Cost per personnel * No. of personnel
2	Farmers' visits to 'model' projects	Cost of travel per person * No. of persons
3	Helpline. (Government schemes have dedicated helplines. No additional set up cost. Cost of training personnel to develop expertise on organic, chemical free, tree based farming and expanding staff.)	Cost of training existing personnel + hiring more personnel
Community dependent on forests		
4	Engagement through Gram Sabha Meeting and attending to concerns.	Cost of Gram Sabha meetings
Consumers		
5	Marketing Campaign for organic produce. Costs include: Cost of campaign design, Campaign production and airtime costs across media, for sustained time period.	Cost of Campaign
Government Departments		
6	Interdepartmental coordination between ministry of agriculture, water and forests. This may require regular meetings. Coordination across state governments in case of inter state rivers. This requires meetings and online sharing of project status. Training of personnel and decision making staff on the organic, chemical free ecosystem and biodiversity.	Cost of project digitisation, training and regular meetings.
Industries		
7	Calling for, encouraging business models developed around value addition to organically harvested horticulture produce. Costs include: signalling of government interest in the sector through campaigns and statements by departmental heads.	Cost of campaign addressed to industries. Cost of consultation with industries.

INDICATIVE BUDGET FRAMEWORK

Intermediate Outcomes	Outcomes
Educate farmers on feasibility of tree based, organic and chemical free farming in their geography	Increased confidence of farmers
Helps farmers learn by seeing	Increased confidence of farmers
Answers follow up questions, eases transition and increases farmers' acceptance of the idea.	Increased confidence of farmers
Gathers traditional knowledge on what trees are best suited to the region and traditional lifestyles, consultative, democratic plan for afforestation.	Increased acceptance for the idea by forest dwellers. Gaining traditional expertise and participation from forest dwellers.
Educates consumers on the benefits of organic fruits. Creates a willingness to pay for organic fruits	Demand Creation.
Creates cohesive understading of project within state government. Creates inter state corrdination.	Reduces implementation gaps.
Creates an ecosystem where the needs of industry is aligned with the farmers produce, thereby eliminating a mismatch of industrial demand and supply.	Creation of demand for organic horticulture produce. Boosts **'Make in India'**. Provides support to doubling farm incomes by 2020.

APPENDIX 6

AFFORESTATION

Afforestation: the sub program of afforestation contains afforesting in all three kinds of land: public owned land with no forest dwellers, land owned by forest dependent communities and land owned by farmers. The nature of pre plantation costs costs remains the same across three heads and they will have to be adjusted to local conditions to arrive at precise numbers. However the total operative costs vary across three kinds of land as farmers need to be compensated for the loss of income during gestation period and similar effects may be faced by forest dwellers as well.

Phase	Sr No	Inputs	Costs
Pre Plantation Phase (0–1 year)	Growing and Procuring Quality Plantation Material (QPM)		
	1	Nursery. Costs include: Cost of land. Estimates suggest 11,500 acres of land for the 1000 km length of river project. A major portion of this can come from private sector, if the government can buy saplings and not grow all of the required QPM.	Size of land parcel x Cost of land
	2	Research and Development on indigenous and locally relevant varieties. Existing agricultural institutions can be leveraged through expansion of staff and increase in grant funds.	Funding to Agrarian Research Institutes.
	3	Pitting. Cost per acre: Rs 6,000	Rs 6,000 x No. of acres
	4	Manuring. Cost per acre: Rs 4,000	Rs 4,000 x No. of acres
	5	Land treatment. Cost per acre: Rs 15,000	Rs 15,000 x No. of acres
	6	Accreditation of nurseries and their produce. Cost include: Expansion of National Horticulture Board's voluntary Recognition of Horticulture Nurseries.	Cost of expansion and strengthening of Recognition of Horticulture Nurseries.

INDICATIVE BUDGET FRAMEWORK

Performance Indicator	Intermediate Outcomes	Outcomes
The total QPM produced/ procured	Geographically indigenous, and locally resillient quality of saplings.	Low rates of tree casuality. High yield of quality produce while preserving the local biodiversity.
Research contribution to cover issues of tree variety to be grown in an area	Geoographically indigenous, and locally resillient quality of saplings.	Low rates of tree casuality. High yield of quality produce while preserving the local biodiversity.
No of acres of the 1 km width pitted	Land preparation for sowing.	Land preparation for sowing.
No. of acres of the 1 km, manured.	Land preparation for sowing.	Land preparation for sowing.
No. of acres of the 1 km treated	Land preparation for sowing.	Land preparation for sowing.
No of QPM Units being accredited.	Mechanism to monitor and regulate the quality of input and therefore the eventual output.	Low rates of tree casuality. High yield of quality produce while preserving the local biodiversity.

APPENDIX 6

AFFORESTATION

Plantation Phase (1–3 years)			
	Plantation in public land		
	7	Sapling. Cost per acre Rs 2800	Rs 2,800 x No of acres
	8	Transport. Cost of sapling	Depends on distance of nursery from river bank
	9	Planting. Cost per acre: Rs 4000	Rs 4,000 x No. of acres
	10	Mulching. Cost per acre: Rs 4000	Rs 4,000 x No. of acres
	11	Pruning and mulching. Cost per acre: Rs 8000	Rs 8,000 x No. of acres
	12	Implements for micro irrigation	Cost of implements
	13	Production and application of herbal pesticides	Cost of herbal pesticides + cost of personnel for application of pesticides.
	14	Grassland vegetation like that by Vetiver	
	Plantation in farmer owned land: In addition to the general plantation costs in public land, as enlisted above, the following are additional costs for farmers' land		
	15	Drip farming Infrastructure with separate valves	Cost of equipment
	16	Compensation to farmers for loss of income: Rs 75,000 in first year + Rs 74,000 in second year + Rs 15,000 in third year	Rs 164,000 x No of farmers
	17	Crop insurance	
	18	Educating farmers, regular monitoring and technical support	
	Plantation in land owned by forest dwellers: In addition to the general plantation costs in public land, as enlisted above, the following are additional costs		
	19	MFP aggregation	Cost of labour and equipment
	20	MFP storage, processing and auction/sale	Cost of infrastructure and operating costs
	21	Skilling and training to maintain community forests and for MFP processing	Cost of training

INDICATIVE BUDGET FRAMEWORK

No of acres of the 1 km sown	Planting of geographically suitable trees.	
No of acres of the 1 km sown	Planting of geographically suitable trees.	
No of acres of the 1 km sown	Planting of geographically suitable trees.	
No of acres of the 1 km mulched	Planting of geographically suitable trees.	
No of acres of the 1 km pruned	Planting of geographically suitable trees.	
No of acres of the 1 km irrigated	Water efficient irrigation.	
No of acres of the 1 km covered.	Protecting produce from disease and pest infestation	Low rates of tree casuality.
Area along the bank covered.	Protecting river bank through non engineering ways	
No. of acres of the 1 km irrigated	Water efficient irrigation.	Subtantial demonstration of Per drop, more crop
No. of affected farmers compensated.	Smoothening farmers' consumption during transition period.	Substantial demonstration of agroforestry models
No of acres of the 1 km insured	De-risking farmers	Protecting farmers' incomes and reducing volatility.
No. of farmers skilled.		
No. of persons paid & weight of MFP collected	Intermediate income for community members involved in MFP collection	Increased welfare of community
Weight of MFP stored and processed/sold	Value addition to MFP; intermediate income for community members involved in processing; income to entire community from MFP	Increased welfare of community
No. of persons skilled/ trained		Sustainable forest resource management and sustainable MFP production

APPENDIX 6

AFFORESTATION

Post-Plantation	Ongoing Monitoring		
	22	Ongoing accreditation of produce	Cost of accreditation
	23	Ongoing monitoring of river flows	Cost of equipment and manpower

INDICATIVE BUDGET FRAMEWORK

Tons accredited	Signalling quality of produce and getting fair price	Ensuring competitive agro based industy
Flow measurement	Increased flow in rivers compared to baseline	Perennial rivers

APPENDIX 6

AGRO-BASED INDUSTRY

Sr No	Inputs	Cost Head
Farmers Producer Organisation (FPO)		
1	Organisation of farmers through legislation, Self Help Groups. Costs inlude: Cost of creating awareness and prmoting take off	Awareness generation
2	Managerial training to farmer or technical assistance	Cost of training or cost of specialised personnel
3	Digital Platforms: ICT Capacity Building – infrastructure for internet, incentivising computers	Cost of providing internet. Cost of incentivising computers.
4	Creation of infrastructure for storage, transport and organised selling	Cost of creating or incentivising creation of infrastructure
Industrial linkages		
5	Fiscal incentives for take up of FPO centric business models	Fiscal incentives like tax rebates, subsidies

INDICATIVE BUDGET FRAMEWORK

Performance Indicator	Intermediate Outcome	Outcome
Number of FPO created	Creating an organised supply of organic produce	Consistent and organised supply of raw material for agro based industry.
No of FPO with skill training or personnel	Creating an organised supply of organic produce	Consistent and organised supply of raw material for agro based industry.
No of FPO with operational access to ICT	Allowing for real time monitoring, buying and selling	This could be a use case for digital india.
The no. of tons for which infrastructure has been created.	Creating a consistent supply of raw material	
The no. of tons which have industries have agreed to buy	Ensuring supply side demand for organic produce	Creating a vibrant agro based industry, improving make in india.

Annexures

ANNEXURE 1

EFFECT OF FOREST COVER ON GROUNDWATER RECHARGE FOR SUSTAINABLE RIVER FLOW

Dr. P. Thambidurai, Ph.D. (IIT Bombay)[1]

ABSTRACT

Effect of forest cover on groundwater recharge is of interest to increase water flow in the river. There is enough quantitative evidence to strongly suggest increase in tree cover will increase the groundwater recharge in tropical regions. Effective changes have been noticed by many workers in the subsurface components of the hydrologic cycle, especially groundwater recharge and base flow. Base flow is the primary source of the river which keeps the river running throughout the year. The proposed project is concerned with the effect of changes in forest cover on the magnitude of peak river runoff for the Indian scenario. Studies relating to changes in land-use and the magnitude of base flow will be carried out in consideration of land-surface slope, drainage density, geology, and other factors during different stages of forest gro

Differences in groundwater recharge within a forested area arise largely due to direct interception. Effective groundwater recharge happens when the majority of rainfall occurs on the tree canopy and moves quickly into the depths of the ground, below plant roots. Estimates of groundwater recharge and discharge will be carried out by studying the rainfall ratio to river flow in the proposed region. Studying the recharge-to-rainfall ratio will help to understand the key factors which will have substantial effects on groundwater recharge.

Also precipitation is likely to play a dominant role in the magnitude and variability of groundwater recharge. Effect of tree cover increase on local precipitation, such as an increase in interception, infiltration and runoff, will be studied in detail. The understanding of groundwater and its contribution to rivers is very important

[1] Assistant Professor (Geological Division), Amrita Centre for Wireless Networks and Applications, Amrita University, Kollam, Kerala

to evaluate the effect of forest growth over a period of time. Determination of base flow and stream analysis will be carried out through comparison of different sub-basins. Hydrograph analysis will be adopted to separate base flow from quick flow which occurs immediately after rainfall. An existing method will be utilized, before and after tree growth, to calculate land cover of the proposed area to determine the effects of changes in tree cover. The development of forest cover could be an effective step to improve the groundwater hydrogeology environment which will ensure sustainable river flow.

1. INTRODUCTION

Two-thirds of the world's population may live in water-limited regions by 2025 (Kuylenstierna et al., 1998). In Africa about 340 million people already lack access to adequate hygienic water (UN, 2009). Rivers are important for water distribution and also in developing the landscape which provides habitats, especially for humans and diverse plant-animal communities. Where does the water in a river come from when it has not rained recently? Base flow is the technical name for flow in a stream or river. River base flow results from groundwater seeping into riverbanks or the riverbed. Base flow is the sole or primary source of streamflow during the annual dry season when rainfall is insufficient to generate substantive runoff. The groundwater flow has a much larger scale and it is controlled by vegetative cover, rainfall, land-surface slope, geology and other factors (Rodriguez et al., 2017). Hydrogeologists have recognized the importance of the interconnected nature of groundwater and surface water. The surface water is always almost connected to groundwater which has critical impact on river water flow.

In general, the base flow can be significant enough to allow the stream to flow around the year (i.e., perennial or permanent stream). Recharge from groundwater to streams and rivers through base flow is the major source for sustained flow in the river except during storms. On average, 40 percent of all flow in United States rivers and streams originates from the groundwater. Water flowing into a stream from groundwater is called a "gaining stream" and this it is the most common source of water for a stream. When the river level rises, for example in response to a storm, water can flow from the river into the channel banks, as the water level in the channel rises above the pre-storm groundwater level. This is known as "losing stream". If the stream over tops its banks to spread over a floodplain, flood water infiltrates to the groundwater under the flood plain. This seepage and infiltration can help reduce the impacts of flooding in downstream areas, and after the storm, the slow release of water from the surrounding saturated area maintains the base flow in the channel. Infiltration through the floodplain to the underlying groundwater table is one of the reasons why maintaining flood plains in an undeveloped (pervious) condition must be an important consideration for planning development.

A stream may switch back and forth between losing or gaining on a seasonal basis during the year and/or during the course of its flow downstream from its headwaters. Conditions may change from gaining to losing at the upstream end of a meander or at the top of an abrupt change in the gradient of the channel. Excessive pumping from a well in the vicinity of a stream may induce a "losing" condition when the zone of drawdown around the well intersects the surface water body. Since groundwater and surface water are not separate resources, when our activities use one of these resources, it often affects the other in a relatively short time frame in terms of quantity and quality.

An important question in hydrogeology is how much base flow occurs in a river in response to a given amount of rainfall. To answer this question we need to know where water goes when it rains, how long does water reside in a watershed, and what pathway does water take to the stream channel. Answering the question of how much runoff is generated from surface water inputs requires partitioning water inputs at the earth's surface into components that infiltrate and components that flow overland and directly enter streams. The pathways followed by infiltrated water need to be understood. Infiltrated water can enter into the subsurface that takes it to the stream relatively quickly, in which case it is called interflow. Infiltrated water also percolates to deeper levels and connects to groundwater, which sustains the steady flow in streams over much longer time scales – the base flow. Figure 1 illustrates schematically many of the processes involved in the generation of groundwater and stream flow.

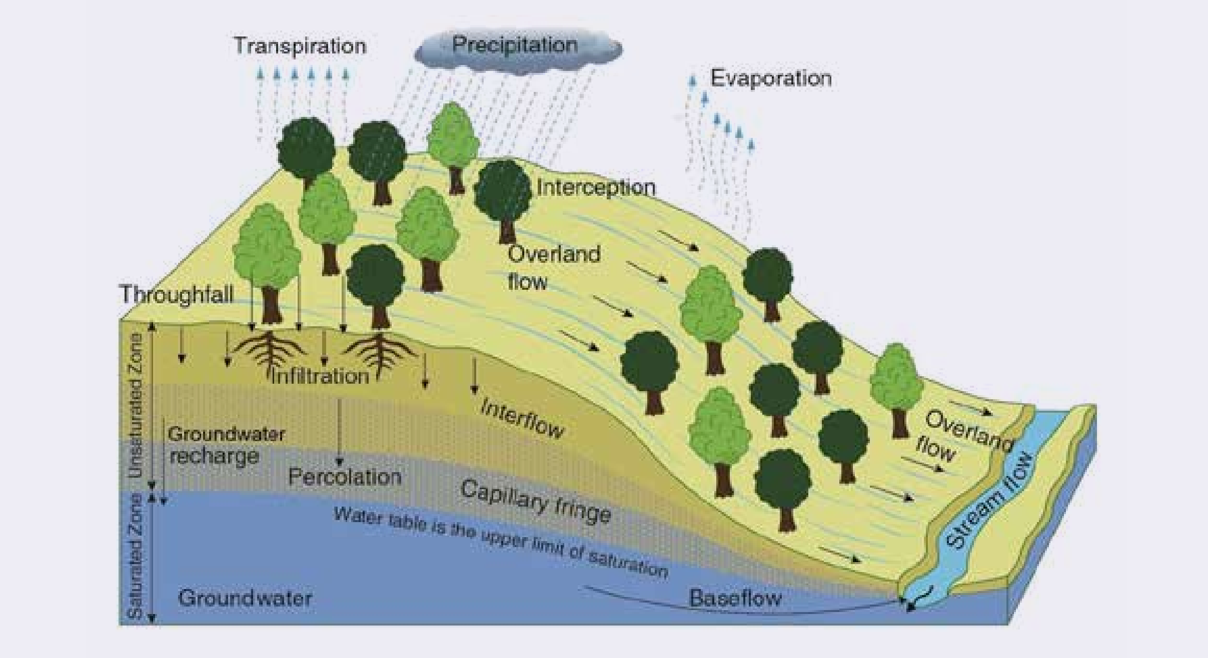

FIGURE 1. PHYSICAL PROCESSES INVOLVED IN RUNOFF AND BASE FLOW

The further discussion will provide an elementary quantitative understanding of the processes involved in the groundwater contribution for stream flow: the mechanisms involved in groundwater generation; and the pathways that water takes to move into streams; physical factors at the land surface (soil) that control the runoff; and infiltration processes of rainwater into the subsurface. Infiltration is the main mechanism through which groundwater recharge can be increased. Infiltration is the movement of surface water into the soil, where it can be temporarily stored, infiltrate into underlying soil and recharge groundwater.

Soil properties have an important role on water inputs at surface and subsurface flow. An increased rate of infiltration is based on favourable soil structure (hydraulic conductivity). To prove this mechanism, there were studies which recognised that trees can improve the hydraulic conductivity and reduce overland water flow (Sandström et al., 1998; Bruijnzeel, et al., 2004; Beck et al., 2013). Several studies of infiltration rates before and after deforestation or forest fires found decreased infiltration rates after the trees were gone (Wondzell and King 2003). Gonzalez-Sosa *et al* (2010) found higher saturated hydraulic conductivity in areas of broadleaved forests and small woods than in permanent pasture soil and cultivated lands. Skorobogatov *et al* (2013) compared saturated hydraulic conductivity in vegetation covered area to the surrounding areas without trees but which had similar soil and topography,and found that trees had a significantly greater impact on soil permeability compared to lawn without trees. Chandler and Chappell (2008) found that median and mean saturated hydraulic conductivity 3 m from the trunks of individual oak trees were a factor of 2.3 and 3.4, respectively, larger than those of the surrounding grassland without trees. The other literature review also addressed in which the ratio of saturated hydraulic conductivity of the A- horizon soil under trees to that under adjacent pasture ranges from 2 to 140.

How can trees increase infiltration rate? Living and decaying roots create a network of well-connected channels in the soil called macro-pores. Water flow through these macro-pores can be up to several hundred times faster than flow through the soil matrix (Aubertin 1971 and Buttle and House 1997; Chandler and Chappell 2008). In addition, organic matter from leaf litter and tree roots improves soil structure, which can increase infiltration rates. Soil structure is improved as soil particles are cemented together by humus, by organic glues created by fungi and bacteria decomposing organic matter, and by polymers and sugars excreted from roots. Not surprisingly, several studies have documented that vegetation maintains adequate saturated hydraulic conductivity over time in bio-retention areas (e.g. Lucas and Greenway 2011, Hatt et al 2009). Breen and Denman specifically compared unsaturated infiltration rates of model soil profiles in above-ground containers with trees, to containers without trees and found that those with trees had higher infiltration rates. This tells us that even at a very young age, the trees were already having a positive effect on the hydraulic conductivity. Bartens *et al* (2009) also found that tree roots affected soil hydraulic conductivity even at a young age, and concluded that "woody roots can increase infiltration relatively quickly before there is opportunity for very large diameter roots to form and when root turnover is likely minimal…" and that therefore, "it seems probable that water travelled around root channels along existing live roots." In addition, studies examine the role of stem flow (that is, the flow of intercepted water conveyed down the trunk or stem of a plant) as a major source of infiltration into the soil (Koichiro, 2001; Johnson and Lehmann, 2006). The infiltration mechanism is presented in Figure 2 a & b.

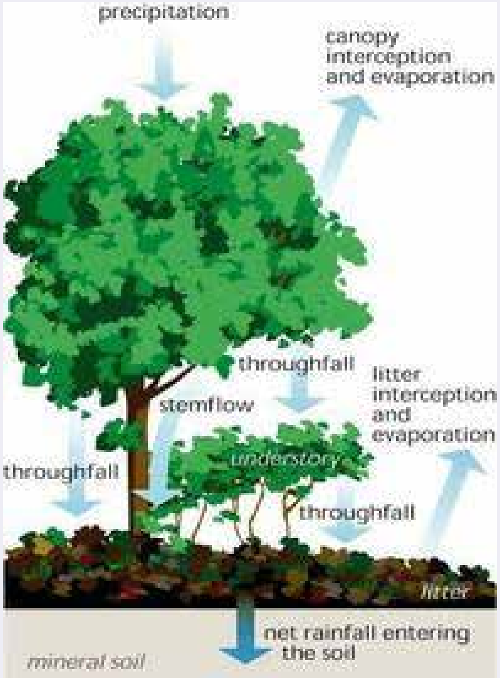

FIGURE 2 (A) INFILTRATION MECHANISM IN TREE COVERED AREA

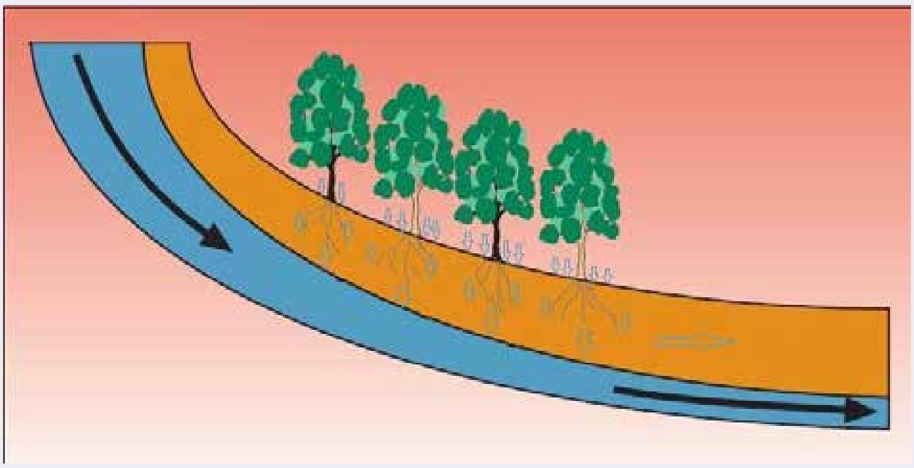

FIGURE 2 (B) SCHEMATIC DIAGRAM HIGH INFILTRATIONS IN FOREST AREA

Johnson and Lehmann (2006) determined that infiltration of stem flow, which results from the partition of rainfall by the tree canopy, is enhanced by root-induced preferential flow. The amount of precipitation accounted for as stem flow ranged from less than 1 to as much as 22 percent of incident rainfall above the forest canopy where the rainfall averaged 24 to 200 inches per year (in/yr). The hydrologic role of stem flow is a water source to the soil beneath the forest. Although the ratio of stem flow to precipitation is small in a forested basin, the effect of stem flow on groundwater recharge might be relatively large.

However, there are reviews and analysis (Taniguchiand, 1996; Zhang et al., 2001; Wu., 2006) which recognized the inconclusive and even contradictory nature of results from studies that attempt to relate hydrogeologic and geomorphic properties, as well as the extent of forest cover, to base-flow magnitude. The reported adverse effect is based on the relationship that exists between evapotranspiration and the altitude at the studied site. Also, the inverse relation may be due to a general decrease in temperature with increasing altitude, which in turn, generally reduces the amount of water consumed by vegetation. Wu and others (2006) did not relate the inverse relation between evapotranspiration and altitude to base-flow magnitude.

Groundwater recharge can come either from the small amount of rainfall that percolates below the root zone of plants or from water seeping into the groundwater from streams, rivers, lakes and dams. The amount of water that percolates below the root zone of crops and pastures can be 10–100 times that percolating below trees. All sources of recharge can contribute to groundwater. Afforestation and deforestation affected low flows of streams (Ramos-Ginés, 1997). A low-flow rate of about 0.47 $(ft^3/s)/mi^2$ was estimated for a predominantly forested watershed in the Municipality of Cidra in the unincorporated territory of the United States. Lower low-flow rates of 0.1 to 0.2 $(ft^3/s)/mi^2$ were estimated for the same municipality from agricultural areas with little or no forest cover. These low-flow rates also can be increased by the base flow. The apparent relation between forest cover and base-flow magnitude of streams in the interested area should be examined prior to establishing land-use practices that require the removal of forest cover. Reductions in forest cover will also lead to a reduction in the hydraulic conductivity of near-surface soils. As a result of tree removal, the once shaded clayey soils are exposed to the drying effects of the sun and hardening by the wind. Soil hardening is accompanied by a loss of macro-porosity caused by the disappearance of the prior root systems. This alteration in combination with slopes that range between 40 and 60 percent reduces water infiltration to the subsurface and increases rapid soil erosion and rainfall runoff.

The previous studies conducted by United States Geological Survey (USGS), indicate that a direct relationship exists between high base flows and the presence of forest cover. High base flows have been documented in streams within mature forested areas (Gómez-Gómez, *et al.*, 2001). The previous research works reveal that increasing forest cover could help preserve the hydrologic, ecological, and societal functions of streams. Ideally, environmentally sustainable land uses can be reconciled with the goal of enhancing the socioeconomic development of the interested region. To determine a relation between the spatial extent of forest cover and base flow in the proposed area in the Indian context the following methodology will be adopted.

2. BACKGROUND

The proposed project is concerned with the effect of changes in land cover on the magnitude of peak stream runoff for the Indian setting. Studies relating land-use changes and the magnitude of base flow in tropical regions are very rare. The relation between streamflow and forest cover is complex, because streamflow is affected by the stage of a forest's growth, land-surface slope, drainage density, geology, and other factors.

3. METHODOLOGY

The relation between the extent of forest cover and the magnitude of base flow will be studied in drainage basins of the proposed area. This will assess how land-use practices such as deforestation and agricultural practices affects the base flow of streams, and will be carried out through intense data acquisition and detailed analysis. This includes land use, rainfall distribution and other climate indicators, streamflow, evapotranspiration, and groundwater.

3.1. *Land-Use Classification - Landforms and Drainage* - Remote Sensing and GIS techniques will be used to generate layers of information of land cover, stream network, slope/contour, forest legal boundaries, settlement locations and village boundaries. The main criterion that will be used to differentiate the various land uses in the study area in these type groups is their similarity, such as in the height and extent of forest canopy in the case of vegetative covers, and the predominance of a paved, impervious surface devoid of vegetation in the case of commercial and rural residential zones. The percentage of land use within the proposed area will be calculated and grouped in each basin which can be determined from the prepared data set (Map layers). Finally, field validation will be conducted with processed data base.

3.2. *Geology* – To understand the geology of the area including rock formations and types of rock, structural aspects will be studied through field examinations.

3.3. *Soil Study* – Physical and chemical characteristics, types of soil, and depth profile data will be collected from the existing source for further understanding and analysis.

3.4. *Rainfall* – Rainfall data will be collected from the existing data source for the proposed region to understand the rain pattern.

3.5. *Streamflow* – Flow rate data will be collected for the past few decades to understand the existing scenario.

3.6. *Evapotranspiration (ET)* – If the ET data is not available then it will be calculated from collected rainfall and streamflow, etc. The mass-balance approach of Giusti (1978) will be used to estimate evapotranspiration (ET) within the study area. In this approach, ET can be considered to be the difference between rainfall and runoff (ET = P–RO) where P is the basin average precipitation and RO is runoff. According to Giusti (1978), ET increases until a threshold in rainfall is reached, beyond which it progressively decreases with further increases in rainfall. The rainfall and streamflow data will be used to estimate evapotranspiration.

3.7. *Groundwater* – Available groundwater data will be used to understand the current condition of the basin.

4. EFFECTS OF FOREST COVER ON BASE FLOW OF STREAMS – TO DETERMINE ONCE FOREST IS DEVELOPED

4.1. *Land use analysis* – To determine the changes in land cover and land use pattern.

4.2. *Rainfall and Climate* - Rainfall stations equipped with tipping-bucket-type rainfall gauges were installed as part of this study at different altitudes to account for the spatial variation in rainfall within the basins. Additional climatological data will be measured to calculate and analyse the rainfall patterns of the region. In addition, installed weather station data will be used to determine temperature changes, wind direction, air moisture, etc.

4.3. *Hydrology* - Test holes will be drilled and a series of piezometers can be installed as much as needed in the proposed basins to obtain the lithologic and groundwater data which define the hydrogeology of the study area. Water-level measurements will be made at regular intervals, and also a slug test can be conducted at representative piezometers (test well) to estimate hydraulic conductivity. The Bouwer and Rice (1976) analysed method may be adopted to compute the values from the slug-test data. Groundwater levels at selected piezometers in test bore wells will provide storage and pathways for groundwater movement.

4.4. *Streamflow* - Streamflow gauging stations will be installed through the length of the stream stretch in the proposed basins to collect continuous streamflow data. Result of the steep slope of the stream channels and the steep hydraulic gradient at the younger stage of stream runoff may occur rapidly. So, relatively streamflow discharge measurements will be measured and analysed to investigate the characterization of the occurrence of low flows in the particular stream. Continuous daily streamflow data will be also estimated for the larger basins and continuous streamflow data for the tributaries.

- Total streamflow was separated into base-flow and runoff components. The base-flow component of continuous streamflow estimated at proposed basins obtained with Hydrograph Analysis Tool.
- The base-flow component will be computed using the "One-

parameter Digital Filter" option. In the case of small basin area where direct runoff is restricted to less than an hour after rainfall events, the measured streams flow will be assumed to be entirely composed of base flow. To integrate the seasonal variations in base flow, the annual mean discharge at the larger basins will be calculated as the average of the daily data, whereas at the smaller basins the annual mean discharge is assumed equal to the average of the discrete measurements. To compare the base-flow-generation capacities between basins in the same paired set, flows will be normalized by drainage area and presented as cubic feet per second per square kilometer.

- *Evapotranspiration (ET)* - Through rainfall data and measured streamflow values, the mass balanced ET will be calculated. For ET calculation the following mass-balance approach (Giusti, 1978) will be used to estimate evapotranspiration (ET) within the study area. In this approach, ET can be considered to be the difference between rainfall and runoff (ET = P–RO) where P is the basin average precipitation and RO is runoff. According to Giusti (1978), ET increases until a threshold in rainfall is reached, beyond which it progressively decreases with further increases in rainfall. The rainfall and streamflow data will be used to estimate evapotranspiration.

5. DETERMINATION OF STREAMFLOW AND BASE FLOW ANALYSIS

The magnitude of base flow within the proposed area will be monitored and calculated with the areal extent of forest cover in the proposed basin measured. The base-flow magnitude will be normalized on a unit area basis for comparison purposes of different sub basin. The understanding of the groundwater (base flow) contribution to stream flows is very important to evaluate the effect of forest cover. There are well established methods for the understanding of the magnitude and dynamics of groundwater discharge into the stream. One such method is the analysis of the streamflow hydrograph. The aim here is to separate and interpret base flow from quick flow which is the short term response to a rainfall event.

In this regard, a multitude of the methods have been developed which can be conveniently categorized into four basic approaches as follow:

1. Graphical base flow separation
2. Filtering-algorithms
3. Frequency Analysis
4. Recession Analysis

The direct flow is primarily the direct response of a rainfall event and includes the overland flow (runoff) and the lateral flow in the soil profile, also known as interflow. The base flow is a component of streamflow which is discharged from the natural storage of aquifers. Certain streamflows can be affected by both direct flow and / or base flow components. Many streamflows can acquire modified base flow situations due to the abstraction and use of water resource directly from the stream or from the groundwater storage. A streamflow can also be affected by the interruption of the direct flow such as by diversion of runoff and water harvesting mechanisms. Therefore it is necessary to separate the direct and base flow of a streamflow in order to understand the component that is more influential on the stream flow as well as to identify the component which is more likely to be affected by land use changes. Moreover in order to have a targeted policy in water resource development and use, it is essential to have a responsible estimation of the direct and base flow components of the stream flow.

The graphical methods separate the base flow on a discharge duration graph by connecting an intersection point of base flow and direct flow upon the hydrograph raising limb's lowest flow point (at a point where direct flow is assumed zero) to a point on the falling limb where it is assumed all flows are changed to base flow. There are several methods that can be used to get the point where direct flow ends upon the falling limb part of the hydrograph. The most popular one is an empirical formula given by following equation (Linsley *et al*., 1975): $D=0.827A^{0.2}$

Where, D is the number of days between the storm crest and the end of the quick or direct flow and A is the area of the catchment in square kilometers.

In stream flow separation, the most frequently used method is the filtering separation method which separates base flow from the streamflow time series data by processing filtering procedure. Although this method does not have any physical or hydrological basis, it aims at generating an objective, repeatable and easily automated index that can be related to the base flow response of the catchment (Arnold *et al.*, 2000). The second most frequently used method is a statistical method known as frequency-duration analysis. It calculates the probability of a given flow that will equal or exceed daily, monthly and annual flows.

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ANNEXURE 2

IMPACT OF POLLUTION ON RIVERS

Cdr. S. Lakshmanan Iyer (Retd.)[1]

ABSTRACT

Within the next one to two decades, water problems in India may constitute a greater crisis than is fathomable today. One factor that needs to be considered consciously is that there is no known resource substitute for water in satisfying the direct living demands of the population. This essentially means we must learn how to live with existing water supply endowments by managing water in terms of its use, development and conservation. India is arguably the oldest civilization nourished sumptuously for hundreds of centuries by the great endowments of Mother Nature, our Great Rivers. The exemplary evolutionary development seen today after these hundreds of centuries is certainly attributed to our rivers. This chapter focuses on one of the key factors that threaten the very existence of these wonderful rivers – pollution.

The National Water Monitoring Programme has identified that 275 rivers out of 445 rivers in the country are polluted. The key causes of pollution in rivers are: discharge of untreated / partially treated sewage and effluents; fertilisers and pesticides from agricultural run-off; and septage (septic tank sludge) disposed of into rivers.

Reusing treated wastewater instead of releasing them into rivers serves the twin purpose of eliminating pollution in rivers coupled with partially meeting the demand for water for non-potable and non-contact applications. Potential applications are irrigation (both within cities and farmland adjoining cities), flushing, road wash, car wash, construction, etc.

To ensure safe, good quality treated wastewater from centralised STPs (including removal of residual toxic chemicals and pathogens) suitable for irrigation of organic farms, the following measures are required:

A chemical-free tertiary treatment using natural systems, such as Soil Biotechnology, is required to be added.

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[1] Director, Anantha Naturals Pvt. Ltd., Coimbatore

Introduction of mandatory continuous on-line, live and transparent monitoring of treatment water quality parameters and operational parameters of centralised STP

The currently installed treatment capacity of STP caters for roughly 40% of wastewater generation. Decentralised wastewater treatment coupled with local reuse can significantly enhance treatment of the remaining untreated 60%.

Utilisation of currently available surface drains (suitably designed and modified using the design conceptualised by Dr. Biplab Patnaik of Life Link Eco Technologies Pvt. Ltd.) could be explored for transportation of sewage. This can significantly bring down sewage transportation costs and eliminate risk of undetected sewage leakage into groundwater or freshwater lines. Underground piping networks would be more suited to storm water transportation.

Immediate cost-effective possibilities to reduce pollution in rivers include use of Bacterial Bioremediation (Manu Bhatnagar, INTACH, 2017) and Vetiver System (Truong, Van, & Pinners, 2009).

Developing processes aligned with principles of Green Chemistry and Green Engineering can significantly reduce industrial effluent potentially up to 90%, while significantly promoting recovery of chemicals and recycling of water. Recycle@Source Solutions by Newreka Green-Synth Technologies Pvt. Ltd. are already providing such solutions to industries. This will not just reduce the pollution load but also help in demand management of freshwater.

Most of the content in the sections that follow in this annexure have been derived from various reliable sources, whose references are indicated in the respective sections. In order to avoid loss of thought process as intended by the author / source under reference, the content from all these sources have been quoted as such in most places. In a few places, however, some text modification was necessary to maintain continuity with respect to the current context.

1. BACKGROUND

(a) Introduction

Water is obtained from a variety of sources, ranging from rivers, wells (shallow as well as bore), ponds & lakes, traditional rainwater harvesting structures or even snow and glacial ice melt. Contemporary sources range from harvested rainwater that is stored in artificial storages like tanks or ponds, harvesting atmospheric dew or even from the sea by desalination.

Water is used in a variety of ways, some of which entail man-made (anthropogenic) substance discharges. They influence the chemical quality of water bodies and may thereby not only harm the aquatic life forms but also impair human usage such as for drinking water.

Contemporary India faces a pressing developmental challenge, namely providing safe, affordable and efficient drinking water and sanitation services to an urban population, the size of which is largely underestimated even by the official records of the census of India. Inadequate water supply and sanitation services impose a disproportionate public health burden on the poor. It also results in unregulated and unsustainable groundwater pumping. The urban water and sanitation services sector needs systemic responses to address these interconnected problems.

India, home to 16 percent of the world's population, has only 2.5 percent of the worlds land area and 4 percent of the world's water resources at its disposal. Precipitation in the form of rain and snowfall provide over 4,000 trillion litres of fresh water to India. Most of this freshwater returns to the seas and ocean via the many large rivers flowing across the subcontinent. A portion of this water is absorbed by the soil and is stored in underground aquifers. A much smaller percentage is stored in inland water bodies both natural (lakes and ponds) and man-made (tanks and reservoirs).

Honouring the fundamental tight to provide basic essential services such as clean water and sanitation has been an unresolved concern across most of the rural and urban landscape in India. Recent studies (Narain, 2012); (RobecoSAM, 2015) confirm that this is due to rapid urbanisation coupled with improper management of the water resources and pollution. Here is a brief snapshot of the water and sanitation in the global scenario:

(i) Accessible and high-quality freshwater is a limited and highly variable resource. Projections show that 40% of the world's population currently lives in water-stressed river basins, and that water demand will rise by

55% by 2050. (OECD, 2015)

(ii) Over-extraction and contamination of aquifers worldwide will pose significant challenges to food security, the health of ecosystems and safe drinking water supply, and increase the risk of subsidence, among other consequences.

(iii) In 2050, 240 million people are expected to remain without access to clean water, and 1.4 billion without access to basic sanitation. (OECD, 2015)

The Indian scenario mirrors the global trend in many ways:

(i) Inadequate waste management systems have resulted in pollution of both surface water resources (all major rivers in India) and ground water resources (RobecoSAM, 2015)

(ii) Only 43.5% of the households in India use tap water as the major source of drinking water among urban residents

(iii) The Ministry of Urban Development assesses that only 72% have water within their premises.

(iv) Only 32% of India's population receives treated water.

(v) 18.6% of urban households do not have access to any form of sanitation facilities at home.

Therefore, clean water and sanitation are seriously critical aspects India as a country needs to be paid closer attention to, while simultaneously focusing on economic growth activities. The UNESCO organization in 2015 has also outlined 'water and sanitation' as one of the 17 key focus areas for sustainable global development over the 2015-2030 period.

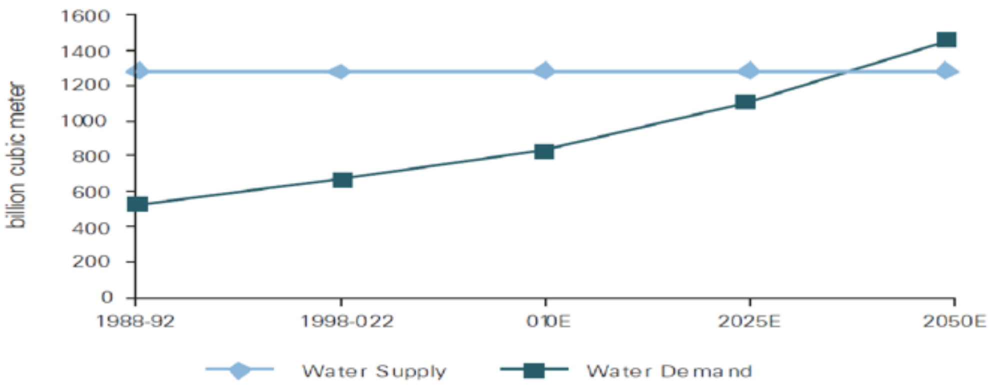
Specifically for India, it is therefore imperative to protect our rivers from drying out as well as eliminate/reduce polluting them to ensure their sustainability towards nourishing our future generations for hundreds of centuries as sumptuously as we have experienced.

2. TRENDS IN FRESH WATER CONSUMPTION

A country is defined as suffering high relative water stress if the demand is greater than 40 percent of the renewable water supply. India has been constantly faring low on the twin measures of water deficiency – absolute standard as well as the relative standard.

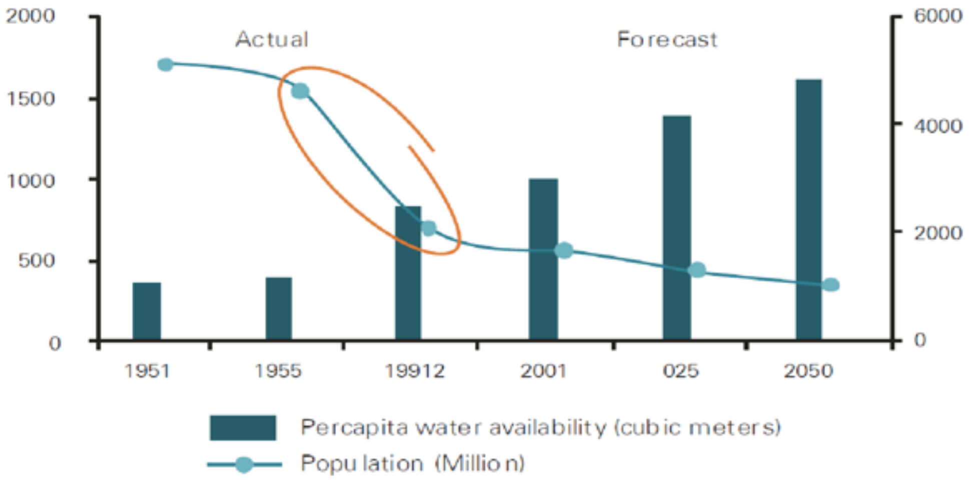
Of the 1,869 trillion litres (or 1,869 billion cubic metres (BCM)) of water reserves, only an estimated 1,122 trillion litres (or 1,122 BCM) can be exploited due to topographic constraints and distribution effects. The demand for water has been increasing at a high pace in the past few decades. (Refer Graphs 1 & 2).

Graph 1: Demand vs. supply curve in India



Source: Standing Sub-committee of Ministry of Water Resources, Development Alternatives, KPMG Analysis

Graph 2: Per capita water availability in India



The consumption in 2010 in the country was approximately 581 trillion litres (581 BCM) with irrigation requirements accounting for a staggering 89%, followed by domestic use at 7% and industrial use at 4%. (KPMG International, 2010)

The National Commission for Integrated Water Resources Development (NCIWRD) estimated that the total withdrawal/utilization for 2010 for all types of uses as 710 BCM. Out of that irrigation accounted for nearly 78% followed by domestic use 6%, industries 5%, power development 3%, and other activities claimed about 8% including evaporation losses, environment and navigational requirements.

The projection for 2050 is 1,180 BCM. Out of this, irrigation is expected to need 68%, followed by domestic use of 9.5%, industries 7%, power development 6%, and other activities, about 9.5%. (Central Water Commission, Ministry of Water Resources, November 2014)

TABLE 1: ANNUAL REQUIREMENT FOR DIFFERENT USES (IN KM^3)

		Year 2010			Year 2025			Year 2050		
Use	Year 1997–98	Low	High	%	Low	High	%	Low	High	%
Surface water										
Irrigation	318	330	339	48	325	366	43	375	463	39
Domestic	17	23	24	3	30	36	5	48	65	6
Industries	21	26	26	4	47	47	6	57	57	5
Power	7	14	15	2	25	26	3	50	56	5
Inland navigation		7	7	1	10	10	1	15	15	1
Environment – Ecology		5	5	1	10	10	1	20	20	2
Evaporation losses	36	42	42	6	50	50	6	76	76	6
Total	399	447	458	65	497	545	65	641	752	64
Groundwater										
Irrigation	206	213	218	31	236	245	29	253	344	29
Domestic	13	19	19	2	25	26	3	42	46	4
Industries	9	11	11	1	20	20	2	24	24	2
Power	2	4	4	1	6	7	1	13	14	1
Total	230	247	252	35	287	298	35	332	428	36
Grand total	629	694	710	100	784	843	100	973	1180	100
Total water use										
Irrigation	524	543	557	78	561	611	72	628	807	68
Domestic	30	42	43	6	55	62	7	90	111	9
Industries	30	37	37	5	67	67	8	81	81	7
Power	9	18	19	3	31	33	4	63	70	6
Inland navigation	0	7	7	1	10	10	1	15	15	1
Environment – Ecology	0	5	5	1	10	10	1	20	20	2
Evaporation losses	36	42	42	6	50	50	6	76	76	7
Total	629	694	710	100	784	843	100	973	1180	100

Source: (Rakesh Kumar, R. D. Singh and K. D. Sharma, 2005)

TABLE 2: WATER REQUIREMENT IN MM³/YEAR (PRODUCTION IN 1000 TONNES)

Sl. No	Category of Industry	Water Requirement per tonne in m^3	Year 2000		Year 2010		Year 2025		Year 2050	
			Production	Water Req.	Production	Water Req.	Production	Water Req.	Production	Water Req.
1	2	3	4	5	6	7	8	9	10	11
1	Iron & Steel	22	174050	3829.1	265350	5837.7	273300	6013	547050	12035
2	Smelters	82.5	203.6	16.76	292.6	24.14	391.6	32.31	537.6	44.35
3	Textiles & Jute	200	51193	8153.7	95094	19019	183507	36701	234618	46924
4	Leather Products	30	1277.5	1244.7	2191.3	65.74	3102.5	93.08	4927.5	147.83
5	Inorganic Chemicals	200	3730	165	8000	1600	16730	3346	30076	615
6	Pharmaceuticals	25	4960	124	8370	209.25	11046	276.2	17170	429.15
7	Distillery	22	1790.8	6357.2	3059.6	66.31	4454.6	318	6020	5203.9
8	Paper & Pulp	200	4950	1260	10350	207	51200	10240	97450	19490

From the available water resources, it is expected that by 2025, on an average, 72% of the total water use will be used in the agricultural sector, while 8% and 7% respectively will be employed for industrial and domestic purposes (Inferred from Table 1). The trends in water consumption by the industry are detailed in Table 2.

Over the next three decades, it is therefore expected that the agriculture requirement would continue to dominate the overall water demand in India. The agricultural output of India is, and will be heavily dependent on the available groundwater and surface water resources.

Looked at in a different way, groundwater availability is around 1,869 BCM in India. From this, 40% cannot be used due to geological and topographical reasons and loss. Only about 4,000 BCM of freshwater is available due to precipitation in the form of rain and snow, most of which returns to the seas through rivers.

The historical evolution of drinking water supply programmes since independence came from an aspiration in 1949 for provision of safe drinking water supply to cover 90% of India's population in coming 40 years, to a necessary inclusion of wastewater treatment and disposal with all drinking water plans in the Twelfth Plan (2012-17) (Review of Water Policies and Programmes with Special Reference to Urban Water Supply, 2012).

The status of groundwater in India as of 2016 is summarised in the Table 3. The trend clearly shows an overexploitation of the groundwater sources over the past two decades.

Any policy initiative needs a clear understanding of what are the consequences or the impacts of water types and how to minimise the undesired consequence and increase the pleasantness of water management.

Arcadis, a Design & Consultancy firm for natural and built assets, in partnership and consultation with the UK-based Centre for Economics and Business Research (CEBR), has developed the Sustainable Cities Water Index with the ultimate goal of being able to rank the sustainability of cities with respect to their water profile and systems. The Index centres around three key sub-indices for water sustainability: resiliency, efficiency, and quality. In turn, these sub-indices are made up of a series of indicators, such as flood risk, green space and pollution. (Arcadis, 2015)

(a) **Resiliency:**

A water resilient city is well prepared to overcome the challenges associated with both too little as well as too much water. It protects its citizens against disasters such as flooding and drought, while ensuring that water-related services continue undisrupted. Even in the face of crises, a water resilient city should be adapted to recover quickly. As a result of climate change, soil subsidence, coastal erosion and urbanization, extreme weather events and water scarcity are becoming more commonplace in many cities, particularly those located in coastal or riverine areas. The quality indicators for Resiliency include:

(i) Water stress

(ii) Green space

(iii) Water-related disaster risk

(iv) Flood risk

(v) Water balance

(vi) Water reserves

From the available water resources, it is expected that by 2025, on an average, 72% of the total water use will be used in the agricultural sector, while 8% and 7% respectively will be employed for industrial and domestic purposes (Inferred from Table 1). The trends in water consumption by the industry are detailed in Table 2.

Over the next three decades, it is therefore expected that the agriculture requirement would continue to dominate the overall water demand in India. The agricultural output of India is, and will be heavily dependent on the available groundwater and surface water resources.

Looked at in a different way, groundwater availability is around 1,869 BCM in India. From this, 40% cannot be used due to geological and topographical reasons and loss. Only about 4,000 BCM of freshwater is available due to precipitation in the form of rain and snow, most of which returns to the seas through rivers.

The historical evolution of drinking water supply programmes since independence came from an aspiration in 1949 for provision of safe drinking water supply to cover 90% of India's population in coming 40 years, to a necessary inclusion of wastewater treatment and disposal with all drinking water plans in the Twelfth Plan (2012-17) (Review of Water Policies and Programmes with Special Reference to Urban Water Supply, 2012).

The status of groundwater in India as of 2016 is summarised in the Table 3. The trend clearly shows an overexploitation of the groundwater sources over the past two decades.

TABLE 3: STATUS OF GROUNDWATER DEVELOPMENT IN INDIA BETWEEN 1995 AND 2011 (PRS LEGISLATIVE RESEARCH, FEBRUARY 2016)

Level of ground water development	Explanation	% of districts in 1995	% of districts in 2004	% of districts in 2009	% of districts in 2011
0-70% (Safe)	Areas which have ground water potential for development	92	73	72	71
70-90% (Semi-critical)	Areas where cautious ground water development is recommended	4	9	10	10
90-100% (Critical)	Areas which need intensive monitoring and evaluation for ground water development	1	4	4	4
>100% (Over-exploited)	Areas where future ground water development is linked with water conservation measures	3	14	14	15

Sources: Central Ground Water Board; PRS.

Any policy initiative needs a clear understanding of what are the consequences or the impacts of water types and how to minimise the undesired consequence and increase the pleasantness of water management.

Arcadis, a Design & Consultancy firm for natural and built assets, in partnership and consultation with the UK-based Centre for Economics and Business Research (CEBR), has developed the Sustainable Cities Water Index with the ultimate goal of being able to rank the sustainability of cities with respect to their water profile and systems. The Index centres around three key sub-indices for water sustainability: resiliency, efficiency, and quality. In turn, these sub-indices are made up of a series of indicators, such as flood risk, green space and pollution. (Arcadis, 2015)

(b) Efficiency:

Clean, usable water is an extremely valuable resource that is essential to the health of a city's citizens and economy. Efficient and controlled management of this resource is, therefore, vital for service continuity in both the production and distribution of water, minimizing cost of service, and preserving this resource for future generations. An often-faced dilemma is how to balance charging customers for the true value of water while maintaining affordability. Higher rates encourage water conservation and reuse, and can positively impact efficiency by encouraging investment in infrastructure improvements; but it can also be cost prohibitive. Low instances of leakage, as well as accountability in terms of water usage in the form of metering, are key to ensuring a city's water systems run efficiently. In many developed economy cities, much of the infrastructure is well past its useful life and the cities have seen the effectiveness of their systems suffer, with an increase in pipe leakage and service interruptions due to infrastructure failure. In many emerging economy cities, metering is relatively rare, and instances of non-revenue water and service interruptions relatively high. The quality indicators for Efficiency include:

(i) Leakage
(ii) Water charges
(iii) Service continuity
(iv) Wastewater reuse
(v) Metered water
(vi) Drinking water
(vii) Sanitation

(c) **Quality:**

In the Index, water quality is arguably the area where performance is highest, with many cities having recognized their critical role in improving quality of life, and thus have made significant investment. However, it remains a challenge for a number of developing cities such as those in Africa and Asia. According to a recent UN report, ten percent of the world's population still does not have access to safe drinking water. Cities in the developed world have historically improved their prosperity and economies only after adequately addressing water quality and sanitation, making them more competitive. Cities in developing nations will need to improve water quality to become prosperous, sustainable urban centres. Unsafe water and lack of sanitation is a major contributor to illness and disease, and lack of accessible and reliable source of potable water can minimize productivity and deter business investment. Polluted waterways restrict recreational activities, make clean up costly and deter liveability. The indicators for quality include:

(i) Drinking water
(ii) Sanitation
(iii) Treated wastewater
(iv) Water-related disease
(v) Water pollution
(vi) Threatened freshwater species

The details are tabulated in Table 4:

TABLE 4: RANKING OF WATER QUALITY INDICATORS (ARCADIS, 2015)

Indicator	Rank	Quality of Life Rationale
Drinking Water	1	Essential to public health and Survival
Sanitation	2	Essential to public health
Water Related Disaster Risk (Flood Risk)	3	Essential to public safety, supply chain and business continuity
Water Related Disease	4	Harmful to public health and economic progress
Water Stress	5	Water shortages have an impact on the ecosystem, quality of life, future city development and business continuity
Water Balance	6	A stable water balance is an indicator for a healthy urban water system
Water Pollution	7	Polluted water is both a public health risk and limits recreational and commercial usability
Water Reserves	8	Adequate safe yield and water reserves help a city through periods of water shortage, important for both public health and the economy
Service Continuity	9	To safeguard drinking water supply and industrial water supply for business continuity
Leakage	10	Leakages cause loss of revenues to invest in the water system
Treated Wastewater	11	To enhance the quality of urban ecosystems and quality of life in cities and enable reuse opportunities
Metered Water	12	Serves the economical sustainability of the water system to accurately account for water use
Water Charges	13	To finance water services and to stimulate economic use of the water and provide for cost recovery and finance system improvements
Green Space	14	To store rainwater, create space, add value to the urban ecosystem and fight urban heat stress
Threatened Species	15	Biodiversity in ecosystems improves the urban environment
Reused Wastewater	16	Puts less strain on supplies and builds in system efficiencies and return on investment

3. TRENDS IN WASTEWATER GENERATION & TREATMENT

(a) Change in wastewater Volumes Over the Years

The system of pipes used to collect and carry rain, domestic wastewater and industrial waste away for treatment and disposal is called the Wastewater system.

The water consumption and wastewater generation volumes have grown, keeping pace with the growth rates of population (Census Data of population is indicated in Table 5).

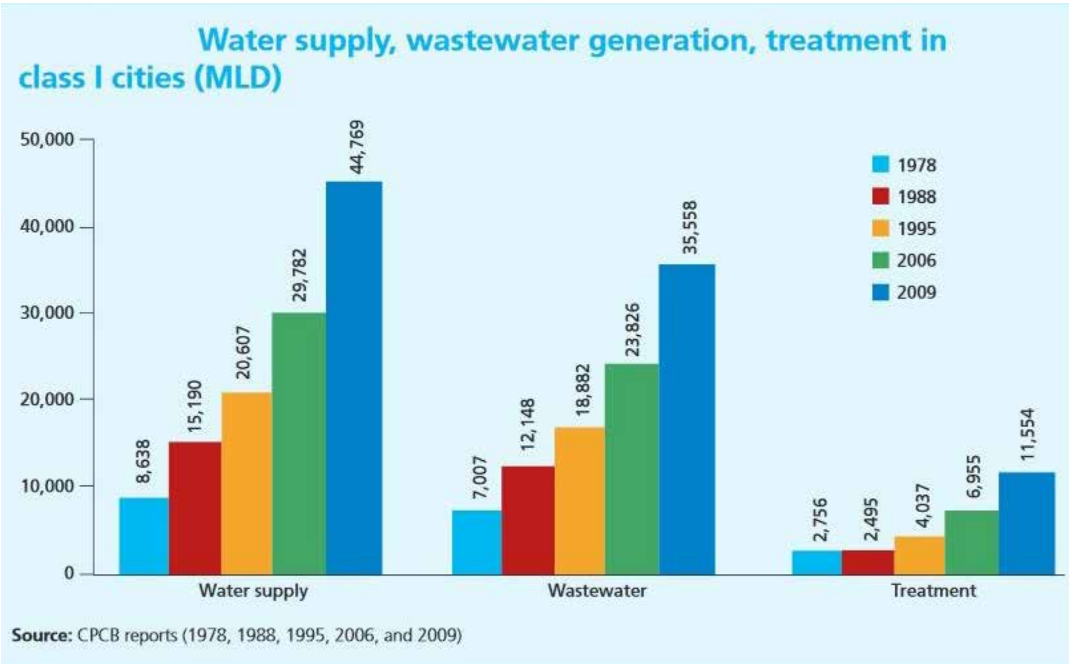
TABLE 5

POPULATION DATA									
TOTAL		URBAN		% URBAN		RURAL		% RURAL	
2001	2011	2001	2011	2001	2011	2011	2013	2015	2017
10286,10,328	12101,93,422	2861,19,689	3771,05,760	27.8%	31.2%	7424,90,639	8330,87,662	72.2%	68.8%

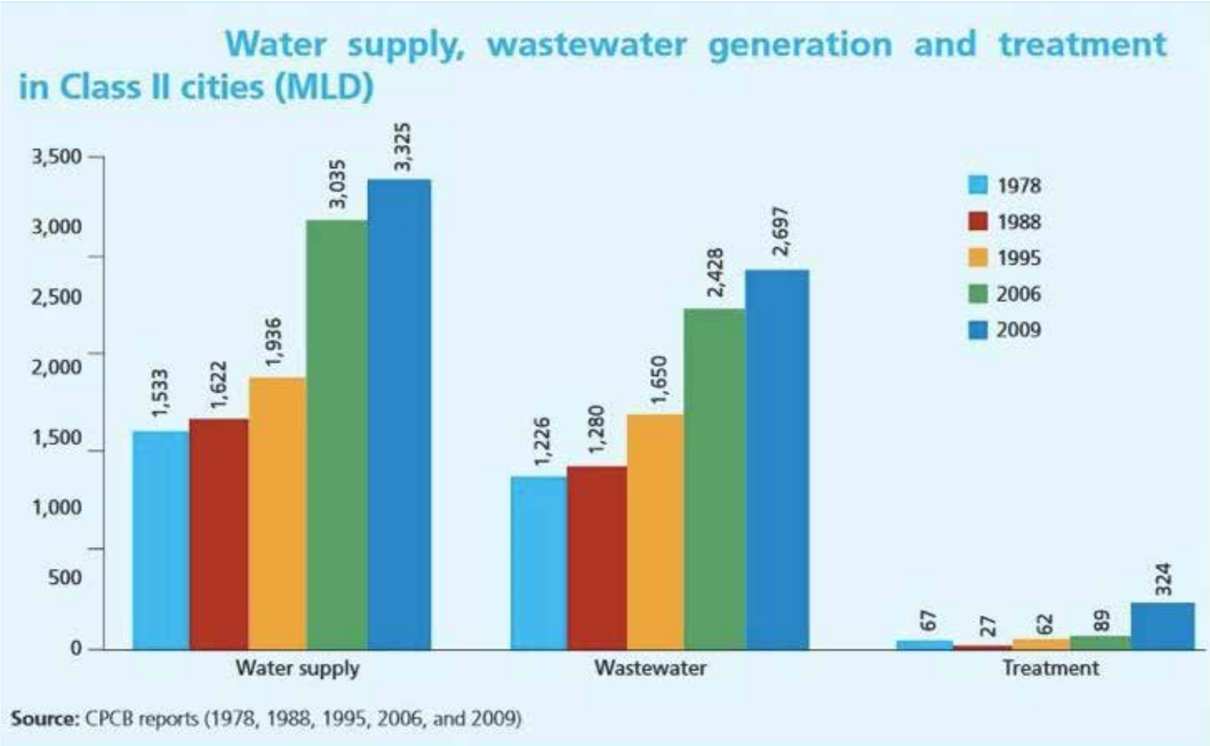
Source: NITI Aayog Website

However, the systems available for sanitation and management of wastewater, effluent and septage have not kept pace with this growth. This is evident from Graphs 3 & 4.

GRAPH 3 SOURCE: CENTRE FOR SCIENCE & ENVIRONMENT, NEW DELHI, MAY 2011



GRAPH 4 SOURCE: (CENTRE FOR SCIENCE & ENVIRONMENT, NEW DELHI, MAY 2011)



In 2009, the Central Pollution Control Board (CPCB) estimated that 38,354 MLD sewage was generated in major cities of India, but the sewage treatment capacity was only of 11,786 MLD (~30%). Similarly, only 60% of industrial wastewater, mostly from large scale industries, was treated.

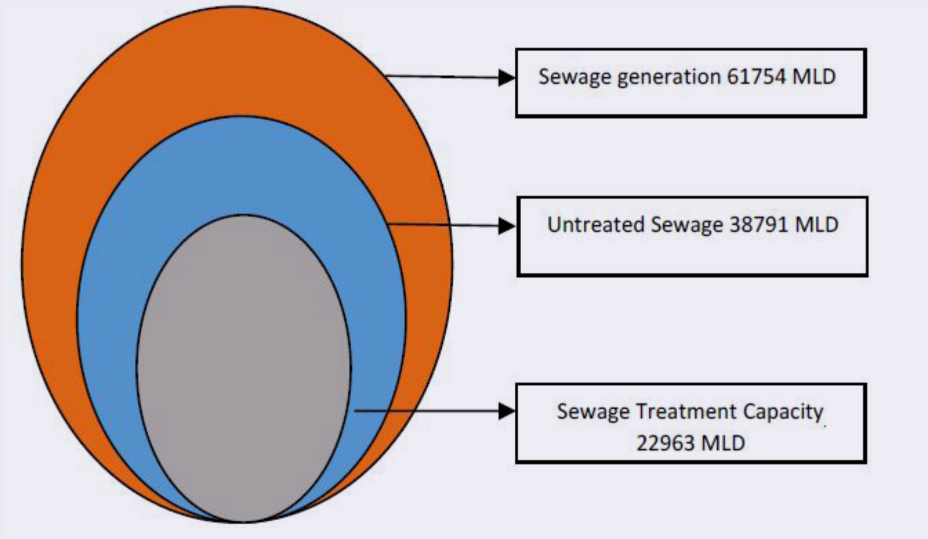
Discharge of untreated sewage into water bodies has resulted in contamination of 75% of all surface water bodies across India (Ministry of Urban Development, 2008).

(b) Wastewater Generation in 2015

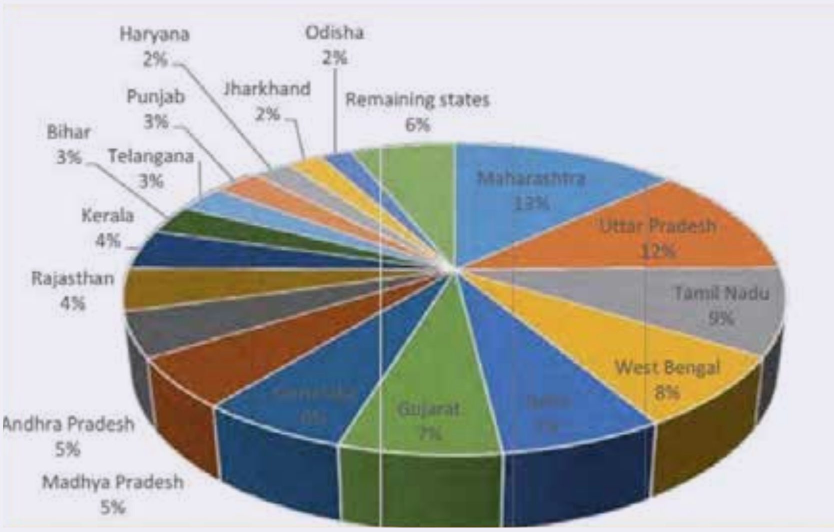
As seen in Graph 5, in 2015, the estimated sewage generation in the country was 61,754 MLD as against the developed sewage treatment capacity of 22,963 MLD (~ 38%). Because of the hiatus in sewage treatment capacity, about 38,791 MLD of untreated sewage (62% of the total sewage) is discharged directly into nearby water bodies (CPCB Bulletin, Vol 1, 2016)

The five states, namely, Maharashtra, Tamil Nadu, Uttar Pradesh, Delhi and

GRAPH 5: STATUS OF SEWAGE GENERATION & TREATMENT – 2015
(CPCB BULLETIN, VOL 1, 2016)



GRAPH 6: STATE-WISE GENERATION OF SEWAGE GENERATION & TREATMENT - 2015 (CPCB BULLETIN, VOL 1, 2016)



Gujarat account for approximately 50% of the total sewage generated in the country. Maharashtra alone accounts for 13% of the total sewage generation in the country. (CPCB Bulletin, Vol 1, 2016) (Graph 6).

Due to agricultural growth, industrialization and urbanization wastewater generation increased in recent years, which is emerging as a potential source for demand management after essential treatment.

(c) Sources of Wastewater

(i) Overview:

(aa) Domestic Sewage
This includes all wastewater generated by home dwellings, public restrooms, hotels, restaurants, motels, resorts, schools, places of worship, sports stadiums, hospitals and other health centres, apartments and the like. They all produce high volumes of wastewater.

(ab) Non-sewage
These include water from floods (storm water), runoff (rain water running through cracks in the ground and into gutters), water from swimming pools, water from car garages and cleaning centres. They also include commercial laundry, commercial kitchens, power generation plants, and so on. Wastewater is also generated from agricultural facilities. Water used for cleaning in animal farms, washing harvested produce and cleaning farm equipment.

(ac) Industrial Wastewater
It is specific for the type of Industry. In India from Tannery to Sugarcane, all industries produce a huge quantity of effluents.

(ii) Constituents of Wastewater

Typical constituents of wastewater are organic and inorganic chemicals, bacteria and other microorganisms (some of which may be pathogenic), fats, oils and grease, etc. The organics and inorganics may be in suspended or dissolved form. Some of these components are nutrients that are useful for plant growth, but cannot be used or harnessed in their present form, mixed in wastewater.

In case of industrial effluents, and in cases of domestic sewage contaminated by mixing of such effluents, there can be various other chemicals (often toxic), such as pesticides, heavy metals, etc.

Today's agricultural run-off emanating from farms where chemical fertilisers and pesticides are extensively used, though not technically "wastewater", have large proportions of these chemicals adding to the toxic load in water.

Many of the chemicals in the above categories are found to disrupt endocrine systems in humans (and therefore, obviously, in other life forms), and are now categorised as "Endocrine Disrupters". Many of the chemicals also do not readily degrade over time and are categorized as Persistent Organic Pollutants (POPs).

Another aspect that may become an area of concern in the years to come are the plethora of pharmaceutical chemicals, the unused components of which get excreted from our body, and obviously find their way to the wastewater stream.

(iii) Wastewater in Urban Areas

In urban areas, wastewater is predominantly from domestic sewage. However, industrial effluents do find their way into the sewage networks. This is partly from small scale units that may be located within residential areas. But the tendency of larger industrial units to dispose their partially treated or untreated effluent into city's sewage networks is not uncommon and cannot be overlooked.

"Septage" is septic tank sludge that is a combination of raw primary sludge and anaerobically produced raw sludge. It has an offensive odour, appearance and contains significant levels of grease, grit, hair, debris and pathogenic micro-organisms. As seen in Figure 1, the Census Data of 2011 shows that about 81%

FIGURE 1: STATUS OF TOILETS AS PER 2011 CENSUS
(CENTRAL PUBLIC HEALTH & ENVIRONMENTAL ENGINEEING ORGANISATION (CPHEEO), NOVEMBER 2013)

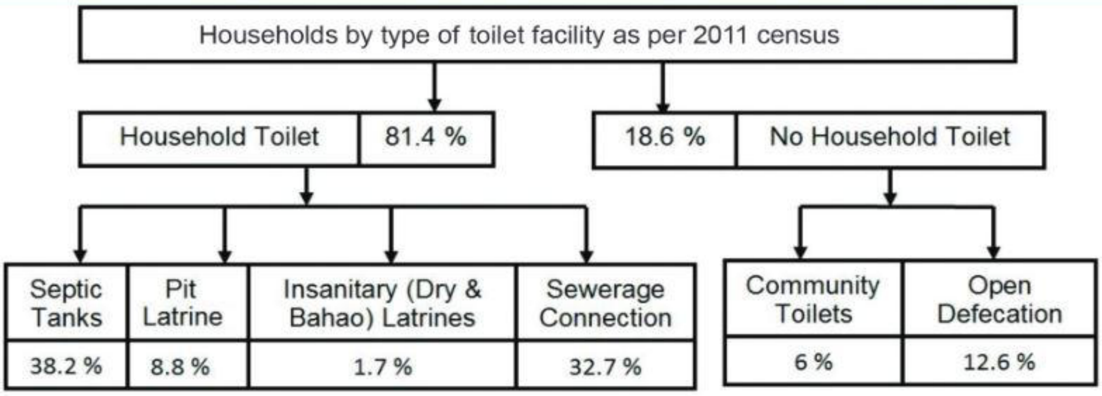


Figure 1.1 Status of Toilets in Urban Households in India

of the urban households have access to a toilet at home. Out of that, 38% of the toilets are based on septic tanks and only 33% are connected to a sewage network.

Septic tanks receive black and/or grey water and separate the liquid from the solid components. A septic tank is generally followed by a soak-pit to dispose of the effluent into the ground. The sludge settled at the bottom and the scum at the top surface of the sewage is allowed to remain in the tank for several months during which they are decomposed by bacteria through anaerobic digestion. Septic tanks are generally provided in areas where a sewerage system is not present and for catering to the sanitary disposal of sewage produced from isolated communities, schools, hospitals and other public institutions.

Septic tanks require de-sludging at regular intervals in accordance with its design and capacity. Often only when a tank gets clogged and filled beyond its holding capacity is de-sludging done. The overflow from the tank finds its way into any nearest waterways or land surface and pollutes it. The effluent and sludge from septic tanks are often rich in phosphates and nitrates. The effluents lead to saturation of surface soil and water bodies with nutrients posing a threat of eutrophication to the surface waters. People and animals in contact with these contaminated areas are susceptible to infections. It also pollutes the groundwater, when the sludge percolates. The leachate from the unmanaged septage virtually disposed on the subsurface can pollute the groundwater. Communities coming in contact with this contaminated soil or water become susceptible to infections and water-borne diseases. (Centre for Science & Environment, New Delhi, May 2011)

(d) Current Status of Wastewater Treatment

(i) Sewage Treatment Plants (STP) and Common Effluent Treatment Plants (CETP):

The status of STPs pan India and of CETPs is summarised in Tables 6 & 7.

TABLE 6 SOURCE CPCB 2016, UPDATED ON DECEMBER 8, 2016

State /UT	Number of CETPs
Andhra Pradesh	11
Gujarat	30
Haryana	14
Himachal Pradesh	1
Jammu and Kashmir	1
Jharkhand	1
Karnataka	9
Kerala	5
Madhya Pradesh	1
Maharashtra	27
NCT of Delhi	13
Punjab	4
Rajasthan	14
Tamil Nadu	49
Uttar Pradesh	8
Uttarakhand	4
West Bengal	1
TOTAL	193

TABLE 7: STATUS OF SEWAGE TREATMENT PLANTS - 2015
(CENTRAL POLLUTION CONTROL BOARD, MARCH 2015)

Sl.No.	Status	Nos. Of STPs	Capacity (MLD)
1.	Operational	522	18883.2
2.	Non-operational	79	1237.16
3.	Under Construction	145	2528.36
4.	Proposed	70	628.64
5.	Total	816	23277.36

As can be seen in data indicated in earlier sections, in 2015, the estimated sewage generation in the country was 61,754 MLD (CPCB Bulletin, Vol 1, 2016). If we look at the installed capacity, only 32.5% of the sewage generated could actually be treated. If only operational STPs are considered, this further drops to 30.5%.

Professor Eldho's compilation of data matches with the above for sewage. He further quotes CPCP, 2009 data that only 60% of industrial wastewater, mostly large scale industries, is treated (Eldho, October 2014).

That means, 70% of the sewage and another significant volume of industrial effluent (40% in 2009) is untreated and is likely to be finding its way to farm lands or nearby water bodies or rivers. Going by Prof. Eldho's observations, the mode of disposal is:

(ad) Indirectly into the rivers/ lakes/ ponds/ creeks in 118 cities

(ae) On to the agriculture land in 63 cities

(af) Directly into rivers in 41 cities

(ag) Discharged both into rivers and on agriculture land in 44 cities

(ah) In many of the coastal cities, the wastewater finds its way into estuaries, creeks, bays, etc.

It is, therefore, no surprise that both groundwater and surface water in many areas in the country are polluted.

(e) Geogenic Pollution of Borewells

Irrational use has led to higher groundwater consumption than recharge. Groundwater levels have reduced drastically in the last 60 years.

Of all the 5723 blocks assessed across India by the Central Ground Water Authority, 839 have been found to be over-exploited, 226 are classified as critical, while 550 are under the semi-critical tag. Thus, as of 2010, around about 29% of India's groundwater blocks are considered to be in need of very careful and judicious action (KPMG International, 2010).

Groundwater contamination is the presence of certain pollutants in groundwater that are in excess of the limits prescribed for drinking water. The commonly observed contaminants include arsenic, fluoride, nitrate and iron, which are geogenic in nature. Other contaminants include bacteria, phosphates and heavy metals which are a result of human activities including domestic sewage, agricultural practices and industrial effluents. The sources of contamination include pollution by landfills, septic tanks, leaky underground gas tanks, and from overuse of fertilizers and pesticides.

It has been pointed out that nearly 60% of all districts in the country have issues related to either availability of groundwater, or quality of groundwater, or both.

Table 8 shows the number of states and districts affected by geogenic contaminants as of July 2014. (PRS Legislative Research, February 2016)

TABLE 8

Geogenic contaminants	Number of affected states	Number of affected districts
Arsenic	10	68
Fluoride	20	276
Nitrate	21	387
Iron	24	297

Source: Central Ground Water Board; PRS.

(f) General Issues Faced in Urban Water Management

All cities are facing water challenges they are not fully equipped to address. From urbanization to climate change and aging infrastructure to water security, cities must identify and prioritize short- and long-term initiatives to sustain or garner a competitive advantage through water. The key challenges faced are explored below.

(i) Rapid Urbanisation
(ii) Water Scarcity
(iii) Water Excess
(iv) Aging and Inadequate infrastructure
(v) Climate Change
(vi) Understanding Water FootprintA product's water footprint

is the volume of freshwater used to produce goods or commodities, taking into account the volumes of water consumed and polluted in different steps of the supply chain. A distinction is made between: Blue water footprint – Volume of surface and groundwater consumed as a result of the production of a good or service

(vii) Green water footprint – Volume of rainwater consumed during the production process

(viii) Grey water footprint – An indicator of freshwater pollution that can be associated with the production of a product over its entire supply chain.

(ix) Direct water use – Refers to the volume of freshwater consumed by a consumer for concrete activities (e.g. cooking or washing) or by a business within a local production process.

(x) Indirect water use – Refers to the volume of freshwater that is embedded in goods that were produced and imported from different regions, such as food, paper, cotton clothes, or in the case of businesses, products from earlier stages of the supply chain. Source: (Water Footprint Network)

4. CURRENT STATUS OF POLLUTION IN RIVERS

(a) Water Quality Monitoring

Central Pollution Control Board (CPCB) is monitoring the water quality of aquatic resources across the country under a three-tier programme, i.e. Global Environmental Monitoring System (GEMS), Monitoring of Indian National Aquatic Resources System (MINARS) and Yamuna Action Plan (YAP). The present water quality monitoring network comprises of 2500 stations covering 28 States and 6 Union Territories across the country.

The parameters monitored include Total Coliforms Organism, pH, Dissolved Oxygen and Biochemical Oxygen Demand (BOD).

Maharashtra, Madhya Pradesh and Kerala have the highest number of river monitoring stations while Delhi, Haryana and Puducherry have the least number of river monitoring stations.

(b) Water Quality Management for Discharge into Rivers / Fresh Water Bodies

The water quality management in India is performed under the provision of Water (Prevention and Control of Pollution) Act, 1974. The basic objective of this Act is to maintain and restore the wholesomeness of national aquatic resources by prevention and control of pollution. The Act does not define the level of wholesomeness to be maintained or restored in different water bodies of the country. The Central Pollution Control Board (CPCB) has tried to define the wholesomeness in terms of protection of human uses, and thus, taken human uses of water as base for identification of water quality objectives for different water bodies in the country.

Since the natural water bodies need to be used for various competing as well as conflicting demands, the objective is aimed at restoring and/or maintaining natural water bodies or their parts to such a quality as needed for their best uses.

TABLE 9: USE-BASED CLASSIFICATION OF SURFACE WATERS IN INDIA (MOEF&CC, 2009)

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	1. Total Coliforms OrganismMPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20 deg C 2mg/l or less
Outdoor bathing (Organised)	B	1. Total Coliforms Organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20 deg C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20 deg C 3 mg/l or less
Propagation of Wildlife and Fisheries	D	1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25 deg C micro mhos/cm - Max.2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l

Thus, a concept of "Designated Best Use" (DBU) was developed. According to this concept, out of several uses a water body is put to, the use which demands the highest quality of water is termed as "designated best use", and accordingly the water body is designated to that. Primary water quality criteria for different uses have been identified. A summary of the use-based classification system is presented in the Table 9 (Centre Pollution Control Board, February 2015).

(c) Causes of Pollution of Rivers

The typical causes of pollution of rivers are the following:

(i) Domestic Sewage, often mixed with storm water

(ii) Industrial Effluents

(iii) Agricultural Chemicals Run-offs

(d) Extent of Pollution of Rivers

Based on the long term assessment of water quality data, 275 rivers out of 445 rivers monitored under the National Water Monitoring Programme are identified as polluted. The sources of pollution range include sewage, industrial effluent and chemicals from agricultural run-off.

The river stretches not meeting the prescribed criteria are designated as polluted stretches. As the level of BOD varies widely in river stretches the same polluted stretches are prioritized in five categories as follows:

(i) Priority Class I: Monitoring locations exceeding BOD concentration 30 mg/l has been considered as the standard of a sewage treatment plant and in a river it appears without dilution. (River locations having water quality exceeding discharge standards for BOD to fresh water sources)

(ii) Priority II: BOD 20-30 mg/l

(iii) Priority III: BOD 10-20mg/l

(iv) Priority IV: BOD 6-10 mg/l

(v) Priority V: BOD 3-mg/l

Table 10 summarises the number of polluted stretches.

Maximum percentage of polluted river stretches is in the states of Maharashtra, Assam and Madhya Pradesh.

TABLE 10: (CENTRE POLLUTION CONTROL BOARD, FEBRUARY 2015)

Priority	Number of Stretches
Priority I	34
Priority II	17
Priority III	36
Priority IV	57
Priority V	158
Total	**302**

5. CURRENT TREATED WATER STANDARDS

Of interest to us in this document are wastewater streams that reach the river, treated or otherwise. The other area of interest is the possibility of treated wastewater for use in irrigation.

The Gazette Notification related to treated effluent standards for various industries and CETPs have been uploaded on the website of MoEF&CC (http://www.moef.nic.in/environmental_standards). The industries are expected to treat their effluents to meet the standards, and the State Pollution Control Boards are responsible for ensuring these are adhered to.

The Economic Times had reported in June 2015 that CPCB was expected to bring in a revised norm for Sewage Treatment Plant discharge. It is not clear if these notifications have been issued. However, a Draft Notification issued on 24 Nov 2015 by MoEF & CC titled "Standards for Sewage Treatment Plants along with Time Frame for Implementation" proposes the following standards (Table 11). It goes on to add that existing STPs are expected to achieve these standards within 5 years of the notification.

TABLE 11

Sl. No.	Industry	Parameters	Standards for New STPs (Design after notification date)*
	Sewage Treatment Plant	pH	6.5-9.0
		BOD	10
		COD	50
		TSS	20
		NH_4-N	5
		N-total	10
		Fecal Coliform (MPN/100ml)	<100

Note:

(i) All values in mg/l except for pH and Coliform.

(ii) These standards will be applicable for discharge in water resources as well as

TABLE 12

Objective of treatment	Primary targets of concrete measures
Removal of Geogenic Substances	Iron, manganese, turbidity, odour, taste, arsenic, nickel, fluoride
Removal of Anthropogenic Substances	Nitrate, organically bound carbon, bacteria, viruses and parasites, pesticides
Increase of the Shares of Recycled Water	Swimming pools (filling water), Industry (food industry) Row water (bank filtration, groundwater recharge)
Protection of Distributed Network	Prevention of corrosion, Prevention of sedimentation, Prevention of bacterial growth
Technical Suitability	Softening of drinking water, miscibility of different waters

Table 12, derived from the 2007 article titled "Drinking water quality: Requirements claimed by National and International Standards" by Hartmut Bartel, (Bartel, 2007), although written in the context of raw water treatment to produce drinking water, is eminently applicable to treated wastewater particularly when we want to consider its treatment, distribution and application for irrigation in organic farms.

6. CHALLENGES OF TREATED WATER QUALITY MONITORING

In the absence of fool proof monitoring and authenticity of water quality test reports, the performance of STPs and ETPs cannot really be ascertained.

Conventional Water Quality Test procedures are lengthy and most STPs/ ETPs maintained in house laboratories are non-functional. The frequency of sampling is usually very low (varies from once in a week to once a month; rarely once in a day). Online real time monitoring sensors and systems available today are the way ahead.

This needs to be coupled with effective inspection by regulatory agencies. Currently, lack of ethics among many pollution regulators renders the law enforcement weak.

Conventional STPs and ETPs also generate a large amount of greenhouse gases. Monitoring air quality is entirely uncharted territory at the moment. The quality of air is equally or even more important for human health as compared to water quality. With advancement of technologies of air quality, such quality monitoring stations need to be established to improve the safety standard of STPs and ETPs.

7. LIMITATIONS / PROBLEMS IN CURRENT WASTEWATER MANAGEMENT SYSTEM:

The gross mismatch between wastewater generation and available operational STPs has already been discussed earlier in this annexure. But apart from this there are other issues that merit mention:

(a) Concerns about Disposal of Untreated Sewage

As has been mentioned earlier, 70% of the sewage and another significant volume of industrial effluent (40% in 2009) is untreated and is likely to be finding its way to farm lands or nearby water bodies or rivers. The mode of disposal is indirectly or directly into rivers/ lakes/ ponds/ creeks, or on agricultural land (Eldho, October 2014).

When disposed into water bodies and rivers, one direct implication is the contamination with nutrients (like nitrates and phosphates), which can lead to eutrophication of the water body. The other direct risk is on health of users of the water due to pathogens and, in case of industrial effluents, toxicity of the chemicals / heavy metals released. If improperly and continuously discharged into the ground, this can lead to contamination of the groundwater also.

But another lesser known, but long-term issue, relates to the loss of phosphorus from its natural cyclic process. This issue is dealt at length in a subsequent section.

(b) Limitations of Centralised Wastewater Collection:

Having a sewage collection network that spans an entire city can potentially have the following problems:

(vi) Onlyone-thirdoftheurbanhouseholdsareconnectedto a sewerage system.

(vii) Only one-third of total wastewater generated is collected in Class I and Class II cities. Only 300-odd cities in India are estimated to have a sewerage network in place. For a set of 1,400 cities, collection efficiency is merely 10 percent.

(viii) Sewerage networks, where they exist, are badly maintained. There are frequent blockages, siltation, missing manhole covers, and gully pits. There is hardly any preventive maintenance, and repairs are made only in case of crises. Often storm water enters sewers, which are not designed to take these loads, leading to overflow onto the surrounding areas. Improper disposal of solid waste also tends to block sewer lines (Wankhade, 2015).

(ix) Thereisasignificantcostassociatedwithitssetup,and adds to the overall cost of centralised treatment setup. These costs cannot be generalised as it depends on the size and density of the city.

(x) Often, the STP is set up but the sewage collection network lags behind, resulting in highly under-loaded operation of the STPs for a prolonged number of years. During this phase, although the STP is available, sewage continues to get disposed outside of the network.

(xi) Atanypointintimetherearerisksofleaksinthesewage network. This can add to the already existing risk of groundwater contamination by sewage loaded with pathogens and nutrients. The same breach provides an access point for storm water into the sewer network during rains, which leads to overloading the STP.

(xii) Sometimes sewage networks are set up but the population build-up to contribute to the sewage is slow. In such cases, the sewage flow is very small and not adequate enough in flow rate to be transported to the STP. This will settle down and solids and sludge will accumulate in the pipes along the way, leading to choking of the network. This will lead to anaerobic conditions resulting in gas (methane, hydrogen sulphide, ammonia, etc.) build-up. It also results in sewage build-up and overflowing out of the network through the manholes located before the choking point. The toxic gas also poses serious health and accident risk to workers who may enter the sewer pipes to clear the choked points.

(c) **Concerns about Underground Sewerage Piping System for Sewage Transport:** (Information that follows is based on a personal conversation with Dr. Biplab Patnaik, Founder MD, Life Link Eco Technologies Pvt. Ltd. (www.lifelink.in))

Traditionally, most Indian cities have open channels for a storm water drainage system which eventually serves as a transport channel for sewage and effluent from human habitation and small scale industries not having captive ETPs.

This is generally considered unhygienic, and therefore, under JNNURM funding, many cities have been provided financial assistance to lay an underground sewerage system to transport sewage to a centralized STP/ETP.

Laying of a sewerage system, involves a huge amount of earth work excavation, and consequently, involves huge cost. Therefore, to reduce the cost of laying, sewer lines are always laid for full flow gradients only. As full flow is not obtained in most situations, the required self-cleansing velocities are not obtained, leading to stagnation due to accumulation of grit, polythene bags, diapers and sanitary pads, and other such deposits, and the sewer lines get choked and start overflowing from the manholes, leading to unhygienic conditions and a lot of inconvenience to the road users and other local residents.

Besides, when manhole covers are opened for maintenance, the poisonous gases generated inside the system come out. These gases are very dangerous to the health of all life forms, and in particular, the sewer line cleaning workers.

Further, it is almost impossible to detect any damage to the underwater sewage pipelines. The resultant leakage of sewage is likely to contaminate the public water supply lines and ground water anywhere along its transmission path.

Lastly, carrying the sewage to the common collection point, and lifting the sewage for its processing also involve huge capital investments and recurring expenses due to energy involved in pumping.

Most of the Class-II cities still have open channels for the disposal of sewage. Hence, the wisest way would be to use the existing channel sewerage network system with suitable modifications. This will avert all the problems associated with underground sewerage systems, apart from saving of a huge sum of money. Such designs are available for implementation.

There has to be a parallel system for storm water drainage alongside open channel for sewage transport in order to avoid intermixing of sewage with storm water. And the underground drainage network is best suited for storm water drainage.

(d) Limitations of Centralised Wastewater Treatment

The centralised STPs also face and result in problems in their operation and maintenance. Some issues are listed below:

(i) It is vulnerable to major fluctuations in hydraulic loads in case there are breaches in the sewage network... low flow in non-monsoon period and overload due to storm water ingress in monsoon. This leads to improper functioning of the STP, resulting in poor quality of treated water and need for additional expenses in maintenance.

(ii) Electricity requirement is continuous for its effectiveness of treatment. Erratic electricity availability will seriously affect quality of treatment.

(iii) Energy requirements are very high and sustained, although system may be under-loaded.

(iv) Any downtime in a centralised system means the entire sewage arriving needs to be disposed as such or otherwise managed pending repairs.

(v) Sludge management is usually an issue due to the smell, particularly during rains. Often, sludge is simply disposed of as solid waste. Such disposal means loss of valuable nutrients, including phosphorus.

(vi) Nitrate management in conventional systems is inefficient. This can result in nutrients build up particularly if treated water is disposed in a surface water system like ponds or rivers. Potentially these nutrients can lead to eutrophication of the water body or river, affecting the other life forms in the water body.

(vii) Permanent loss of phosphorus to aquatic sediments due to improper / inadequate treatment.

(viii) The treated water from Centralized STPs are available at the extreme end of cities and it is cost prohibitive to reach the treated water back to the consumer for secondary usage. This, among other reasons is a case for decentralised STPs.

(e) Concerns about Industrial Effluents

Proper treatment and subsequent reuse of industrial effluent is still a goal by and large not achieved yet. This is largely due to a lack of commitment on the part of the effluent generator, which in turn stems from lack of strictness, and loopholes in the enforcement of norms by the regulators. The incentives for compliance and punitive action for non-compliance are probably inadequate and ineffective, given that wastewater is only now beginning to be seen not as a problem to be disposed of, but as a resource that can be utilised.

Given this background, the typical pollution related issues that stem from industrial effluents are:

(i) Choice of an improper or inadequate ETP, leading to inadequate treatment, and thereby the effluent, although technically treated, is not safe enough for discharge. CETPs are particularly vulnerable from this context, as they cater to a multiple, diverse industrial processes.

(ii) Perception that expenses on ETP is a wasted / unwanted expense. This creates an additional organic and inorganic load (including toxins) on the centralised STP (which is not designed to handle toxic effluents), or directly contaminates the water body, river or land, if not treated at all. In some cases, this way of disposal actually damages the sewerage network itself, which is not designed to transport toxic or corrosive fluids. Typical attempts to short-cut the process include the following:

(aa) Have an ETP for name's sake, but surreptitiously dispose the effluent into the nearest sewer / storm water line, either by the polluter or a hired contractor.

(ab) Run the ETP only for name's sake, either for few hours in a day or run it only prior to visit by the regulator.

(f) Challenges faced by CETP Units:

(ix) Existing treatment schemes are unable to handle ever-increasing hydraulic load, new pollutants, and increasingly stringent regulatory norms.

(x) Improper technological combination for wastewater treatment is discouraging water reuse and recycling.

(xi) Poor management of treatment units.

(xii) No separate treatment units to deal with hazardous and toxic effluents.

(xiii) Dismal percentage of water reuse practice in industries.

(xiv) Lack of access to capital investments and working capitals.

(g) Loss of Phosphorus from Nature's Cycle

Phosphorus is a non-renewable resource, quite limited in availability (unlike nitrogen) in the bio-geo-chemical cyclical process of Nature.

The Phosphorus Cycle in natural terrestrial ecosystems is completely cyclic, involving its uptake into plants, followed by animals on land, and thereafter, its return back to the soil through urine and excreta on a regular basis and as dead plant and animal biomass at the end of their life process.

However, in today's anthropocentric world, the cyclic nature of the phosphorus use is broken, and phosphorus leaks out from terrestrial ecosystems into the aquatic ecosystems, which first creates problems like eutrophication and secondly, is lost almost permanently. This loss is taking place through modern agro-chemical practices and modern day sanitation and sewage systems, which leaches significant amounts of nutrients into the surface and ground waters.

To compensate for this loss, artificial application of phosphorus based fertilisers is resorted to, which is mined from phosphate rock, found only in limited quantities in very few places on the planet (Table 13).It is important to note the following:

(a) Phosphate is a critical resource largely misused and now running low.

(b) Phosphate rock is the world's main source of phosphorus fertiliser. It is a non-renewable resource that has taken 10-15 million years to form from seabed to soil via tectonic uplift and weathering (Global Phosphorus Research Initiative, 2017).

It takes one ton of phosphate to produce every 130 tons of grain, which is why the world mines about 170 million tons of phosphate rock every year to ship around the world and keep soils fertile. (Pearce, July 2011)

All farmers needs phosphorus, yet, 85–90% of the world's reserves of phosphate rock is controlled by just five countries (Morocco, China, Algeria, Syria and South Africa).

Bou Craa, in Western Sahara, now under the political control of Morocco,

	Mine production 2013	Mine production 2014[e]	Reserves[4]
United States	31,200	27,100	1,100,000
Algeria	1,500	1,500	2,200,000
Australia	2,600	2,600	1,030,000
Brazil	6,000	6,750	270,000
Canada	400	--	76,000
China[5]	108,000	100,000	3,700,000
Egypt	6,500	6,000	715,000
India	1,270	2,100	35,000
Iraq	250	250	430,000
Israel	3,500	3,600	130,000
Jordan	5,400	6,000	1,300,000
Kazakhstan	1,600	1,600	260,000
Mexico	1,760	1,700	30,000
Morocco and Western Sahara	26,400	30,000	50,000,000
Peru	2,580	2,600	820,000
Russia	10,000	10,000	1,300,000
Saudi Arabia	3,000	3,000	211,000
Senegal	800	700	50,000
South Africa	2,300	2,200	1,500,000
Syria	500	1,000	1,800,000
Togo	1,110	1,200	30,000
Tunisia	3,500	5,000	100,000
Vietnam	2,370	2,400	30,000
Other countries	2,580	2,600	300,000
World total (rounded)	225,000	220,000	67,000,000

TABLE 13: PHOSPHATE ROCK – WORLD MINE PRODUCTION RESERVES (KILO TONS) (U.S. GEOLOGICAL SURVEY, JANUARY 2015)

is a mine containing one of the world's largest reserves of phosphate rock. (Pearce, July 2011)

Morocco is the world's largest exporter and India is the largest importer. (Pearce, July 2011)

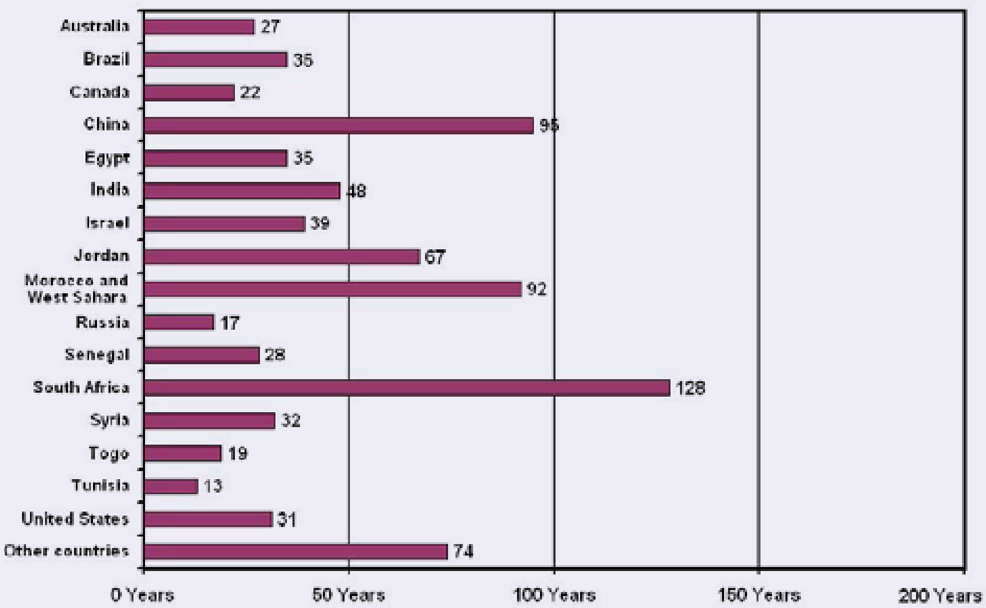
While our bodies only need around 0.4 kg of P each year (1.2 g per day), we are mining 22.5 kg of phosphate rock for each person's diet. Between the phosphate rock mine and the food in our stomachs, up to 80% of P is lost in the process from fertilizer production, application on fields, uptake by crops, food processing and retailing and final consumption. (Global Phosphorus Research Initiative, 2017)

Each year, the human population produces 3 million tonnes of phosphorus in our urine and faeces globally (Global Phosphorus Research Initiative, 2017). These can, potentially, be easily recycled and brought back into our agriculture system.

Figure 2 and Graph 5 explain this scenario.

FIGURE 2 PHOSPHATE ROCK – WORLDWIDE RESERVE ESTIMATES
(ECOSANRES, STOCKHOLM ENVIRONMENT INSTITUTE, MAY 2008)

GRAPH 7: PHOSPHATE ROCK – YEARS OF EXTRACTION REMAINING BASED ON CURRENT RESERVES FROM 2006 USING A 2% YEARLY INCREASE (SOURCE: USGS)
(ECOSANRES, STOCKHOLM ENVIRONMENT INSTITUTE, MAY 2008)



8. CURRENT WATER POLLUTION MITIGATION OPTIONS

(a) Policy Overview

(i) Presently there are NO separate regulations/ guidelines for safe handling, transport and disposal of wastewater in the country.

(ii) As per the Constitution of India (Item No. 5 & 6 of the 12th Schedule of Article 243 W), Water supply and Sanitation is a State subject

(iii) 74th Constitution Amendment Act 1992, provides a framework and devolves upon the urban local bodies for providing water supply and sanitation facilities in urban areas.

(iv) Ministry of Environment and Forests (MoEF), gives technical and financial support schemes for treatment of effluents generated from SSI units located in clusters.

(v) The existing policies for regulating wastewater management are based on certain environmental laws and certain policies and legal provisions like:
(aa) Water Prevention and Control of Pollution Rules, 1975
(ab) National Environment Policy, 2006
(ac) National Sanitation Policy, 2008
(ad) Hazardous Waste (Management and Handling) Rules, 1989
(ae) Municipalities Act; District Municipalities Act

(b) Technologies for Wastewater Treatment

(i) Centralised

(aa) Old-age Natural Systems: Although no longer preferred as solutions there are some old ones still in use.

- Oxidation Pond
- Waste Stabilisation Pond
- Aerated Lagoons
- Constructed Wetlands

(ab) Conventional Treatment Systems: These kind of systems are predominant as on date.

- Activated Sludge Process (ASP)
- Extended Aeration
- Upflow Anaerobic Sludge Blanket (UASB)
- Trickling Filter (TF)

(ac) Some Recent Technologies: These kind of systems are recent but are getting increasingly popular

- Sequential Batch Reactor (SBR)
- Membrane Bioreactor (MBR)
- Moving Bed Biofilm Reactor (MBBR)
- Integrated Membrane Processes (UF-RO, MBR-RO, UF-RO-EDR)

(ii) Decentralised

(aa) Conventional Systems:

Many of the above mentioned centralised systems are available for use at a decentralised level. More popular among them are ASP, SBR, MBR and MBBR.

(ab) Membrane based treatment systems:

Over the past three decades, there has been a world-wide increase in the number of water treatment plants employing cost-effective membrane based wastewater treatment technologies involving membrane bioreactors (MBR) and reverse osmosis (RO). Such technologies have been successfully developed and applied in countries such as Singapore (e.g. NEWater process for wastewater reuse). These can be leveraged for decentralised treatment applications in India at point of generation of waste to prevent direct discharge into rivers, lakes and other aquifers. However, the management of rejects from RO Plants will need to be properly and effectively addressed.

(ac) Alternative Systems:

As the names suggest, the alternative systems differentiate themselves by undertaking wastewater treatment using methods / pathways that deviate significantly from conventional approaches.

- Decentralised Wastewater Treatment System (DEWATS):

This is a system that is based on anaerobic processes. It consists of:

» Settling Tank

» Anaerobic Baffled Reactor

» Anaerobic Filter

» Planted Gravel Filter

DEWAT systems are typically set up for up to 1 MLD wastewater. It is low on energy use, and the water is typically suitable for irrigation. For non-contact applications like flushing, etc. that require higher quality water, additional polishing may be needed.

Since there will be residual nutrients in the treated water, this is not safe enough for release into water bodies without further polishing.

This is an approved technology by (Ministry of Environment, Forests & Climate Change (MoEF&CC, 2009) and Ministry for Drinking Water & Sanitation (MoDW&S, 2015).

Additional information can be obtained from Consortium for DEWATS Dissemination Society (CDD, 2016).

- Soil Biotechnology (SBT):

SBT is a technology developed and patented by Indian Institute of Technology Bombay more than a decade ago. (Shankar, Patnaik, & Bhawalkar, 2002)

An SBT system consists of an impervious containment. Organic wastewater is processed in an ecosystem consisting of soil-like media, bacterial culture, geophagus earthworms, natural mineral additives and select plants. Natural mineral additives are also used as a process regulator in order to archive desired treated water quality. Purification takes place by adsorption, filtration and biological reaction.

The process operates in aerobic mode – thus eliminating possibility of foul odour and pathogens in the process. The wastewater processing area is thus developed into a green belt, which easily integrates into any existing landscape.

Soil- Plant chemistry allows utilisation of pollutants both organic and inorganic from in the process; thus achieving tertiary treatment without use of synthetic chemical in the process. Air quality also improves in the vicinity due to the green belt created.

Unlike conventional systems, zero energy is spent on aeration, and yet, very high levels of aeration are naturally obtained. Energy requirement is only for pumping and distribution of sewage on processing area. Compared to conventional system this is very low (typically 25% of ASP), and the system offers long-term reliability of over 15 years.

Since Dissolved Oxygen (DO) levels are very high, the treated water is also highly compatible to aquatic life and is extremely suitable for release into water bodies. Apart from irrigation, this water, without additional disinfection or processing can be directly used for various non-contact uses like flushing, road / car wash, construction, groundwater recharge, etc.

SBT systems are based on functioning of terrestrial ecosystems in Nature. Therefore, the process, by design, integrates with the natural bio-geochemical cycles of nature and automatically harvests out of the water, and fixes in soil / plant biomass, the valuable nutrients like phosphorus discussed earlier.

Water quality upgradation could also be achieved for different end use applications by suitable SBT process design.

Due to its aesthetic appeal such a system could be located close to habitation or even near waterways. The system owes its stability and sustainability to the biodiversity created. So the processing area could well serve as biodiversity zone and repository of medicinal/

herbal species offering scope for monetization of flower, fibre and medicinal herbs.

This is an approved technology by (Ministry of Environment, Forests & Climate Change (MoEF&CC, 2009) and Ministry for Drinking Water & Sanitation (MoDW&S, 2015)

Additional information can be obtained from IIT Bombay or Life Link Eco Technologies Pvt. Ltd. (Life Link Eco Technologies Pvt. Ltd., 2014), who have pioneered commercialisation of SBT.

- Phytorid

Phytorid is a technology that involves a constructed wetland exclusively designed for the treatment of municipal, urban, agricultural and industrial wastewater. It has been developed by National Environment Engineering & Research Institute (NEERI).

The system is based on the specific plants, such as Elephant grass (Pennisetum purpurem), Cattails (Typha sp.), Reeds (Phragmites sp.), Canna sp. and Yellow flag iris (Iris pseudocorus), normally found in natural wetlands with filtration and treatment capability. Some ornamental as well as flowering plants species can also be used for treatment as well as for landscaping purposes.

The phytorid technology can be constructed in series and parallel modules / cells depending on the land availability and quantity of wastewater to be treated.

The phytorid technology treatment is a subsurface flow type in which wastewater is applied to cell / system filled with porous media such as crushed bricks, gravel and stones. The hydraulics is maintained in such a manner that wastewater does not rise to the surface retaining a free board at the top of the filled media.

The system consists of the following three zones:

» Inlet zone comprising of crushed bricks and different sizes of stones

- » Treatment zone consisting of the same media as in inlet zone with plant species
- » Outlet zone
- » The treated effluent is useful for municipal gardens, fountains and irrigation.

Since the process is partially aerobic and anaerobic, there will be residual nutrients in the treated water – this may not safe enough for release into water bodies without further polishing.

This is an approved technology by Ministry for Drinking Water & Sanitation (MoDW&S, 2015)

Additional information can be obtained from NEERI (www.neeri.res.in)

- Reed Bed

The process was developed in 1970 by Dr Reinhold Kickuth of Germany. The system is most suited to decentralized wastewater treatment in small colonies, hotels, etc.

It is based on the principle of attached growth biological reactors similar to conventional trickling filters with a combination of aerobic and anaerobic zones. The contaminants present in the wastewater are treated as they seep through the root-zone of the plants by a combination of plants, soil, bacteria and hydraulic flow systems resulting in physical, chemical, and microbiological processes. Oxygen present in the zones facilitates the degradation of wastewater.

Relative to other above alternative systems, the area requirement is much higher.

Also, since the process is partially aerobic and anaerobic, there will be residual nutrients in the treated water – this may not safe enough for release into water bodies without further polishing.

This is an approved technology by (Ministry of Environment, Forests & Climate Change (MoDW&S, 2015)

- INTACH's Bacterial Bio-remediation

A bacterial bioremediation process, applied on a polluted flowing river itself, using a combination of dosing of anaerobic bacteria and floating and submerged media has been piloted by Indian National Trust for Art & Cultural Heritage (INTACH) on a stretch of the Assi River near Varanasi.

The results show about 80% reduction in BOD and 50% reduction in COD a month after initiation of the intervention. . (Manu Bhatnagar, INTACH, 2017)

The Case Study section at the end of this chapter provides additional information about this initiative.

Based on the information available, the following may be surmised:

» It is a low-cost intervention that can be immediately applied in its present form in any feasible polluted stretch of rivulets / streams across India.

» While the river water quality has not reached the aspired water quality, the reduction is very significant and warrants its use, particularly as a short-term and medium-term intervention.

» The system in its present form may find immediate application only on river stretches that are not too wide. Modifications for application on wider stretches may need to be worked upon.

» This is an immediate solution for reduction in pollution in river stretches where there are no existing STP facilities resulting in direct disposal of sewage into the river.

- Vetiver System

The Vetiver System – use of South Indian variety of vetiver plants

(*Chrysopogon zizanioides*) – has been extensively used globally for a very wide range of applications including phytoremediation of sewage / wastewater. (Truong, Van, & Pinners, 2009)

This system can be used in rivers to achieve multiple goals simultaneously, such as:

- Its use in floating wetlands can reduce pollutants in static or flowing water
- Its plantation along river bank slopes can not only effect removal of pollutants near the bank but also effect slope stabilisation, soil erosion control, and even reduce the damage to banks in case of floods.

For additional details about the Vetiver System please read Annexure 13 on Vetiver.

9. OPEN CHANNEL SEWER TRANSPORTATION – A REVOLUTIONARY CONCEPT

Dr. Biplab Patnaik, Founder Managing Director of Life Link has conceptualised a revolutionary design and process for safe transportation of sewage using open surface channels, as against underground sewage lines. His system can ensure that the sewage transport can be made safe and hygienic.

This eliminates all the risks and problems associated with underground sewage networks. Existing underground sewage networks can be modified to transport storm water.

Discussions suggest that this option could modified suitably and applied on existing surface sewer networks in many cities and towns.

Additional details can be obtained from Dr. Biplab Patnaik (biplab@lifelink.in).

10. THE GREEN CHEMISTRY & GREEN ENGINEERING – A LONG TERM STRATEGY FOR INDUSTRIAL EFFLUENTS

All the solutions generally discussed get restricted to addressing the manifestation of the disease (in the case of water pollution, it gets restricted to improving the methods of treatment). While this is an inescapable short-term measure, the medium- and long-term vision must examine ways to reduce the pollution load at its source. It is in this context that Green Chemistry offers very interesting possibilities.

The 12 Principles of Green Chemistry and the 12 Principles of Green Engineering are the guiding principles. They are listed at the end of this section.

For example, in a pharmaceutical production process, the current industrial practice is to collect and mix all these effluents together so that the acidic streams partially neutralise the alkaline stream and the neutralisation cost during primary treatment can be reduced. This mixing creates a cocktail of 40-50 different chemicals. It is impossible to separate or recycle them or to recover any solvent or product; the only option is to take the effluent for some end-of-pipe treatments like aerobic or anaerobic treatment, biological or biochemical treatment, incineration, etc.

The key issue here is that this just converts one form of waste into another. Most of the time, we have very little or no idea about the ecological impact of these molecules. Hence, this is potentially a huge threat to human health, our water and other living creatures. It is also a cost-centric approach to dealing with waste and hence adds up to the cost of production. Finally, it is a tremendous waste of resources.

Here is where green chemistry and engineering can play a vital role now and in future. They address the environmental challenges at the source level, rather than on treating waste after it is generated.

All of this might seem significantly challenging and frustrating as we go through the laboratory and scale-up. However, the rewards are enormous, as the process chemistries become simple to execute. Approaching a product from the standpoint of green chemistry offers not only quality products but also lowest cost products. It minimises raw material use, energy use and waste treatment costs.

The total amount saved is estimated to reach $65.5 billion by 2020. Just by bringing inefficient companies up to the baseline standard of the industry as a whole, it is possible to capture more than $40 billion in cost savings and avoided liabilities. (Nitesh Mehta, Dr Komal Maheshwari, November 2012)

Green Chemistry based solutions are being promoted in India by Newreka Green-Synth Technologies Pvt. Ltd. (See www.newreka.co.in) under their Recycle@ Source program. See Case Studies at the end of this annexure.

The 12 Principles of Green Chemistry have been developed by Paul Anastas and John Warner (American Chemical Society, 2017). They are listed below:

a. **Prevention**: It is better to prevent waste than to treat or clean up waste after it has been created.

b. **Atom Economy:** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

c. **Less Hazardous Chemical Syntheses**: Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

d. **Designing Safer Chemicals**: Chemical products should be designed to effect their desired function while minimizing their toxicity.

e. **Safer Solvents and Auxiliaries**: The use of auxiliary substances (e.g. solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

f. **Design for Energy Efficiency**: Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

g. **Use of Renewable Feedstocks**: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

h. **Reduce Derivatives:** Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

i. **Catalysis**: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

j. **Design for Degradation**: Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

k. **Real-time Analysis for Pollution Prevention**: Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

l. **Inherently Safer Chemistry for Accident Prevention**: Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

The 12 Principles of Green Engineering have been developed by Paul Anastas and Julie Zimmerman (American Chemical Society, 2017). They are listed below:

a. **Inherent Rather than Circumstantial**
Designers need to strive to ensure that all materials and energy inputs and outputs are as inherently non-hazardous as possible.

b. **Prevention Instead of Treatment**
It is better to prevent waste than to treat or clean up waste after it is formed.

c. **Design for Separation**
Separation and purification operations should be designed to minimize energy consumption and materials use.

d. **Maximize Efficiency**
Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.

e. **Output-Pulled Versus Input-Pushed**

Products, processes, and systems should be “output pulled” rather than “input pushed” through the use of energy and materials.

f. **Conserve Complexity**
Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition.

g. **Durability Rather Than Immortality**
Targeted durability, not immortality, should be a design goal.

h. **Meet Need, Minimize Excess**
Design for unnecessary capacity or capability (e.g. “one size fits all”) solutions should be considered a design flaw.

i. **Minimize Material Diversity**
Material diversity in multicomponent products should be minimized to promote disassembly and value retention.

j. **Integrate Material and Energy Flows**
Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows.

k. **Design for Commercial “Afterlife”**
Products, processes, and systems should be designed for performance in a commercial “afterlife.”

l. **Renewable Rather Than Depleting**
Material and energy inputs should be renewable rather than depleting.

11. WAY AHEAD

In order to effectively address the issues and find solutions to the pollution of rivers, muti-dimensional strategies will be required.

Based on the understanding of the issues involved as detailed in preceding paragraphs and the options available, the solutions to be proposed needs to factor in the following:

a. The current centralised wastewater treatment capacity can treat only less than 40% of the total wastewater generated in the country. Alternative solutions are needed for managing the balance 60% untreated volume.

b. Nitrate discharge and Phosphate loss into water bodies needs to be stemmed.

c. Ways to reduce the dependence on fresh water by reusing 100% of the wastewater generated.

d. Consequently, Centralised STPs need to ensure delivery of treated water quality suitable for:

   (i) Reuse in the area of generation by industry or domestic users for non-potable, non-contact uses, such as irrigation, flushing of toilets, car wash, construction, etc.

   (ii) Reuse for irrigation of farmland that may be switching to Organic Certification.

   (iii) In the unlikely case that no reuse options are available, safe discharge into rivers and other water bodies without polluting them further may be considered.

e. Given the poor track record of conventional centralised STPs in ensuring water quality, final tertiary / quaternary treatment using chemical-free natural systems such as Soil Biotechnology must be mandatory so that high quality water free of chemicals is available for organic cultivation / other non-potable reuse applications envisaged.

f. Set up mechanisms to process presently untreated sewage and harvest both the water and the nutrients therein. The decentralised route seems to be the most cost-effective way out. Additional centralised treatment options need to be considered only in case space constraints in the area of wastewater generation rules out possibility of decentralised treatment options.

g. Set up mechanisms to manage and process septage and harvest resources therein.

h. Undertake an audit of existing centralised STPs and introduce online automated live monitoring of critical parameters to bring in accountability and reliability in their operation.

i. Switching to surface transport of sewage (with suitable modifications, as proposed by Dr. Biplab Patnaik) and underground transport of storm water will eliminate multiple issues linked to transport of sewage.

j. As an interim measure, inspiration can be drawn from the Bacterial Bioremediation Pilot Project of INTACH on Assi River, which can be suitably adapted and implemented across many polluted stretches of rivers across India.

With the above in view the way ahead is categorised into short-term, medium-term and long-term goals.

Wastewater characteristics	Wastewater quality	Treatment options
Low TDS and low BOD	Low organic	Chemical treatment
Low TDS and high BOD	Organic effluent	Anaerobic + aerobic treatment
Low TDS and high COD	Highly organic	Chemical oxidation by hydrogen peroxide or ozone or sodium hypochlorite Chemical + biological treatment
	Refractory	Chemical oxidation + biological treatment
High TDS	Inorganic salts	Solar evaporation Forced evaporation (after separation of volatile organic matter) Membrane separation
High TDS and high COD	Highly organic effluent	Incineration (based on calorific value) +Secure landfill of incineration ash
	Waste is not easily biodegradable but toxic	Thermal Decomposition Chemical oxidation (hydrogen peroxide, ozone, *etc.*) Evaporation + Secured landfill
	Waste is not toxic but mostly inorganic salts	Chemical treatment (recovery, precipitation *etc.*) Evaporation + secured landfill of evaporated residue

TABLE 14: GUIDELINES FOR SELECTION OF ETP
(ELDHO, OCTOBER 2014)

(a) Short Term Goals:

(i) Review current standards of water quality to be achieved for Treated Water particularly for release into water bodies / rivers.

(ii) Promulgate revised standards if need be, for use in irrigation of crops by farmers, to make it safe for meeting Organic Farming standards.

(iii) Commission a detailed technical audit to evaluate and establish current status of centralised STPs. The following could be some Terms of Reference for this exercise:

(aa) Mechanisms for testing of wastewater parameters of incoming effluent and outgoing treated water, and reliability of the mechanisms in use

(ab) Parameters being tested regularly, and modifications, any that may be needed, to ensure adequate quality for reuse for irrigation of Organic Farms or for safe discharge into water bodies or rivers

(ac) Status of machinery and their upkeep

(ad) Availability and consumption patterns of electricity

(ae) Evaluation of residual life of the STP based on assessment of the machinery, civil structure, etc.

(af) Use this and more data to calculate the Operation & Maintenance costs of running the STP

(ag) Recommendation on instrumentation and electronics required for live online monitoring of functioning of all STPs

(iv) Add a suitably designed natural treatment system (such as one based on Soil Biotechnology) to ensure the tertiary chemical-free treatment of treated water from centralised STPs. This will ensure the treated water is suitable for use for organic agriculture.

(v) All new centralised sewage collection networks must capitalise and expand on the existing surface open sewer network (in lieu of setting up underground sewage networks). Technical design and methodology for this possibility is available with Life Link Eco-technologies Pvt. Ltd.

(vi) Promote Decentralised Wastewater Treatment and reuse for those areas not yet connected to the centralised sewage network.

(vii) Bacterial Bioremediation pilot project of INTACH on Assi river, should be suitably adapted and implemented across many polluted stretches of rivers across India. Floating wetland designs proposed by various institutions such as INTACH, Vetiver Network International and Life Link Eco Technologies Pvt. Ltd. must also be concurrently implemented with such initiatives.Introduce system for Septage Management. Actionable way forward has been suggested in the "Policy Paper on Septage Management in India" (Centre for Science & Environment, New Delhi, May 2011)

(viii) Review and revise Urban Water Management & Planning. The Sustainable Cities Water Index (Arcadis, 2015) and the Case Studies cited therein may be used as a reference and guidance point.

(ix) CPCB to set up mechanisms to ensure that ETPs are set as per technical requirement of the effluent. A suggestive guideline is indicated in Table 14, but a lot of detailing is required.

(x) Awareness generation in communities for managing pollution and usage of treated water for irrigation, by involving reputed on-field NGOs if need be (such as Pani Foundation).

(b) Medium-Term Goals:

(i) Ensure compliance of all STPs / ETPs (including older STPs / ETPs) to revised, more stringent norms.

(ii) Set up live online monitoring systems for STPs, building up on the presently established ENVIS databases.

(iii) Privatise the Operation & Maintenance of all the centralised STPs, and build in a revenue model to make the person / institutions generating wastewater to pay for the service on the one side, and generate revenue from sale of the high quality treated water now available. This water can be made available to industries and for irrigation.

(iv) Set up underground storm water network where surface sewage transport has been set up.

(v) Initiate process of interchanging the storm water from surface to underwater, and sewage from underground to surface in areas where underground sewage network has been set up.

(vi) Set up a Unified Regulator and Advisor on Pollution. This could be along the lines of Telecom Regulatory Authority or Insurance Regulatory Authority, who will be mandated to ensure that the now privatised STPs are functioning as per desired standards.

(vii) Incentivise industries willing to invest in Green Chemistry R&D directed towards reducing effluent and recovering resources from their “waste”. The viability of this approach is demonstrated in the Case Study of Recycle@Source Solutions by Newreka Green-Synth Technologies Pvt. Ltd. (Nitesh Mehta, Dr Komal Maheshwari, November 2012)

(c) Long-Term Goals

(i) Move towards Sustainable Smart Cities and Sustainable Smart Villages.

(ii) Ensure treatment of 100% sewage and its reuse in irrigation and other non-potable use.

(iii) Promote EcoSan (short for Ecological Sanitation) as a solution for rural sanitation. (Department for Natural Resources and the Environment, SIDA, 1998)

(iv) Make Green Chemistry and Green Engineering a mandatory pre-requisite for all industries.

12. CONCLUSION

All said and done, in the long term, unless and until we, as individual citizens, become conscious enough and are willing to take the responsibility for the resources that we use and waste that we generate, it will be difficult to sustain a clean and green plant.

But until that level of consciousness is reached, mandating responsible behaviour through regulation, followed by enforcement with punitive action on defaulters is perhaps inescapable.

This needs to be coupled with policies that promote incentivised options that shift the perception from “waste” to “resource”, making it economically attractive to opt for recycling of resources rather than disposing of them. From this point of view, funding research on Green Chemistry and incentivising industries willing to invest R&D efforts to align their production processes to the guiding principles of Green Chemistry will be more than well worth it.

13. CASE STUDIES

(a) Singapore’s NEWater: (Pricewaterhouse Coopers, September 2016)

Singapore’s success in using treated wastewater (referred to as NEWater) for industrial supply is a good case in point and is relevant to the discussion on water supply and reuse of treated wastewater in India.

Singapore imports water from Malaysia, and has very limited sources of water within its boundaries. Since 1958, the country has consistently sought to improve its water security by improving rainwater harvesting and by source diversification. Reuse of treated wastewater is one of the four ‘national taps’, alongside desalination, rainfall and imports. NEWater contributed towards one-third of the water supplied in Singapore.

NEWater plants use an advanced tertiary treatment process that has three stages—microfiltration/ultrafiltration, reverse osmosis, and ultraviolet treatment. The quality of NEWater meets the standards of freshwater from the catchment lakes.

NEWater is directly supplied to industries to meet the non-potable water demand, which accounts for 55% of the total water demand. Only a small proportion of NEWater is used to augment freshwater in reservoirs for indirect potable reuse.

By 2060, it is estimated that approximately 70% of water demand in Singapore will be non-domestic, and NEWater capacity would be expanded to provide for 55% of total water demand.

The cost of producing NEWater is in the range of 0.30–0.50 SGD per cubic metre, lower than the cost of producing desalinated water (0.50–1.00 SGD per cubic metre). This has led the government to focus on development of NEWater systems as a viable strategy to achieve self-sustenance in the water sector. The tariff for NEWater is set at 1.9 SGD per cubic metre and reflects the full life cycle cost of producing and supplying NEWater.

There are four NEWater plants in Singapore with a combined production capacity of 531 million litres per day (MLD). A further 227 MLD is expected to come online by the end of 2016. Two plants are operated by the Public Utility Board (PUB), the public water utility of Singapore, while the other two are operated by private companies under the Design Build Own Operate (DBOO) model.

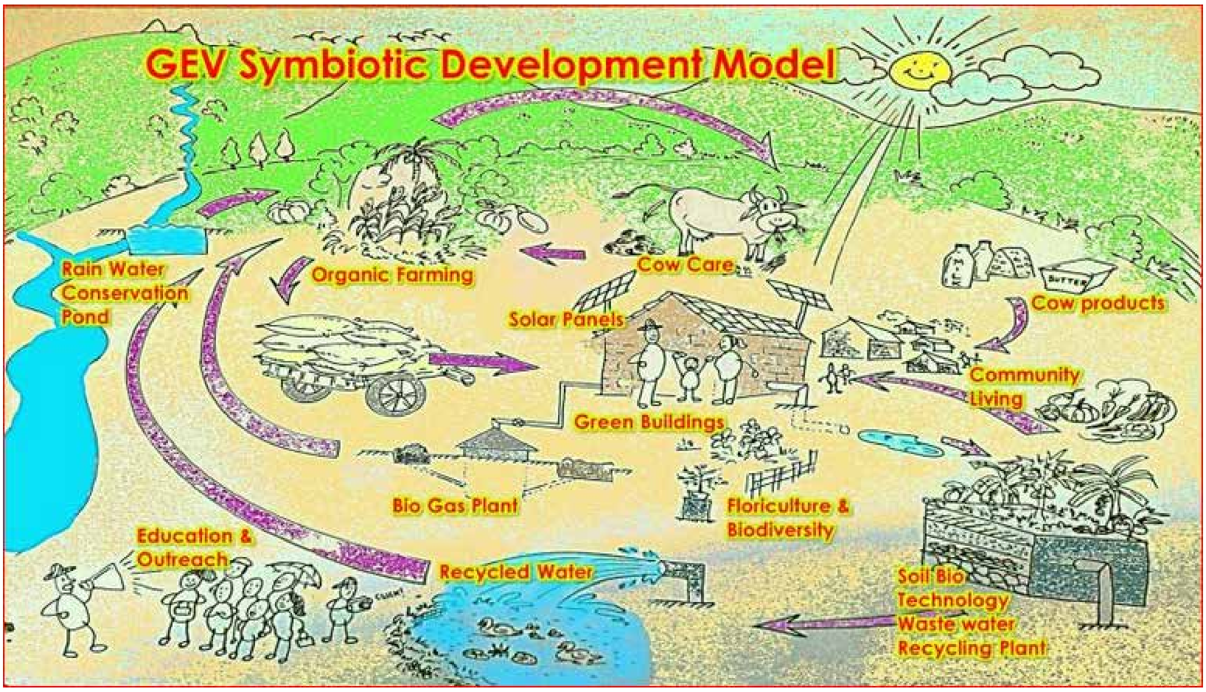
(b) Govardhan Eco Village

Govardhan Eco Village (GEV), a 70-acre sustainable farming community and retreat centre on the foothills of the Sahyadri Mountains, 108km north of Mumbai, India. It was founded by Radhanath Swami, the spiritual mentor for International Society for Krishna Consciousness (ISKCON)'s Centre in Chowpatty, Mumbai. He envisioned a sustainable farm community in India and inspired his followers to create GEV.

Despite its humble beginnings in 2003, GEV is now an award-winning eco-community where the technology of modern science combines with Vedic wisdom.

The range of initiatives of this community includes organic farming, livestock care, eco-friendly architecture, water conservation measures, recycling of wastewater and organic solid wastes through Soil Biotechnology based processes, use of alternative energy options like solar power, etc. (See Fig 3)

FIGURE 3



Their social initiatives include projects related to rural employment and education, promotion of arts and handicrafts, etc.

Their work has found recognition in many a forum, some of which are listed below:

(i) Smart Cities India Award (May 2017) in the "Smart Village Award" category for being a sustainable project in Wada district of Maharashtra

(ii) UNWTO Award for Excellence and Innovation in Tourism in the NGO Sector Jan 2017 Madrid Spain

(iii) Best Green Water Stewardship Award - Golden Globe Tigers Summit, Kuala Lumpur 2015

(iv) Green Apple Environment Award (Nov 2015) for Environmental Best Practice

(v) Aqua Excellence Award at the IX World Aqua Congress (Nov 2015) for

Outstanding Contribution towards cause of Sustainability – Social Sector

(vi) SKOCH Renaissance award for water conservation - 2013 - Presented by Mr. P. Chidambaram (ex-Finance Minister, India), Mr. Montek Singh Ahluwalia (Ex Deputy Chairman, Planning Commission of India)

(vii) Listing in the Limca Book of Records for its agricultural innovation in restoring a 4-acre wasteland into a cultivable vegetable garden

(c) Recycle@Source Solutions by Newreka Green-Synth Technologies Pvt. Ltd.

Green Chemistry based solutions are being promoted in India by Newreka Green-Synth Technologies Pvt. Ltd. (See www.newreka.co.in) under their Recycle@Source program.

In Recycle@Source systems, the effluent stream is treated with a customised proprietary performance additive, which selectively removes the organic and inorganic impurities to the maximum possible extent, without removing the intermediate or finished product. Thus the same stream can be recycled back into the same process step as reaction or extraction medium – hence the name.

This is not the same as conventional zero liquid discharge systems where treated water is reused in ways other than the process from which it was generated. Recycle@Source, means recycling the entire liquid effluent stream generated from a particular process, back to the same process. It is inherent, a profit centre, systematic, preventative, simple, integral and in-built.

Recycle@Source enables the industry to:

(i) Eliminate or minimise the liquid effluent load

(ii) Increase productivity, where effluent load handling is a limitation to expanding capacity

(iii) Enhance yield, as intermediate or finished products being lost in the aqueous effluent stream are recycled back

(iv) Ensure consistent quality (Their proprietary catalyst does not allow impurities to build up)

(v) Improve overall economics

(vi) Reduce the cost of effluent treatment and disposal

This is illustrated in the following two case studies:

(i) CASE STUDY 1: (Nitesh Mehta, Dr Komal Maheshwari, November 2012). The conventional process in the production of an intermediate for an anti-retroviral drug used Raney nickel as a reduction catalyst, with a solvent as the reaction medium and another for product extraction.

When Green Chemistry was implemented, the solvent was replaced with water as a reaction medium, Raney nickel was replaced with a proprietary, non-pyrophoric and safe to handle reducing agent and high pressure was replaced with atmospheric pressure, a temperature below 100°C and a pH of 5-7.

In the last three years, the customer has not used fresh water in the batches, except to make-up for evaporation loss. Yields have improved by 10% compared to the conventional catalytic hydrogenation process. This has saved over 1 million litres of fresh water. The product amine quality is consistently more than 99% on High Performance Liquid Chromatography (HPLC) with 10% yield improvement per recycle.

(ii) CASE STUDY 2: (Nitesh Mehta, Dr Komal Maheshwari, November 2012)

H-acid is one of the oldest and largest volume dye intermediates being manufactured. India alone produces 20,000 tonnes/year. H-acid is known as one of the most polluting intermediates in this industry sector, with an E-factor of about 50, and this waste contains carcinogenic naphthalene-based molecules. The high E-factor is also an indicator of process inefficiency. Only 53% of theoretical yield is achieved.

A highly acidic mother liquor gets generated which is deep red in colour, with a COD of 150,000 and TDS of 15-25%. Currently, this effluent is taken for some end-of pipe treatment but none of the conventional primary or secondary treatments can break down the naphthalene-based organic molecules in the mother liquor. Each kilo of H-acid generates 25 kg of hazardous aqueous effluent stream.

Using Recycle@Source, it has been possible to recycle this mother liquor back into the process to dilute the reaction mass obtained after fusion more than 15 times, which reduced the effluent load by 90%. The mother liquor obtained after isolation is taken for treatment with a catalyst selectively to remove undesired impurities, then recycled back into the process instead of water. This solution gives an overall 10% rise in yield. Even after 15 recycles, the quality of H-acid is consistently as per the standards.

(d) INTACH's Bacterial Bio-remediation (Manu Bhatnagar, INTACH, 2017)

bacterial bioremediation process, applied on a polluted flowing river itself, using a combination of dosing of anaerobic bacteria and floating and submerged media has been piloted by Indian National Trust for Art & Cultural Heritage (INTACH) on a stretch of the Assi River near Varanasi.

The 3.5 km long Assi river flows through some very densely populated built-up areas directly discharging wastewater and dumping garbage, including carcasses, directly into the river. The entire stretch has also been severely encroached.

The discharge in the river is estimated to be between 65 to 70 MLD. The water is fast flowing owing to the elevation difference of 27m between origin and river level.

The interventions undertaken were as follows:

(i) Dosing of Bacteria Concentrates: Naturally occurring, anaerobic and facultative live bacterial strains (100 litres of concentrate per day dosed into the stream at 6 carefully selected locations). The bacteria degrades organic pollutants, enhances dissolved oxygen levels and removes odours.

(ii) Increase retention time by installing soil bag weirs: Create a lagoon on the upstream side allowing settling and allow for greater retention period on the otherwise fast flowing stream

(iii) Installation of coir log bundles: Coconut coir logs are specially redesigned with coco-peat inside the core. This serves as a medium for bacteria to reside, grow and treat the pollutants, serves as a filtering medium to a certain extent and serves to reduce the velocity of water flow by obstructing the flow. 75 logs were dispersed and anchored at 20 locations.

(iv) Installation of submerged Bio-Media: Two types of Bio-Media were adopted:

(aa) Submerged Bio-Media which serves as medium for anaerobic bacteria to reside, grow and treat the pollutants

(bb) Moving Bed Bio-Media which serves as a medium for the facultative bacteria

(v) Manual removal of floating waste: done to provide an aesthetic appearance and to retain operational efficiency.

The cost of bioremediation treatment was Rs. 4.24 Cr annually in the first year with cost reducing to Rs. 3.75 crores in subsequent years at constant price.

The effectiveness of this intervention is seen in Table 15.

TABLE 15: CHANGES IN WATER QUALITY PARAMETERS BY BIO-REMEDIATION IN ASSI RIVER

PARAMETER	Pre Treatment	Intermediate Stage [14 Days]	AFTER 30 Days Of Treatment	% REDUCTION ACHIEVED
B.O.D	185	69.7	30	83.7 %
C.O.D	240	232	120	50 %
T.S.S	196	228	116	50 %
Oil & Grease	04	Nil	Nil	

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ANNEXURE 3

CLIMATE CHANGE AND BUILDING RESILIENT COMMUNITIES

Swayamprabha Das, Ph.D.[1]

ABSTRACT

Environment being a complex web of functional ecosystems that criss-cross and interweave across geographic, physical and biological peripheries, it is important for the communities to protect their livelihoods in the wake of climate change and emerging climate crisis.

Climate change affects the balance of natural ecosystems (i.e. forests, river basins, sea level) and socio-economic systems (i.e. agriculture, fisheries, irrigation and power projects). The impacts arise through changing temperature, precipitation, rising sea levels, and the increase in the number and intensity of natural disasters. Such occurrences affect water and food security, and leave behind a long term impact on agriculture, water resources and sanitation, forests and biodiversity. Challenges from climate change can be reduced if the communities are supported with scientific evidence and suitable technological advancement for uptake of climate adaptive practices.

This paper attempts to present a glimpse of the food-water/river-climate change nexus from a common man's perspective. It is important to note that river bank plantation and horticulture tree plantation are to be understood in the context of safeguarding the communities at risk from extreme weather conditions that leads to breakdown of economic-social-cultural fabric.

1. INTRODUCTION: CLIMATE CHANGE, FORESTS AND WATER

Climate change[1] is perhaps emerging as one of the greatest environmental challenges of the twenty-first century, that is further intensified due to population growth, economic development and increased demand on the natural

[1] Development professional (Policy and programmes) and Isha volunteer

resources for food and energy needs. As scientific evidences and information on global warming emerges, the role of forests and associated ecosystems assume greater relevance in the context of climate change.

In recent decades, changes in climate have impacted natural and human systems, indicating the sensitivity of natural and human systems to changing climate. Changing precipitation patterns, changing seasons and changes in cropping season, ocean acidification, migration of species due to fluctuations in temperature are some of the visible changes recorded. Pollution (air, water, soil), soil degradation, desertification and deforestation are some of the ramifications that have aggravated poverty, and impacted health and food security. Climatic variations or extreme weather conditions are leading to periodic droughts and floods, affecting large numbers of population, among which the poor and the marginalized are affected the most. Since people's lives, livelihoods and the environment are intertwined, it necessitates a comprehensive approach to protecting our natural resources and securing livelihoods in the wake of climatic variations.

Climate being an inter-play between the elements in nature – land, water and air – forests and water bodies (rivers, wetlands, etc.) inevitably take the centre stage in the discourse on climate change. As per FAO, forests have four major roles in climate change: they currently contribute about one-sixth of global carbon emissions when cleared, overused or degraded; they react sensitively to a changing climate; when managed sustainably, they produce woodfuels as a benign alternative to fossil fuels; and finally, they have the potential to absorb about one-tenth of global carbon emissions, projected for the first half of this century, into their biomass, soils and products and store them – in principle in perpetuity.[2]

As the climate regulation capacity of many ecosystems deteriorates and/or experiences abrupt and non-linear changes, plant and animal populations will experience negative impacts at local and regional scales. These impacts may include all of the climate change effects already predicted or chronicled – changes in the timing and distribution of water (e.g. droughts, floods, snowpack availability); increases in insects, invasive species, and disease; habitat and biodiversity loss; and shifts in species ranges. In addition, ecosystem services degradation often leads to declines in human well-being. This is especially true in agrarian/rural communities and developing nations, where declines in ecosystem services can have a rapid, direct impact on incomes and standards of living, exacerbating poverty and increasing inequality[3]. A warming planet and changing climate will also alter the distribution, volume, timing, and type of precipitation, as well as modify the distribution and timing of water needs. The water supply and storage network designed for pre-change conditions will be less suitable for the new conditions. Meanwhile, increasing populations and warmer conditions will increase the demand for water. Climate change will also probably alter the quality of water, affecting the effectiveness of water supplies needed for certain purposes.

IPCC Fifth Assessment Report(AR5)[4] mentions that: "In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate. Evidence of observed climate change impacts is strongest and most comprehensive for natural systems. Some impacts on human systems have also been attributed to climate change, with a major or minor contribution of climate change distinguishable from other influences (Figure 1.11). Impacts on human systems are often geographically heterogeneous because they depend not only on changes in climate variables but also on social and economic factors. Hence, the changes are more easily observed at local levels, while attribution can remain difficult. [WGII SPM A-1, SPM A-3, 18.1, 18.3–18.6]. Probably improved understanding of the risks and impacts of climate change on sensitive/fragile ecosystems like the forests and water bodies like rivers will help to identify, prioritize and undertake practical actions in climate change adaptation and mitigation.

The most dominant climate drivers for water availability are precipitation, temperature and evaporative demand (determined by net radiation at the ground, atmospheric humidity and wind speed, and temperature). Temperature is particularly important in snow-dominated basins and in coastal areas, the latter due to the impact of temperature on sea level (steric sea-level rise due to thermal expansion of water). [WGII 3.3.1] In short, the total annual river runoff over the whole land surface is projected to increase, even though there are regions with significant increase and significant decrease in runoff. However, increased runoff cannot be fully utilised unless there is adequate infrastructure to capture and store the extra water. Over the oceans, a net increase in the term 'evaporation minus precipitation' is projected.[5]

Changing conditions will lead to habitat changes, biodiversity loss, migration of species; it is but expected that these factors play a role in how rivers will be affected by climate change. Streams, ponds and other water bodies will be affected differently based on their geo-positioning and their resilience to stress from natural and man-made changes. With temperatures expected to rise 1-8 degrees Celsius by 2050, climate change, it is projected, will cause a varied amount of effect on river ecosystem.

River ecosystems have been severely impacted by a multitude of human uses over decades. Water abstraction, damming, pollution and habitat modification have dramatically diminished the functionality of these systems. Small mountainous streams that are usually less inhabited, remained relatively undisturbed, whereas the rivulets and smaller tributaries in the plains and in the southern peninsula face greater challenges from human interface. Physical alterations in catchments affect most rivers, disrupt their continuum and the interactions between the stream and its terrestrial surroundings. Thereby, they affect biodiversity at large.[6]

Climate change as a stressor operates across ecological zones and biomes that are contingent upon interaction and linkages with air, water and soil – in other words, are sensitive to changes in temperature and precipitation.

2. CLIMATE CHANGE IMPACTS IN INDIA

India is a mega-diverse country with agro-ecological zones ranging from the Himalayas to the plains to the deserts to the plateaus to coastal areas and islands. India is also a land of rivers, that help regulates groundwater recharge, support vegetation on their banks, and provide a habitat for fishes and aquatic wildlife in their waters. The river also transports and distributes, free of cost, sand and sediments that are utilised for construction. But then the rivers and associated ecosystems are under duress from natural and anthropogenic impacts that threaten to destabilise the entire ecosystem. Running waters are particularly vulnerable to global change and its associated stressors because they are relatively isolated and fragmented within terrestrial landscapes and are already heavily exploited for the goods and services they provide. Only 0.006% of the world's surface is represented by running waters, yet freshwater ecosystems contain approximately 6% of all described species, many of which have restricted thermal and hydrological tolerances (Perkins *et al* 2010).[7]

The World Bank Group commissioned the Potsdam Institute for Climate Impact Research and Climate Analytics to look at the likely impacts of temperature increases from 2ºC to 4ºC in three regions. The scientists used the best available evidence and supplemented it with advanced computer simulations to arrive at likely impacts on agriculture, water resources, cities and coastal ecosystems in South Asia, Southeast Asia and Sub-Saharan Africa. Some of their findings for India include[8]:

EXTREME HEAT

What we know	India is already experiencing a warming climate.
What could happen	Unusual and unprecedented spells of hot weather are expected to occur far more frequently and cover much larger areas. Under 4°c warming, the west coast and southern india are projected to shift to new, high-temperature climatic regimes with significant impacts on agriculture.
What can be done	With built-up urban areas rapidly becoming "heat-islands", urban planners will need to adopt measures to counteract this effect.

CHANGING RAINFALL PATTERNS

What we know	A decline in monsoon rainfall since the 1950s has already been observed. The frequency of heavy rainfall events has also increased.
What could happen	A 2°C rise in the world's average temperatures will make India's summer monsoon highly unpredictable. At 4°C warming, an extremely wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century. An abrupt change in the monsoon could precipitate a major crisis, triggering more frequent droughts as well as greater flooding in large parts of India. India's northwest coast to the south eastern coastal region could see higher than average rainfall. Dry years are expected to be drier and wet years wetter.
What can be done	Improvements in hydro-meteorological systems for weather forecasting and the installation of flood warning systems can help people move out of harm's way before a weather-related disaster strikes. Building codes will need to be enforced to ensure that homes and infrastructure are not at risk.

DROUGHTS

What we know	Evidence indicates that parts of South Asia have become drier since the 1970s with an increase in the number of droughts. Droughts have major consequences. In 1987 and 2002-2003, droughts affected more than half of India's crop area and led to a huge fall in crop production.
What could happen	Droughts are expected to be more frequent in some areas, especially in northwestern India, Jharkhand, Orissa and Chhattisgarh. Crop yields are expected to fall significantly because of extreme heat by the 2040s.
What can be done	Investments in R&D for drought-resistant crops can help reduce some of the negative impacts.

AGRICULTURE AND FOOD SECURITY

What we know	Even without climate change, world food prices are expected to increase due to growing populations and rising incomes, as well as a greater demand for biofuels. Rice: While overall rice yields have increased, rising temperatures with lower rainfall at the end of the growing season have caused a significant loss in India's rice production. Without climate change, average rice yields could have been almost 6% higher (75 million tons in absolute terms). Wheat: Recent studies shows that wheat yields peaked in India and Bangladesh around 2001 and have not increased since, despite increasing fertilizer applications. Observations show that extremely high temperatures in northern India – above 34°C – have had a substantial negative effect on wheat yields, and rising temperatures can only aggravate the situation.
What could happen	Seasonal water scarcity, rising temperatures, and intrusion of seawater would threaten crop yields, jeopardizing the country's food security. Should current trends persist, substantial yield reductions in both rice and wheat can be expected in the near and medium term. Under 2°C warming by the 2050s, the country may need to import more than twice the amount of food-grain than would be required without climate change.
What can be done	Crop diversification, more efficient water use, and improved soil management practices, together with the development of drought-resistant crops, can help reduce some of the negative impacts.

GROUNDWATER

What we know	More than 60% of India's agriculture is rain-fed, making the country highly dependent on groundwater. Even without climate change, 15% of India's groundwater resources are overexploited.
What could happen	Although it is difficult to predict future groundwater levels, falling water tables can be expected to reduce further on account of increasing demand for water due to a growing population, more affluent lifestyles, as well as the services sector and industry.
What can be done	The efficient use of groundwater resources will need to be incentivized.

GLACIER MELT

What we know	Glaciers in the northwestern Himalayas and in the Karakoram range – where westerly winter winds are the major source of moisture – have remained stable or even advanced. On the other hand, most Himalayan glaciers – where a substantial part of the moisture is supplied by the summer monsoon – have been retreating over the past century.
What could happen	At 2.5°C warming, melting glaciers and the loss of snow cover over the Himalayas are expected to threaten the stability and reliability of northern India's primarily glacier-fed rivers, particularly the Indus and the Brahmaputra. The Ganges will be less dependent on melt water due to high annual rainfall downstream during the monsoon season. The Indus and Brahmaputra are expected to see increased flows in spring when the snows melt, with flows reducing subsequently in late spring and summer. Alterations in the flows of the Indus, Ganges, and Brahmaputra rivers could significantly impact irrigation, affecting the amount of food that can be produced in their basins as well as the livelihoods of millions of people (209 million in the Indus basin, 478 million in the Ganges basin, and 62 million in the Brahmaputra basin in the year 2005).
What can be done	Major investments in water storage capacity would be needed to benefit from increased river flows in spring and compensate for lower flows later on.

WATER SECURITY

What we know	Many parts of India are already experiencing water stress. Even without climate change, satisfying future demand for water will be a major challenge. Urbanization, population growth, economic development, and increasing demand for water from agriculture and industry are likely to aggravate the situation further.
What could happen	An increase in variability of monsoon rainfall is expected to increase water shortages in some areas. Studies have found that the threat to water security is very high over central India, along the mountain ranges of the Western Ghats, and in India's northeastern states.
What can be done	Improvements in irrigation systems, water harvesting techniques, and more-efficient agricultural water management can offset some of these risks.

2.1 Projection of Change in Freshwater Availability

According to the IPCC reports, the per capita availability of freshwater in India is expected to drop from around 1,820 m^3 currently to below 1,000 m3 by 2025 in response to the combined effects of population growth and climate change. [WGII 10.4.2.3] More intense rain and more frequent flash floods during the monsoon would result in a higher proportion of runoff and a reduction in the proportion reaching the groundwater. [WGII 10.4.2] Agricultural irrigation demand in arid and semi-arid regions of east Asia is expected to increase by 10% for an increase in temperature of 1°C. [WGII 10.4.1] Coastal areas, especially heavily populated Asian megadelta regions, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from rivers. [WGII 6.4, 10.4.3] Changes in snow and glacier melt, as well as rising snowlines in the Himalayas, will affect seasonal variation in runoff, causing water shortages during dry summer months. One-quarter of China's population and hundreds of millions in India will be affected (Stern, 2007). [WGII 3.4.1, 10.4.2.1][9]

According to the 2013 World Bank report, major rivers such as the Ganges, Indus and Brahmaputra, depend significantly on snow and glacial melt water, which makes them susceptible to climate-change induced glacier melt and reductions in snowfall. The report projects a rapid increase in the frequency of low snow years in the future, well before 2°C warming takes place. This could increase the risk of flooding, threatening agriculture.[10]

Variation in river flows from year to year is also very strongly influenced in some regions by large-scale atmospheric circulation patterns associated with ENSO, NAO and other variability systems that operate at within-decadal and multi-decadal time-scales. [WGII 1.3.2.1][11] Floodplains and rivers are closely interlinked, and so changes in the flow of the river reflect also in the geomorphology of the floodplains. Hence, management of river ecosystems needs to take into account the floodplains and water channels, as means of flood/drought management plans or climate change action plans.

2.2 Projection of Change in Forests

The Third Assessment Report of IPCC documents that the forest ecosystems could be seriously impacted by future climate change. Even with global warming of 1-2°C, most ecosystems and landscapes will be impacted through changes in species composition, productivity and biodiversity. Two studies in Himachal Pradesh and Western Ghats indicated moderate to large-scale shifts in vegetation types, with implications for forest dieback and biodiversity. Biodiversity is likely to be impacted under the projected climate scenarios due to the changes or shifts in forest or vegetation types (in 57 to 60% of forested grids), forest dieback during the transient phase, and different species responding differently to climate changes even when there is no change in forest type. Climate change will be an additional pressure and will exacerbate the declines in biodiversity resulting from socio-economic pressures.[12]

In 2085, 77% (A2) and 68% (B2) of the forested grids in India are likely to experience shift in forest types.

- Shift towards wetter forest types in the northeastern region and drier forest types in the northwestern region in the absence of human influence
- Increasing atmospheric CO2 concentration and climate warming – doubling of net primary productivity under the A2 scenario and nearly 70% increase under the B2 scenario
- 77% of the grids under A2 and 68% under B2 scenario are likely to undergo vegetation change. This indicates that well over half of the area under forests in India is vulnerable to the projected climate change
- International Union of Forest Research Organization projected that in a warmer world, the current carbon regulating services of forests (as carbon sinks) may be entirely lost, as land ecosystems could turn into a net source of carbon dioxide later in the century.

2.3 Projection of Change in Agriculture

Agriculture is the source of livelihood for nearly two-thirds of the population in India. It is predominantly rain-fed covering about 60% of the country's net sown area and accounts for 40% of the total food production. Droughts and floods are frequent and the sector is already facing a high degree of climate variability. The performance of agriculture sector has a direct bearing on food supplies and food security. India is projected to become the most populated country by 2030 and will need to produce an additional 100 million tonnes of food grains to feed the large population. In the agriculture sector, the need for comprehensive risk management and insurance is further enhanced due to these reasons.[14]

The World Bank report *"Turn Down The Heat: Climate Extremes, Regional Impacts and the Case for Resilience"*, prepared by the Potsdam Institute for Climate Impact Research and Climate Analytics mentions that "in India, more than 60% of the crop area is rain-fed, making it highly vulnerable to climate-induced changes in precipitation patterns. It is estimated that by the 2050s, with a temperature increase of 2°C-2.5°C compared to pre-industrial levels, water for agricultural production in the river basins of the Indus, Ganges and Brahmaputra will reduce further and may impact food adequacy for some 63 million people". Sustainable agriculture can be defined as the form of agriculture aimed at meeting the food and fuel needs of the present generation without endangering the resource base for the future generations.

3. INDIA'S CLIMATE CHANGE ACTION PLANS / POLICY IMPERATIVES

In many ways, climate change means changes in the planet's water cycles. Drier conditions in some places, wetter conditions in others, earlier snowmelt, groundwater depletion, increased evapotranspiration, and more frequent storm events are all included in the list of anticipated climate changes. Clearly, the effect that these hydrologic changes will have on forests and grasslands is of major concern to the community and policy makers. Climate change will alter the world's forest and grassland ecosystems in ways that will affect their ability to deliver the critical ecosystem services that support human health and well-being[15]. In anticipation of wide-scale ecosystem change and the potential loss or change in the supply or distribution of ecosystem services, land owners and managers can focus on strengthening forest and grassland resilience and adaptive capacity so these landscapes might continue to provide life-supporting benefits into the future[16].

India's Climate Change Action Plans – National Action Plan on Climate Change (NAPCC)

The Government of India has accorded top priority to the issue of climate change. The Prime Minister's Council on Climate Change in 2008 launched the climate change mission that focused on solar power, energy efficiency, sustainable habitat, water, sustainable agriculture, green (forests), sustaining Himalayas, and strategic knowledge. The Action Plans on eight crucial sectors provide the necessary policy, regulatory and institutional framework. At the State level, the State Action Plan on Climate Change has been prepared covering adaption and mitigation strategies to support the NAPCC.

It is interesting to note, that even prior to the NAPCC of 2008, climate change and environment finds mention in the **National Environment Policy (NEP) 2006**, by means of promoting sustainable development along with respect for ecological constraints; and also in the **National Policy for Farmers, 2007** that focuses on sustainable development of agriculture. The NAPCC provides a sharper focus on eight areas and provides for implementation of initiatives – either mitigation and adaptation to combat climate change. The NAPCC is supplemented by actions at the State and local level through individual State Action Plan on Climate Change (SAPCC). There have been efforts to integrate climate change issues into the state planning process and involve multi-stakeholders (NGOs, private sector, etc) to drive implementation at local levels.

India's INDC to UNFCCC mentions "vulnerabilities in India differ among states, among regions and among different groups of people within the same region due to substantial variations in topography, climatic conditions, ecosystems as well as diversity in its social structures, economic conditions and needs of different communities."

3.1 The National Mission for Green India (GIM)[17]

The National Mission for Green India or Green India Mission is one of the eight Missions outlined under the National Action Plan on Climate Change (NAPCC). It aims at protecting; restoring and enhancing India's diminishing forest cover and responding to climate change by a combination of adaptation and mitigation measures. It envisages a holistic view of greening and focuses on multiple ecosystem services, especially, biodiversity, water, biomass, preserving mangroves, wetlands, critical habitats, etc. along with carbon sequestration as a co-benefit. This mission has adopted an integrated cross-sector approach as it will be implemented on both public as well as private lands with local communities playing a key role in planning, decision making, implementation and monitoring. The stated Goals of Mission are:

- To increase forest/tree cover to the extent of 5 million hectares (mha) and improve quality of forest/tree cover on another 5 mha of forest/non-forest lands
- To improve/enhance ecosystem services like carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; along with provisioning services like fuel, fodder, and timber and non-timber forest produces (NTFPs);
- To increase forest based livelihood income of about 3 million households

GIM puts "greening" in the context of climate change adaptation and mitigation. Greening is meant to enhance ecosystem services such as carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; as well as other provisioning services such as fuel, fodder, small timber and non-timber forest products (NTFPs).

The Mission aims at responding to climate change througha combination of adaptation and mitigation measures, which would help: enhancing carbon sinks in sustainably managed forests and other ecosystems; adaptation of vulnerable species/ecosystems to the changing climate; and adaptation of forest-dependent communities.

The Green India Mission recognizes the influences and potential that the forests and other natural ecosystems have on climate adaptation/mitigation, and food, water, environmental, and livelihood security of tribal and forest dwellers specifically, and the nation at large, in the context of climate change. GIM also recognizes the role of forests in the water security and states: "Forests are vital for maintaining the hydrological cycle and regulating water flows and sub-soil water regimes, recharging the aquifers and maintaining the flow of water in rivers and rivulets. Forest eco-systems are the source of a large number of rivers and rivulets in the country. The forested watersheds have better availability as well as quality of water than watersheds under alternative land uses. For example the Shimla catchment forest was established in early 20th century exclusively for securing the catchment and to protect over 19 springs and streams that provided drinking water supply for Shimla town, subsequently the summer capital of British India. It comprises of over 1000 ha of very dense forest."[18] The draft also takes into account livelihood security of local communities. Forests provide a range of provisioning services, particularly fuel-wood, fodder, small timber, NTFP and medicinal plants, and artisanal raw material like canes and bamboo, that are crucial to livelihood security of forest dependent communities. Nearly 27% of the total population of India, comprising of 275 million rural people, depend on forests for their livelihoods. It also includes 89 million tribal people, who constitute the poorest and marginalized section of the country. NTFP sector with annual growth rate between 5-15% also contributes to 75% of forest sector export income.

On June 15, 2016, the Ministry of Environment, Forests and Climate Change, Government of India placed the draft National Forest Policy in the public domain for comments and suggestions. It is slated to replace the National Forest Policy, 1988. The draft National Forest Policy (NFP) proposes the levy of a 'green tax' for facilitating ecologically responsible behaviour and supplementing financial resources essential to address forestry woes. "The budget of the forestry sector should be appropriately enhanced so that the objectives enshrined in this policy can be achieved. Environmental cess, green tax, carbon tax may be levied on certain products and services for facilitating ecologically responsible behaviour, garnering citizen's contribution and supplementing financial resources," the draft policy says. Furthermore, the policy mentions that climate change concerns should be effectively factored into all the forest and wildlife areas management plans and community ecosystem management plans. The policy says, "Large-scale expansion of agro-forestry and farm forestry should be encouraged through commensurate incentives and operational support systems such as lowering the input costs and enabling access to reasonably priced quality planting material."

3.2 National Mission for Sustainable Agriculture (NMSA)[19]

Sustainable agriculture can be defined as the form of agriculture aimed at meeting the food and fuel needs of the present generation without endangering the resource base for the future generations. Sustaining agricultural productivity depends on quality and availability of natural resources like soil and water. Agricultural growth can be sustained by promoting conservation and sustainable use of these scarce natural resources through appropriate location specific measures. Indian agriculture remains predominantly rain-fed covering about 60% of the country's net sown area and accounts for 40% of the total food production. Thus, conservation of natural resources in conjunction with development of rain-fed agriculture holds the key to meet burgeoning demands for food grain in the country. Towards this end, National Mission for Sustainable Agriculture (NMSA) has been formulated for enhancing agricultural productivity especially in rain-fed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation.

NMSA derives its mandate from Sustainable Agriculture Mission which is one of the eight Missions outlined under National Action Plan on Climate Change

(NAPCC). The strategies and programmers of actions (POA) outlined in the mission document aim at promoting sustainable agriculture through a series of adaptation measures focusing on ten key dimensions encompassing Indian agriculture namely: 'Improved crop seeds, livestock and fish cultures'; 'Water Use Efficiency'; 'Pest Management'; 'Improved Farm Practices'; 'Nutrient Management'; 'Agricultural insurance'; 'Credit support'; 'Markets'; 'Access to Information' and 'Livelihood diversification'. During XII Five Year Plan, these measures were embedded and mainstreamed on to ongoing/proposed Missions/programmes/Schemes of Dept. of Agriculture & Cooperation (DAC & FW) through a process of restructuring and convergence. NMSA architecture has been designed by converging, consolidating and subsuming all ongoing as well as newly proposed activities/programmes related to sustainable agriculture with a special emphasis on soil and water conservation, water use efficiency, soil health management and rain-fed area development. The focus of NMSA will be to infuse the judicious utilization of resources of a commons through a community based approach.

NMSA caters to key dimensions of 'Water use efficiency', 'Nutrient Management' and 'Livelihood diversification' through adoption of a sustainable development pathway by progressively shifting to environmentally friendly technologies, adoption of energy efficient equipments, conservation of natural resources, integrated farming, etc. Besides, NMSA aims at promoting location-specific improved agronomic practices through soil health management, enhanced water use efficiency, judicious use of chemicals, crop diversification, progressive adoption of crop-livestock farming systems and integrated approaches like crop-sericulture, agro-forestry, fish farming, etc.

India's INDC mentions the various Government of India policies/missions targeting various threats to agriculture. Some of the important ones are National Food Security Mission, Mission for Integrated Development of Horticulture, National Mission for Sustainable Agriculture, Paramparagat Krishi Vikas Yojana to promote organic farming practices, Pradhan Mantri Krishi Sinchayee Yojana to promote efficient irrigation. The National Mission on Sustainable Agriculture (NMSA) aims at enhancing food security and protection of resources such as land, water, biodiversity and genetics. The mission focuses on new technologies and practices in cultivation, genotypes of crops that have enhanced CO_2 fixation potential, which are less water consuming and more climate resilient. India has developed 580 district level contingency plans (covering many states) based on early warning systems and other weather forecasting systems. The National Initiative on Climate Resilient Agriculture (NICRA) includes research on adaptation and mitigation, which covers crops, livestock, fisheries and natural resource management. Further, a Scheme has been launched to provide in mission mode Soil Health Card to every farmer. Additionally, 100 mobile soil-testing laboratories have been set up across the country. The National Agroforestry Policy (NAP) of India aims at encouraging and expanding tree plantation in a complementary and integrated manner with crops and livestock. It will help protect and stabilize ecosystems, and promote resilient cropping and farming systems to minimize the risk during extreme climatic events. It will also complement achieving the target of increasing forest/ tree cover.

3.3 National Water Mission[20]

The main objective of the National Water Mission (NWM) is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". The five identified goals of the Mission are: (a) comprehensive water data base in public domain and assessment of impact of climate change on water resource; (b) promotion of citizen and state action for water conservation, augmentation and preservation; (c) focused attention to vulnerable areas including over-exploited areas; (d) increasing water use efficiency by 20%, and (e) promotion of basin level integrated water resources management.

Relatively very large temporal and spatial variation in rainfall and consequently in the river flow and groundwater aquifers are important features of the water resources in India. Although the impact of climate change on water resources has not been accurately quantified, various studies indicate that it could contribute to further intensification of extreme climate events. Further, the features of water resources – both the availability and the quality – may also be considerably affected by the changes in land use in the form of urbanization, industrialization and changes in the forest cover. Realizing that the various processes which influence the hydrologic cycle are of dynamic nature, precise quantification of the impact specifically due to climate change may not be a simple task, and it would be necessary to make suitable assumption at the initial stages and undertake detailed simulation studies with more and more data as they become available with time. However, the likely impact of climate change on water resources could be in the form of:

- Decline in the glaciers and the snowfields in the Himalayas
- Increased drought-like situations due to overall decrease in the number of rainy days in many parts of the country
- Increased flood events due to overall increase in the rainy day intensity
- Effect on groundwater quality in alluvial aquifers due to increased flood and drought events
- Influence on groundwater recharge due to changes in precipitation and evapotranspiration
- Increased saline intrusion of coastal and island aquifers due to rising sea levels.

From the above, it is apparent that in the context of likely impact of climate change on water resources, the most vulnerable areas in India would include (a) drought prone areas, (b) flood prone areas, (c) the coastal regions, (d) regions with deficient rainfall, (e) areas with over-exploited, critical and semi-critical stages of groundwater development, (f) water quality affected areas, and (g) snow-fed river basins. For achieving the objectives of the National Water Mission, long-term sustained efforts, both in terms of time bound completion of identified activities and ensuring the implementation of identified policies and enactment of necessary legislation through persuasion at different levels with the State Governments, have been envisaged.

Various strategies for achieving the goals have been identified which lead to integrated planning for sustainable development and efficient management with active participation of the stakeholders. This will involve identifying and evaluating the development scenario and management practices towards better acceptability, based on an assessment of reliable data and information regarding the impacts of climate change on water resources.

4. ADAPTIVE SOLUTION FOR CLIMATE RESILIENT COMMUNITIES

Climate change vulnerabilities and impacts are highly diverse and locally specific, long term and difficult to predict. Based on different definitions of climate and non-climate related adaptation, IPCC in 1996 defined adaptability and adaptation as follows: "Adaptability refers to the degree to which adjustments are possible in practices, processes or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of changes in conditions." Adaptation therefore, involves adjustments to climate variability and change in order to decrease the vulnerability of communities, regions, and nations.

4.1 River-bank Plantations

There are many areas where river lengths are considerable. The ground on either side of the river is partly within reach of the high level of water during periods of flooding. Beyond this level – and on the fringes of the agricultural land – strip plantation can be established to produce wood, fuelwood and fodder. Generally, the width of such strips is limited but does constitute a useful and productive linear plantation. Underground water is available at different levels. The species to be planted should be matched with this water level variation. Spacing within and between the rows depends on the characteristics of the species and the rotation planned for the crop. In the more arid areas, trees with xerophytic habit constitute the outermost rows while those close to the river bank are the ones with higher water requirement. In such locations, phreatophyte species such as *Populus* spp., Acacia *nilotica, Dalbergio sisso, Prosopis* spp. can be planted.[21]

River bank plantation also acts as a shelter belt for protection against extreme weather events, like floods and cyclones. It also provides a suitable habitat for the avian species and tree species that are inter-dependent for existence. Species suitable for canal or river bank plantations are those which can yield fuel, pulpwood and timber. Bamboo and teak raised in suitable well drained soils will prove of high economic value. Bamboo can be harvested every 3 to 4 years. The other species recommended are *Eugenia ambolana, Dalbergia sissoo, Mangifera indica, Acacia arabica, Ailanthus excelsa, Terminalia arjuna, T. belerica, Pongamia glabra, Muduca latifolia, Tamarindus indica, Azadirechta indica, Sesbania* species and *Casuarina equisetifolia*.[22]

4.2 Carbon Sequestration and Forestry

According to the State of Forests Report 2015[23], Forest and tree cover of India has increased by 5,081 square kilometre (21.34 percent) (3, 775 sq km and 1, 306 sq km) between 2013 and 2015; the total forest cover as percentage of geographical area was 24.16 percent.

The report also mentions that the total carbon stock has also increased by 103 million tonnes or an increase of 1.48 percent. The total carbon stock in the country's forest is around 7, 044 million tonnes. The increase in the carbon stock shows the commitment of the country towards achieving the INDC target of additional carbon sink of 2.5 to 3.0 billion tonnes of CO_2.

The green corridors along the river banks will not only build resilient ecosystems but support combating global warming and climate change effects, while optimizing GHG sequestration and providing for ex-situ conservation of native species of the region

As long as forests are managed in a sustainable way, there can be a multitude of benefits: for the climate, for people and for wildlife. Timber is renewable and can replace other materials that require much larger fossil fuel inputs for their production. They provide shade, alleviate flooding, and create a valuable wildlife habitat. Non-Timber Forest produce (NTFPs) and minor forest produce, play an important role in shaping the lives and livelihoods of the communities, especially the tribal and the forest dependent ones.

4.3 Climate Adaptation – Agro-forestry for Environmental Security

Agriculture

Climate-smart agriculture (CSA), as defined and presented by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, contributes to the achievement of sustainable development goals. It integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars: 1. sustainably increasing agricultural productivity and incomes; 2. adapting and building resilience to climate change; 3. reducing and/or removing greenhouse gases emissions, where possible.

The current concern is on the extent and magnitude of climate change. Agricultural policy will require more flexible food policies that can anticipate the selection of crops for the planting seasons and provide for seed varieties that can adapt to drastic climatic variability. Historical trends show a noticeable increase in mean temperature and large variation in monsoon rainfall in India and the IGP region. Climate change is likely to reduce yields of most crops in the long-term, and increased climatic variability could cause significant fluctuations in production in the short-run[24]. Recent studies on regional and global simulation models also indicate that a moderate increase in temperature will have a significant negative impact on rice, wheat and maize yields in India[25]. Climate change may further worsen the agricultural production system in the IGP region by increasing water scarcity, the frequency and severity of floods, and causing further decline in soil carbon[26]. Impacts of frequent and severe droughts and floods on crop production have already been observed in many parts of the region, Therefore, the climate change and variability may lead to greater instability in food production and threaten the food security of millions of smallholder farmers in the IGP.[27] The forest policy will need to account for erosion mitigation measures in areas where precipitation is predicted to be high, and water-intensive industries will need to take account of variations in water availability and siltation issues related to changes in precipitation.

It is widely accepted that the poorest are disproportionately vulnerable to climate change and the least able to adapt (Parry et al., 2007; Black et al., 2011). This can be largely attributed to their reliance on the natural resource base for their livelihood. Developing countries such as India are thus more likely to be vulnerable to the effects of climate change. Severe changes affecting the natural resource base will impact livelihoods of the poor in these countries. IPCC studies indicate that the vulnerability of a region depends to a great extent on its wealth, and that poverty and inequality limit adaptive capabilities (IPCC, 2011). Patnaik and Narayanan (2005) argue that socio-economic systems "typically are more vulnerable in developing countries where economic and institutional circumstances are less favourable". Furthermore, due to its effects on livelihoods, climate change is predicted to impose significant aggregate costs for society (House of Commons, 2008; Parry et al, 2007; Stern, 2007). For example, the total cost of adaptation to climate change was estimated at over $100 billion in the run-up to the Copenhagen Climate Change Conference (Black et al., 2011). Therefore policies promoting adaptation to climate change are critical in the coming years.[28]

Rural households derive one-fifth to one-quarter of their income from forest and tree resources and are therefore amongst the most vulnerable to climate change impacts on forests. It has been noted that forest ecosystems provide services that reduce the vulnerability of communities and broader society to climate change by: providing livelihood provisions to the local communities; conserving and regulating soil, water and microclimate in forests and agricultural lands; and regulating water quality and protecting soil from erosion and landslides through large scale soil and moisture conservation works. By improving the management of forests and allocating adequate rights at the local level, under the national acts like the Forest Rights Act 2006 and the Panchayat (Extension to Scheduled Areas) Act, 1996 and devolution of rights and concessions by the State Government, the adaptive capacity of forest-dependent people has been greatly improved

Agroforestry

The **National Agro-forestry Policy 2014,** which deals with the practice of integrating trees, crops and livestock on the same plot of land, was launched on February 10, 2014 – the first day of the World Congress on Agro-forestry, held in Delhi. The policy deals with problems that agro-forestry sector is facing at present, including adverse policies, weak markets and a dearth of institutional finance. It is widely accepted that agro-forestry has the potential to achieve sustainability in agriculture while optimising its productivity and mitigating climate change impact.

The four-day World Agro-forestry Congress held in New Delhi in 2014 underlined the benefits of agroforestry – restoring barren land, reducing poverty and malnutrition by tripling yields, feeding animals, protecting running water, conserving biodiversity, protecting wildlife, and holding and repairing soils. It also noted that there has been a decline in agro-forestry practices in India.[29]

There are various agro-forestry industries which are dependent on agriculture or forest produce for their raw material. Pulp and paper industries, fiber board manufacturing units and various small scale cottage industries (furniture, incense sticks, handicraft) are dependent on forest/farmers for raw material.

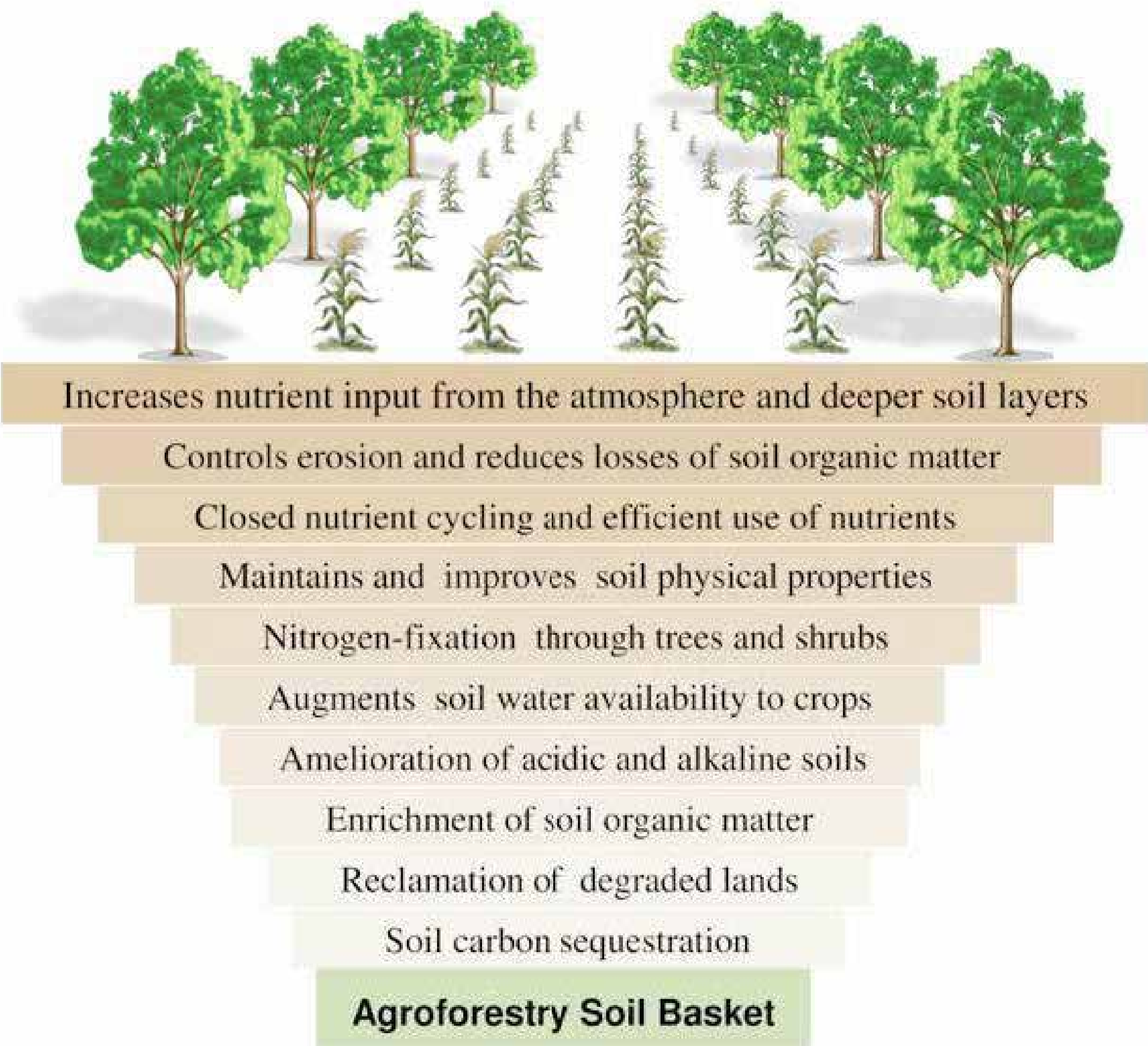
Trees in agro-forestry systems not only provide direct benefits (food, fodder, fuelwood, fertilizers, fibers, etc) but also improve soil fertility, reduce soil erosion, filter atmospheric pollutants and, most importantly, maintain carbon balance. Growing multipurpose trees along with agricultural crops, has been considered as a panacea for maladies of intensive agriculture and deforestation.

It is considered to be one of the key paths towards prosperity of small and marginal farmers facing the challenges of low and uncertain yields, deterioration of the soil and environmental resources and suffering from hunger, malnutrition and poverty, particularly in areas that have been bypassed by the green revolution[30]. Agro-forestry helps to cope with climate change by storing carbon, providing trees as buffers for weather-related production losses, enhancing resilience in climate impacts and using trees as a source of income and a diversity of food through tree-based products[31]. Farmers believe agro-forestry is a boon particularly during drought when rain-fed crops fail and trees provide fodder, fruit, vegetable, fuelwood, timber and fiber for sustaining rural livelihood.

According to FAO[32], agro-forestry improves above ground biodiversity as it provides more habitats and food for birds, small mammals, reptiles, earthworms, insects, etc., which in turn lead to an increase in species diversity and population. Agro-forestry helps in reducing biodiversity loss by providing a protective tree cover along agricultural fields and by providing habitat for a diversity of flora and fauna. It helps in conserving genetic diversity of ethnocultivars or landraces and for trees that are in danger of loss and require priority conservation[33]. Altieri opined that since AFS are more diverse and have low-input strategies, these have greater biological interactions and thus are richer in biodiversity[34]. Agro-forestry can (1) provide secondary habitats for species, (2) reduce the rate of conversion of natural habitats, and (3) create a benign and permeable matrix (corridor) between habitat (5) and conservation of biological diversity by providing other ecosystem services such as erosion control and water recharge, thereby preventing the degradation and loss of surrounding habitats[35] (31, 35).

The following represents the design and development peculiar to agro-forestry systems for biodiversity as well as for commerce.

The studies indicated that under agro-forestry systems, organic carbon and available nutrients in the soil increased as compared to a system of growing only trees or a sole agricultural crop.[36] Experimental evidence under an agri-silvi horticultural system (aonla + leucaena + black gram) in rain-fed conditions showed that after nine years organic carbon was increased by 65 to 109.4% under closed canopy conditions, and by 28.1 to 62.5% under open canopy as compared to the initial value (0.32%). The trees are performing a prominent role in enhancing soil organic carbon. The organic carbon percent under the canopy of aonla is higher than that of open canopy, owing to the fall of aonla leaves, being mostly



restricted to the tree canopy[37] . An increase in organic carbon, and available N, P and K content in a Khejri (Prosopis cineraria) based silvi-pastoral system compared with no-Khejri soil, indicates the need for retention/plantation of Khejri trees on pasture land. The Khejri based system has led to higher fodder production to meet the needs for food, fodder, fuel and small timber . An increase in soil organic carbon status of surface soil has been observed: 0.39% to 0.52% under Acacia nilotica + Saccharum munja, and 0.44% to 0.55% under Acacia nilotica + Eulaliopsis binata after five years. There are indications that Acacia nilotica (a tree) + Eulaliopsis binata (a grass) are conservative, more productive and less competitive and are suitable for eco-friendly conservation and rehabilitation of degraded lands of the Shivalik foot hills of subtropical northern India. [38]

The studies of an agri-silvicultural system growing of Albizia procera with different pruning regimes, showed that the organic carbon of the soil increased by 13-16% from their initial values which was five to six times higher than growing of either a sole tree or a sole crop[39]. Evaluation of soil chemical properties in a traditional agro-forestry system of the north-eastern region indicates a spectacular increase in soil pH, organic-C, exchangeable Ca, Mg, K, and build up of available P under different agroforestry practices within 10-15 years. Similar results have been shown when MPTS (Multipurpose trees and shrubs) were evaluated in an extremely P-deficient acid Alfisol in Meghalaya. MPTS, including Alnus nepalensis, Parkia roxburghii, Michelia oblonga, Pinus kesiya, and Gmelina arborea led to: a) greater surface cover , b) a constant leaf litter fall and extensive root systems with a 96.2% increase in soil organic carbon, c) a 24.0% increase in aggregate stability, d) an increase of 33.2% in available soil moisture and e) a reduction of 39.5% in soil erosion. Soils under Acacia auriculiformis, Leucaena leucocephala and Gmelina arborea have a persistently high humification rate, while soils under the canopy of Michelia champaca, Tectona grandis and Dalbergia sissoo show low humification of the organic matter . Such improvements in soil quality under agro-forestry systems have a direct bearing on long-term sustainability and productivity of soils, being a viable option for eco-restoration, maintenance of soil resources for obtaining ecosystem services, such as good air and water quality in the area.[40]

Horticulture

The **Horticultural Statistics at a Glance 2015,** released by the Agriculture Ministry showed that most horticultural crops are grown with assured irrigation and, therefore, are more resilient to monsoon deficits. Two consecutive droughts and freak weather in 2014 and 2015 dented India's foodgrain production and worsened rural distress, but the horticulture sector escaped these weather shocks and registered record production in 2014-15.[41]

Annual growth in horticulture has seen **fruit production grow faster** than vegetables though the latter constitute the largest segment of this sector of agriculture. The estimates released by the Agriculture Ministry shows that during 2016-2017, production of fruits rose to 92 million tonnes (about 2% higher than the previous year), while vegetable production fell marginally. India is the second largest fruit producer in the world, after China. Hence, preferment for fruit cultivation makes better socio-economic sense in the given scenario.

The book *Climate-Resilient Horticulture: Adaptation and Mitigation Strategies, 2013* [42] recognizes the impact of climate change (occurrence of drought and floods, change in rainfall pattern and sudden change in temperatures), that is likely to alter the growth pattern of plant flowering, fruiting and yield and quality of produce, besides increasing vulnerabilities to pest and diseases. Development of high-temperature tolerant cultivars, change in production systems and use of new tools and technology would help in adaption to climate change. The potential of perennial fruit and plantation crops for higher carbon sequestration provides an opportunity to be a sink for increased carbon dioxide and, additionally, opportunity for soil carbon sequestration.[43]

In India, increase in mean annual maximum temperature was 0.76°C and mean minimum temperature was 0.22°C during the period, commencing from 1901 to 2003.. Increase in annual mean temperature was 0.49°C in the same period. In terms of increase in temperature, the west coast of India is warmer, followed by the Northeast India and the Western Himalayas when compared to other regions of the country. The years 2009 and 2010 were recorded as the warmest in the country since 1901. Increase in temperature and rainfall was noticed in the country in tune with the global warming and climate change though spatial and seasonal differences were evident. At the same time, rainfall during the monsoon season was in deficit in recent years like 1987, 2002 and 2009 which adversely affected the food grain production in India. In the case of thermo-sensitive crops like tea, coffee, cardamom, cocoa, cashew and black pepper, the projected increase of 2–3°C in temperature may directly affect the cropped area and productivity. The observations on mango and cashew flowering also indicated that increase in night temperature during winter is a concern as seen in 2010. The coconut productivity in Kerala is likely to decline under the projected climate change scenario as the occurrence of floods and summer droughts is likely to affect the crop adversely, and frequency of their occurrence is likely to increase under the projected climate change scenario. Therefore, proactive technologies need to be developed against global warming and climate change for sustenance of crop production in horticulture as a part of "climate resilient horticulture".[44]

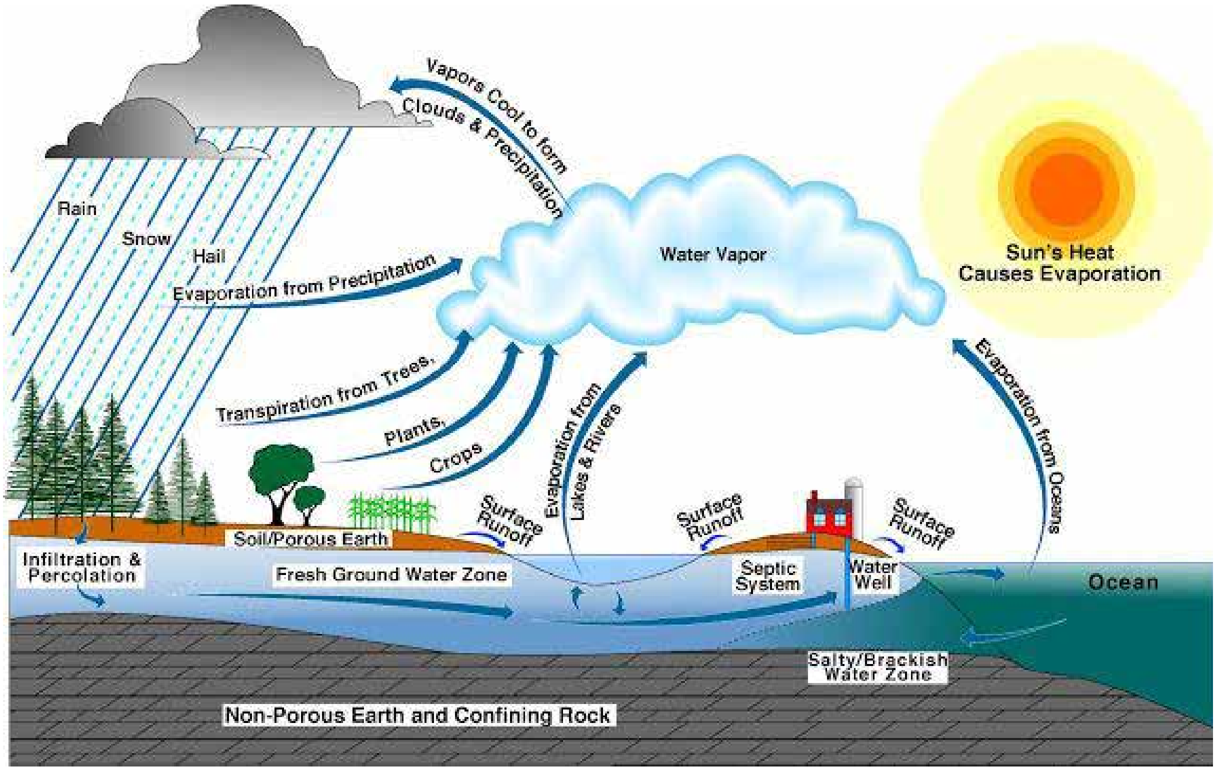
Overall, the impact of global warming, change of seasonal patterns, excessive rain, melting of the ice cap, flood, rising sea level, drought, pollination cycle, fruit ripening, etc. leading to an extremity of all kinds, is likely to bring about a change in the vegetable crops, spices, flowering and fruiting trees.

Adopting conservation agriculture, using renewable energy, forest and water conservation, reforestation, etc. to sustain the productivity, modification of present horticultural practices and greater use of greenhouse technology are some of the solutions to minimize the effect of climate change. Development of new cultivars of horticultural crops tolerant to high temperature, resistant to pests and diseases, short duration and producing good yield under stress conditions, as well as adoption of hi-tech horticulture and judicious management of land use resources will be the main strategies to meet these challenges.[45]

5. TREE – WATER – CLIMATE NEXUS

Tree – Water Nexus

Food for all living organisms originates from trees and other members in the plant kingdom. Every single organism depends directly or indirectly on trees for their survival. Trees not only provide food for other organisms, but also shelter and give protection to many different types of organisms including humans. In



addition, trees also provide wood, shade, oxygen and clean air. During heavy rains, trees reduce the risk of flooding. There are two major ways in which trees provide protection against flooding.[46]

1. Trees allow water to be drained into the ground

Experts say that woodland acts as a barrier to floodwater, with the trees preventing soil erosion, reducing sediment going into rivers and increasing water absorption into the ground. This slows rainwater running off into swollen streams and helps lower peak flood levels.

2. Trees help prevent flooding

When plants grow in an area, their roots dig deep into the soil and create space between soil particles. When it rains in highlands, water that flows downhill gets drained into the space created by the root system of plants. Due to this, chances of flooding are greatly reduced. When plants are absent, especially in rocky areas, rocks prevent water from seeping into the ground. This phenomenon is also observed in paved roads. Since there is no room for water to seep, flooding occurs in nearby water bodies. When a layer of water runs off a rocky surface, it reduces friction and the following layers of water will run more freely as there is less friction. If more water is dumped into rivers and lakes than they can handle, these water bodies tend to overflow and the banks burst and cause flooding. If there are more trees in an area that is prone to water runoffs, the root system of trees can create space between these rocks and hence reduce the amount of water being dumped into lakes and rivers.

According to a study by FAO[47], degradation of forests limits the storage capacity of this sponge, leading to water shortages during dry seasons and, in wet seasons, to brief destructive floods, during which very little water is absorbed by the soil. This is why large areas of formerly productive land, where annual rainfall is relatively high, have become desertified once tree cover is removed. Forest buffer zones around lakes and streams act as a filtering system, reducing the amount of sediment, agricultural chemicals and pesticides in the watercourses. The loss of this filtering system results in high levels of sediment and dissolved minerals in rivers and streams which reduce crop growth and disrupt fisheries.

Increased reforestation on unstable land, and around lakes, rivers and streams can thus help to increase the water-retention capacity of land and improve water quality, both of which benefit food production. Forests can also enhance water quality in other ways. Studies in Nigeria, Indonesia and other countries have shown that, when the forest is removed, minerals and nutrients that trees absorb or recycle end up making their way, unchecked, into drainage water. Apart from the disadvantage of losing minerals and nutrients from the immediate area, the extra nutrients in the water enhance the growth of oxygen-depleting organisms on canal and river beds, and reduce the overall value of the water for irrigation purposes. Hence, healthy forests and wetland systems provide a host of watershed services, including water purification, groundwater and surface flow regulation, erosion control, and stream bank stabilization. The importance of these watershed services will only increase as water quality becomes a critical issue around the globe. Their financial value becomes particularly apparent when the costs of protecting an ecosystem for improved water quality are compared with investments in new or improved infrastructure, such as purification plants and flood control structures – in many cases it is often cheaper and more efficient to invest in ecosystem management and protection.[48]

TREE – CLIMATE NEXUS

Trees also exert a substantial influence on both local microclimates and, possibly, on global climate. Trees affect temperature, humidity, moisture availability and light conditions in their immediate vicinity. The success of many agro-forestry systems depends in part on the trees' capacity to moderate soil and air temperatures, and to increase relative humidity – two factors important for improved crop growth.

Recent research also suggests that forests may have an effect on climate through their influence on rainfall patterns, surface reflectivity and other meteorological variables. One reason is the change in the way sunlight is reflected from the earth's surface when forests are destroyed. In a living forest, sunlight is absorbed by leaves, branches and tree trunks. When the forest is destroyed, reflectivity is increased, and the land absorbs less heat. Atmospheric circulation and rainfall patterns are then significantly altered. Furthermore, in deforested areas, much less solar energy is used to evaporate moisture from the leaves of plants and trees. This leads to further climatic changes, and tends to increase temperatures during the daytime and lower those at night.

Forests are also an important cog in the carbon cycle. Forests that are cut down and burned release their carbon into the atmosphere, adding to the concentration of atmospheric carbon dioxide which is one of the major contributors to the global warming caused by the greenhouse effect. Living forests play the opposite role, removing carbon dioxide from the atmosphere. Large-scale reforestation has been suggested as one important way to help reduce the expected global warming. But afforestation would have to be carried out on a continental scale if it were to achieve substantial reductions in quantities of carbon dioxide in the atmosphere.

6.CONCLUSION

With a change in biodiversity, many rivers may lose some of their economic value. A more effective adaptation strategy would focus on maintaining and restoring watershed health and resiliency, because such systems are more likely to provide a sustained flow of ecological services in face of ongoing and future disturbances, including those associated with climate change (Baron 2002). The types of actions that might be implemented will differ dramatically in different landscapes – they will depend on dominant watershed processes, key watershed services, and principal threats to those services. They could include:[49]

- **Protecting and restoring riparian forests** to reduce stream temperatures and increase the quality of aquatic habitats.
- **Improving or decommissioning roads** to reduce erosion, increase floodplain connectivity, decrease peak flows, and reduce temperature impacts.
- **Restoring meadows, wetlands, and floodplains** to improve ecological continuity, increase water storage, reduce flood flows, increase local late-season summer low flows, and decrease stream temperatures. Restoring

India will be able to meet its ambitious targets to tackle climate change and climate variability through targeted schemes and programmes, like those mentioned in the INDC report to UNFCCC.

In 2015, the Ministry of Road Transport & Highways (MoRTH) formulated the **Green Highways (Plantation and Maintenance) Policy, 2015** wherein a 140,000 km long "tree-line" along both sides of national highways will be developed over five years. This policy came in the wake of the 'poor quality and lack of maintenance of green cover along most national highways'.[51]. The Green Highway policy links to the MNREGA scheme, and takes into account soil suitability, commercially viable tree species/ fruit bearing trees and involves the Panchayats in the area.

It is proposed that tree plantation along the river banks, as and where feasible, should be accorded similar or higher priority and should be suitably promoted on similar lines as the Green Highways (Plantation and Maintenance) Policy, 2015. Such a policy will contribute to both the adaptation and mitigation strategy for addressing climate change in the country.

The water–food–energy nexus[52] has emerged as a new perspective in debates concerned with balancing potentially conflicting sectoral imperatives of large-scale development investments concerned with energy, water or food security. Brahmaputra basin, Mekong river basin, Amu Dariya River basin[53] are some of the areas where such studies have been undertaken. Similar studies in the Indian context may be initiated to inform policy and support with integrated planning at the local level.

Water, energy and food security will only be achieved if the connections between all three are fully recognized by policymakers and practitioners. Sustainable natural resource use will need to be negotiated at all levels, from the community level upwards. Difficult trade-offs will undoubtedly emerge and hard decisions will have to be taken. Policymakers should seek to promote equitable benefit sharing.

and maintaining persistently wet places in the terrestrial environment as "biological oases" for watershed resilience and building a network of refugia.

- **Maintaining and restoring environmental flows** needed to support myriad stream processes in watersheds and aquatic ecosystems.
- **Removing migration barriers and re-establishing habitat connectivity** to help species adapt to changing conditions.
- **Strategically reducing wildfire risks** in watersheds vulnerable to excessive erosion, stream temperature increases, and other impacts.

As part of the Working Group II (WGII) contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change, the summary for policymakers focuses on recent work assessing climate change impacts, vulnerability, and adaptation[50]. Adaptation is context-specific, with no single approach for reducing risks appropriate across all settings. A number of principles, mentioned in the report, for effective adaptation has been summarized as below:

- Adaptation planning and implementation can be enhanced through complementary actions across all levels, from individuals to governments.

- A first-step towards adaptation is reducing vulnerability and exposure to present climate variability.
- Adaptation actions at all levels of governance are contingent on different societal values, objectives, and risk-perception; recognising this plurality of contexts benefits decision-making processes.
- Decision support is most effective when it is sensitive to context and the diversity of decision types, processes, and constituencies.
- Existing and emerging economic instruments can foster adaptation by providing incentives for anticipating and reducing impacts.
- Constraints such as limited financial and human resources, limited integration and coordination, projected uncertainties, and competing values can interact to impede adaptation planning and implementation.
- Poor planning that is too short-term in thinking can result in unforeseen maladaptive consequences.
- Significant trade-offs, co-benefits, and synergies exist between mitigation and adaptation, with interactions occurring both within and across regions.

The prospects for sustainable development pathways are very much dependent on what the world accomplishes with climate change mitigation, both in terms of scale required and the time-spans available. Opportunities for effective adaptation measures are therefore decreasing over time, increasing the risk of some areas exceeding adaptation limits. Transformational changes in economic, social, technological and political decisions and actions can enable climate-resilient pathways, and can be encouraged through iterative, deliberative approaches and innovation.

Integrating climate change adaptation considerations into policy processes and decision-making across a range of sectors and scales is important in managing the impacts of climate change. The present situation is critical given the priorities related to development targets including poverty eradication, energy access, health and education and the increase in vulnerabilities due to climate change. The two cannot be dissociated from each other and innovative mechanisms need to be devised to address the trade-off between development and adaptation. **Availability and access to finance and technology** for adaptation is very important. Scaling up of adaptation finance and technologies need to be mainstreamed in order to build climate resilient societies. Besides demanding global support for finance and technology, strategies need to be devised to promote local, traditional knowledge and innovation entrepreneurship.

SMART Agriculture, SMART Water Management, SMART Forest Management will eventually lead to resilient communities that can adapt to changing climate and harvest economic benefits. With a change in local practices, i.e. afforestation and horticulture along the river, the riverine communities will be able to build livelihood security without the fear of drought-flood crisis.

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ANNEXURE 4

CASE OF REVIVAL OF SPRINGS IN THE WATERSHED OF GAGAS RIVER IN UTTARAKHAND

Ajay Rastogi[1]

The Gagas river originates in the sacred forests of Pandukholi in Almora district, of Kumaon Himalayas in the state of Uttarakhand. The river is largely defined through the flow of over fourteen major streams or gadheras on both banks, and flows for about 50 km prior to merging with Ramganga (West) river. The river basin is spread over 500 square km with a population of over 120,000 in 370 villages.

Springs, or naulas as they are traditionally called, are the main source of water in the hills for the people. Overflow from these springs also contributes to small streams which in turn join to form rivulets and rivers. About 15 years ago, the ecological situation had worsened in many parts of the catchment of Gagas river to the extent that the majority of springs had either dried up completely or their flow was restricted to only certain months of the year. It was then that the Ranikhet based Pan Himalaya Grassroots Development Foundation forged a coalition of interest between communities of 70 villages to form a "Gadhera Bachao Samiti". This body decided to plant native trees in their catchment of approximately 1000

[1] Founder Director, Foundation for Contemplation of Nature, Ranikhet, Uttarakhand Himalaya

hectares area. They raised over 1 million saplings of over twenty native species of trees and shrubs in small village nurseries and planted them in the catchment. Simultaneously, they undertook locally appropriate soil conservation measures by digging small trenches or ponds across the gradient of the slope. These are locally called Nals and Khals. This improved the moisture regime in the plantation areas as well as infiltration. As the trees started to come up, many springs started to flow round the year, and the overall water situation in the Gadhera improved tremendously.

Heartened by their efforts of ecological restoration – having revived the hydrological cycle by providing a fresh vegetal cover on degraded commons and renewed traditional methods for soil and moisture conservation – the communities also started to adopt several other related technologies. Swift spread of appropriate technologies in cross cutting sectors like drinking water, environmental sanitation, renewable energy and rainwater harvesting further improved the overall situation. Hundreds of families invested in installation of bio-gas digesters which provide clean cooking gas and thereby reducing not only the drudgery of women and children head loading firewood from distant forests but also the biotic pressure on scarce forest resources.

As a result of this improved water and biomass availability, agriculture was revived. Food security and livelihoods improved through land-use optimization and establishment of market linkages directly between producer-farmers and consumers. Over 1,500 women farmers came together to form a Farmer Producer Company which aggregates, processes and adds value to local produce through appropriate marketing. The annual turnover of this community owned enterprise is now close to Rs. 20 million and provides supplementary incomes on a sustainable basis to these shareholders.

Gagas river basin is typical scenario in the Indian Himalayan region and massive eco-restoration activities ought to be spearheaded panning the Himalayas to restore and renew the hydrological cycle in hundreds of similar river basins. However, the lesson of Gagas river basin is that a holistic approach may be the only way forward for eliciting the support of local communities to participate in such sustainable development programs.

ANNEXURE 5

CASE STUDY OF RIVER RESTORATION PROJECT (DANUBE RIVER)

River restoration in India poses great challenges, due to various factors, including population density, encroachment on floodplains of the river, a multitude of stakeholders, as well as conflicting state interests and political interests. In order to gain valuable insights from other river restoration projects around the world, cases need to be equally challenging and complex. In this context, we have chosen the Restoration Project of the Danube River.

Some basic facts about the Danube:

1. It crosses over 19 countries.
2. The length of the river is 2860 km
3. Total area of the river basin is 801,463 km

1. BASIC FEATURES OF THE DANUBE:

The Danube River Basin (DRB) covers a total area of around 801.000 km and collects water from the territories of 19 countries in Central and Southeastern Europe (Germany, Austria, Switzerland, Italy, Poland, the Czech Republic, Slovenia, Slovakia, Hungary, Croatia, Serbia, Romania, Bosnia and Herzegovina, Macedonia, Albania, Montenegro, Moldova, Bulgaria, and Ukraine).

Today, around 83 million people inhabit the DRB. Sixty cities in the DRB have a human population of more than 100.000. Culturally, the DRB consists of a wide variety of languages, traditions, histories, and religions. The political and social conditions and the corresponding economic status of the DRB countries are more diverse than those in any other European river basin.

The Danube is the second longest river in Europe (2826 km), and its large delta forms an expansive wetland (area: 5640 km) of global importance. The mean annual discharge of the Danube at its mouth is 6480 km/s, corresponding to a total annual discharge of 204 km. The Danube is divided into three sections that are almost equally long, and separated by distinct changes in geomorphic characteristics: The Upper, Middle and Lower Danube. A characteristic feature of the Danube is the alternation between wide alluvial plains and constrained sections along the main stem.

2. FLOODPLAIN CONDITION BEFORE AND AFTER REGULATION AND RESTORATION

Before regulation, active floodplain width reached > 10 km in the Upper Danube and > 30 km in the Middle and Lower Danube. In the Upper Danube, most floodplains and fringing wetlands have been converted into agricultural and urban areas, or have been isolated by dams and artificial levees, and therefore are functionally extinct. However, along the Middle and Lower Danube, large near-natural floodplains still remain. Before the river regulation, vegetated islands used to form another prominent landscape element in the DRB. Along the Austrian Danube, around 2000 islands were present before the regulation; today, only a few remain. However, islands are still abundant in the Hungarian/Serbian (Middle Danube) and the Bulgarian/Romanian sections (Lower Danube). Remaining near-natural floodplains and vegetated islands may serve as important nuclei for conservation and management actions; at the same time, they are sensitive indicators to assess the ecological state of river corridors.

3. THE ISSUES WITH THE RIVER:

Source: http://www.danubeparks.org/files/855_DanubeRiverMorphologyRevitalization.pdf

Key water management issues: The Danube Basin Analysis in 2004 provided the first comprehensive characterization of the entire DRB (ICPDR, 2005) including the key water management issues. It comprised a basin-wide pressure and impact analysis to estimate the risk for water bodies of failing the management objective of the EU Water Framework Directive (WFD), i.e. to achieve ‘good ecological status’, by 2015 (European Commission, 2000).

Hydromorphological alterations: Hydropower generation, flood protection, land reclamation, and navigation are the main driving forces for hydromorphological alterations in the DRB. Approximately 700 major hydraulic structures (dams and weirs >15 m), including 156 large hydropower dams, have been built in the DRB. Approximately 30% of the length of the main stem is impounded through 78 major hydraulic structures. Less than 15% of the Upper Danube remains free-flowing.

Alterations of the sediment regime: The dams along the main stem have severely interrupted sediment transport in the Upper Danube. The Iron Gate dams retain approximately two-thirds of the suspended solids. Therefore, sediment delivery to the Delta decreased from 53 to 18 million tons/year, resulting in severe coastal erosion (after WWF, 2008, quoted by Sommerwerk N. et al., 2010). River-bed incision further reduces low water levels and impedes the hydrological connection between the channel and its floodplains.

Water pollution: Despite an overall improvement in water quality over the past few decades, the Danube and its tributaries remain exposed to multiple point and nonpoint pollution sources. The construction and upgrade of wastewater treatment plants (WWTP) have reduced the input of biodegradable organic matter in the Upper Danube during the past three decades. In the Middle and Lower Danube, water quality remained relatively high until the 1970s, but then deteriorated owing to rapid industrial development, poor pollution control, and inputs from heavily-polluted tributaries. However, the high self-purification capacity of the remaining natural river sections and alluvial wetlands has buffered these adverse effects, and at the same time has maintained a relatively high biodiversity up to now.

Non-native and Invasive species: For centuries, European inland waterways have provided opportunities for the spread of non-native aquatic species. At present, a complex network of more than 28,000 km of navigable rivers and canals connects 37 European countries, creating a biological 'meta-catchment' that encompasses large parts of the continent (after Panov et al., 2009, quoted by Sommerwerk N. et al., 2010). The Danube River belongs to the Southern Invasive Corridor that links the Black Sea with the North Sea via the Rhine-Main-Danube Canal. At present, 141 alien and cryptogenic taxa have been reported for the DRB (www.alarmproject.

net). Several non-native species are true invasive species that currently represent prevalent components of the aquatic community: Asian clam; Chinese pond mussel; spinycheek crayfish, and *Dreissena polymorpha*. New introductions are constantly recorded. The Ponto-Caspian Region not only serves as a suitable recipient for non-native species, but is also a key European 'donor area' for alien species.

4. STRATEGIES ADOPTED TO RESTORE THE RIVER

Source: http://www.danubeparks.org/files/855_DanubeRiverMorphologyRevitalization.pdf

4.1 PROACTIVE STRATEGIES

1. **EU Water Framework Directive (WFD):** The EU WFD considers the river basin as the key spatial unit to understand and sustainably manage water resources. The Danube River Basin Management (DRBM) Plan is the instrument to ensure good status in all water bodies by 2015 and beyond (after ICPDR, 2009, quoted by Sommerwerk N. et al., 2010). The availability of high-quality monitoring data is crucial for the compilation of the DRBM Plan and allows for a cost-efficient implementation of the EU WFD. Building on existing national monitoring networks, the TransNational Monitoring Network (TNMN) was set up in 1996 (adapted in 2006 in order to comply with WFD requirements) under the umbrella of the ICPDR.

   The monitoring efforts through the TNMN have been supplemented by 'Danube expeditions': two Joint Danube Surveys (JDS 1 in 2001 and JDS 2 in 2007) were earned out by multidisciplinary teams of scientific experts. These international expert teams collected hydromorphological, physico-chemical, and biological data along the entire Danube main stem, as well as along selected tributaries, in a standardized way. In total, 280 environmental parameters were evaluated. The JDS are supported by the DRB governments, private and public-run laboratories, private companies, and local authorities and NGOs.

2. **Proactive management options for nutrient reduction**: The model MONERIS (Modeling Nutrient Emissions into River Systems) was used to

quantify point and diffuse source emissions for seven emission pathways into surface waters as well as in-stream retention processes. In addition, management options are implemented in the model that can be evaluated according to their potential to reduce nutrient emissions.

3. **Proactive management of protected areas**: Within the DRB, 1071 freshwater protected areas (>500 ha) have been identified. However, it is difficult to estimate the total area of protection sites within the DRB because various protection categories spatially overlap. For example, parts of the Danube Floodplain National Park east of Vienna (Austria) are concurrently designated as a NATURA2000 site, Ramsar area, UNESCO Biosphere Reserve, National Park, Nature Reserve, IBA (Important Bird Area) and Protected Landscape. Moreover, there is variation throughout the DRB countries whether aquatic ecosystems are the focus of protection, and categories like 'National Park' and 'Nature Reserve' are often not in accordance with the international categories of the IUCN

4.2 REACTIVE MANAGEMENT STRATEGIES – RESTORATION

1. **In the Upper Danube Basin (Germany, Austria), channel widening, re-connection of sidearms, shoreline restoration, and re-establishing the continuum for migratory fish and benthos are the main activities** (e.g. near Ingolstadt, Germany; in the Wachau valley, Austria). In the Middle Danube, restoration projects mostly focus on the re-connection of former branches of the river. In the Lower Danube, large stretches have been embanked and restoration projects focus on the integration of former floodplains and wetlands into the river flow regime (e.g. Bulgaria opening polders for water to flow into the Danube Delta in Romania).

2. **River restoration projects along the Danube are mostly designed and implemented locally.** Usually, national river engineering administrations constitute the highest level of planning. Moreover, cultural diversity and political and language barriers hinder the exchange of experiences regarding the design and implementation of river restoration strategies. Proper monitoring (i.e. assessing success) is mostly lacking. The Danube

River Network of Protected Areas aims to fill these gaps and to serve as an adequate future information platform (www.danubeparks.org).

3. **The International Commission for the Protection of the Danube River (ICPDR) initiated a spatially-explicit prioritization approach for restoration, with a focus on fish species migrating long and medium distances in the DRB.** Barrier-free fish migration along key migration routes is envisaged by 2015 (ICPDR 2009). Barriers along the main stem and close to the mouth of major tributaries need to be re-opened first for achieving this high-priority goal.

ACTIVITIES CONDUCTED UNDER THE DANUBE RIVER RESTORATION

Source: http://www.danubeparks.org/files/855_DanubeRiverMorphologyRevitalization.pdf

To accomplish this phase *Preparation of the Danube River's Revitalization of the finalized proposed projects for the assessment with the selection of at least two projects per every standard criterion* the following activities were achieved through different approaches:

ACTIVITY 1: INVENTORY OF FINALIZED PROJECTS FOR DANUBE RIVER'S REVITALIZATION.

This first activity consists in the assessment of the finalized proposed restoration projects.
Materials: The documentation is based on various sources of information.

- Scientific literature – books, articles, and other scientific publications (e.g. Binder W., (2008), *River restoration: an European overview on rivers in urban areas*. In ECRR Conference on River Restoration; Buijse A. D. et al., (2002), *Restoration strategies for river floodplains along large lowland rivers in Europe*, In Freshwater Biology Journal; Drost H.J. et al., (2002), *Research for ecological restoration in the Dunavat-Dranov region, Danube Delta;* Holubova K. et al., (2003), *Middle Danube tributaries: constraints and opportunities in lowland,* In Lowland River Rehabilitation "An international conference addressing the opportunities and constraints, costs and benefits to rehabilitate natural dynamics, landscapes and biodiversity in large regulated lowlands rivers");

- Official Web sites of natural parks along the Danube bodies and as well as of international networks and organizations (ECRR, WWF etc.).
- The presentation of the projects took into account the following selection criteria:
- Scientific importance of the project;
- Relevance of the thematic area in which the proposed theme is employed in relation to the dynamics of international scientific research;
- Contribution to scientific knowledge development;
- Promoted/strengthened research directions in Danube River's Morphology and Revitalization.

Activity 1.1. Logistics study regarding the inventory methods and means for Danube River's Revitalization projects.

Methods: In this activity we made an inventory of the methods and means that will be applied in the next phase of the project *Comprehensive Danube River's Revitalization Assessment and preparation of the Best Practices Danube River's Revitalization Manual*, based on the previous DDNI projects experience*: Integrated Management of European Wetlands (IMEW), Master Plan for Master Plan – support for sustainable development in DDBR Tulcea county/ Romania Logical Framework Analyse (LFA), Room for the River in Cat's Bend, Romania, as follows:*

- Interactive planning Sketch Match;
- focus groups and semi-structured interviews;
- tree problems.

Activity 1.2. Classification of Danube River's Revitalization Project on subclasses.

Methods: Starting from the *Los Angeles River Revitalization Master Plan*[1] developed by the City of Los Angeles Department of Public Works were taken and adapted several standard criteria of revitalization for Danube River, representing the base for the following 4 criteria subclasses:

- Danube River's restoration and rehabilitation through Lateral Connectivity;

- Danube River's restoration and rehabilitation through Longitudinal Continuity;
- Capture Community Opportunities;
- Create Value.

ACTIVITY 2: DANUBE RIVER'S RESTORATION AND REHABILITATION THROUGH LATERAL CONNECTIVITY

During the last decades, the perception of river–floodplain systems has been significantly improved by the application of new theoretical concepts. The 'river continuum concept' addresses the longitudinal linkages within rivers, while the 'flood pulse concept' integrates the lateral river–floodplain connections in both tropical and temperate climates.

In most riverine systems, hydrological connectivity between the Danube River and its floodplain is restricted to groundwater pathways; geomorphological dynamics are mostly absent.

This second principle, lateral connectivity, focuses on the goals of developing continuously. This is linked to an overall network of channel connections that extend the River's influence into its surroundings and provide ways for water circulation in and out of wetlands. Further, the Lateral Connectivity system develops new linkages to strengthen the connectivity between riparian systems along the Danube.

Goals of Lateral Connectivity:

- Create a continuous ecological corridor River Greenway, adjacent to the Danube River consisting of the extension wetlands into Neighborhood; connect the surroundings with the Danube River.

ACTIVITY 3: DANUBE RIVER'S RESTORATION AND REHABILITATION THROUGH LONGITUDINAL CONTINUITY

As a very long-term goal, the River's ecological and hydrological functioning can be restored through the creation of a continuous riparian habitat corridor within a hydro network of branches and channels, as well as through the removal of concrete walls, where feasible. While completely restoring the Danube Valley to a naturalized condition is not likely to be feasible, restoration projects to address flood control requirements and river channels could be naturalized in significant areas.

Three goals complement the efforts to restore functioning river ecosystems:

- E*nhance flood storage* – focuses on off-channel storage of peak flood flows in order to reduce flow velocities, which is a necessary precondition for ecosystem restoration;
- *enhance water quality* – seeks to improve the quality of water through the implementation of a comprehensive, landscape-based system for filtering;
- *restore the ecosystem functions* – aims to restore the natural ecosystems affected by human activity and restoration of these ecosystems function.

ACTIVITY 4: CAPTURE COMMUNITY OPPORTUNITIES

In the past, communities have turned their back on the River, viewing it as an unsafe, unpleasant place that primarily functions to transport flow and to form a waterway. Constant danger of floods and the desire to obtain land for urban development and economic activities safe from flooding have led to extensive damming and draining, eliminating large areas of floodplains, and affecting natural ecosystems. These works had negative consequences for local communities near the river, who lost their identity and traditional occupations.

The restoration of lateral connectivity will create new opportunities for local riparian communities.

The study will identify opportunities to engage residents in the community planning process:

- Engage residents in the community planning process and consensus building;
- Provide opportunities for educational and public facilities;
- Cultural heritage of the river and foster civic pride; **create value.**

Core elements of this principle include the goal of improving the quality of life by providing new opportunities for traditional economic activities and jobs. River Revitalization can introduce a broad range of benefits that will enhance Danube

Valley liveability and result in greater economic prosperity. Goals include:

- improve the quality of life;
- increase employment;
- create an adequate territorial planning with emphasis on protecting natural and cultural heritage, biological diversity, and land. The use of renewable natural resources directly benefit local communities.

The above mentioned four criteria subclasses were related to the FORECAST project (Facilitating the application of Output from Research and Case Studies on Ecological Responses to hydro-morphological degradation and rehabilitation) preliminary restoration and revitalization measures, in order to be analyzed in the next phase – *Comprehensive Danube River's Revitalization Assessment and preparation of the Best Practices Danube River's Revitalization Manual*. These measures are temporarily classified according to the Environment Agency of England and Wales and the River Basins Management Plans of the countries represented in the project.

Preliminary classification of measures after the FORECAST project:

- to improve water flow quantity;
- to improve sediment flow quantity;
- to improve flow dynamics;
- to improve longitudinal connectivity;
- to improve river bed depth and width variation;
- to improve in-channel structure and substrate;
- to improve lateral connectivity;
- to improve riparian zones;
- to improve floodplains.

ACTIVITY 5: A PUBLIC DEBATE ABOUT THE DANUBE RIVER'S REVITALIZATION PROJECTS ASSESSMENT.

DDNI Tulcea has the logistical capacity to organize a symposium (public debate). This activity will be accomplished in the next phase and its aim will be to select two projects for each subclasses of Danube revitalization and to formulate strategic guidelines for based on their implementation results.

Source: http://www.danubeparks.org/files/855_DanubeRiverMorphologyRevitalization.pdf

ANNEXURE 6

ROLE OF FORESTS ON RAINFALL & RAVINE LAND RESTORATION

Dr. K. Kumaran[1]

Forest-driven water and energy cycles are poorly integrated into regional, national, continental, and global decision-making on climate change adaptation, mitigation, land use, and water management. Forests and trees must be recognized as prime regulators within the water, energy, and carbon cycles. If these functions are ignored, planners will be unable to assess, adapt to, or mitigate the impacts of changing land cover and climate.

Functions inherent to forests offer solutions to water availability and cooling (**Syktus and McAlpine, 2016**). By evapo-transpiring, trees recharge atmospheric moisture, contributing to rainfall locally and in distant locations. Cooling is explicitly embedded in the capacity of trees to capture and redistribute the sun's energy (**Pokorny** *et al.,* **2010**). Further, trees' microbial flora and biogenic volatile organic compounds can directly promote rainfall. Trees enhance soil infiltration and under suitable conditions, improve ground water recharge. Precipitation filtered through forested catchments delivers purified ground and surface water **(Neary** *et al.,* **2009).**

FORESTS ARE INTIMATELY LINKED TO RAINFALL AND WATER AVAILABILITY

Forests play a role in regulating fluxes of atmospheric moisture and rainfall patterns over land. The Earth's land and ocean surfaces release water vapor to the atmosphere. On continental surfaces, this process is aided by forests and other vegetation through evapotranspiration (ET) - evaporation from soil and plant surfaces and transpiration of water by plants (**David Ellison** *et al.,* **2017**).

1 Professor and Head, Department of Tree Breeding, Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam.

On average, at least 40% of rainfall over land originates from ET, with greater contributions in some regions such as the Rio de Plata river basin, where ET from the Amazon forest contributes more than 70% of rainfall **(Van der Ent** *et al.*, **2010)**. Transpiration contributes a large scale of terrestrial ET **(Jasechko** *et al.*, **2013)**, thereby producing a part of the water vapor available for rainfall.

Because water use is intrinsically local, conventional definitions of the water balance are typically bounded by the catchment. However, the terrestrial production of atmospheric moisture through ET represents the principal continental contribution to catchment water balance **(David Ellison** *et al.*, **2017)**.

The impact of forest-derived ET can be seen in satellite observations of rainfall: over most of the tropics, air that passes over forests for ten days typically produces at least twice as much rain as air that passes over sparse vegetation **(Sparcklen** *et al.*, **2012)**. Higher relative humidity has likewise been found to raise the likelihood of precipitation. A 10% rise in relative humidity can lead to two to three times the amount of precipitation **(Khain, 2009)**. Satellite observations further suggest that European forests are a major influence on cloud formation **(Teuling** *et al.*, **2017)**.

Trees and forests contribute to the intensification of rainfall through the biological particles they release into the atmosphere, which include fungal spores, pollen, bacterial cells, and biological debris. Atmospheric moisture condenses when air becomes sufficiently saturated with water, and much more readily when suitable surfaces, provided by aerosol particles, are present **(Sheil, 2014)**. In the Amazon forests, potassium-salt-rich particles with clear biological origins also appear to be directly linked to cloud formation and precipitation **(Pohlker** *et al.*, **2012)**.

FORESTS TRANSPORT WATER LOCALLY AND GLOBALLY

Due to prevailing wind patterns, atmospheric moisture from both oceanic evaporation and ET from forest, vegetation, and soil surfaces is transported across planetary surfaces. Little uncertainty surrounds the basic idea that atmospheric moisture is transported from one location to another and is important for downwind precipitation.

The biotic pump theory (**Makarieva and Gorshkov, 2007**) suggests that the atmospheric circulation that brings rainfall to continental interiors is driven and maintained by large continuous areas of forest beginning from coasts. The theory explains that, through transpiration and condensation, forests or trees actively create low pressure regions that drain moist air from the oceans, thereby generating prevailing winds capable of carrying moisture and sustaining rainfall far within continents (**Nobre, 2014**).

FORESTS REGULATE WATER SUPPLIES

Forests may be particularly important for the so-called "water towers" of larger regions. High altitude forests have a special ability to intercept and cloud droplets. Condensation on plant surfaces, including dense epiphytic lichen and moss communities, provide additional moisture for tree growth, ET, infiltration, groundwater recharge, and ultimately runoff (**Pepin** *et al.*, **2010**). Montane cloud forests appear to exhibit higher rates of infiltration and dry season flow than lands converted to agriculture (**Munoz Vilers** *et al.*, **2015**).

Scientific evidence typically highlights substantial losses in stream flow following afforestation and reforestation, while forest clearing results in increased stream flow. The dominant paradigm implies a tradeoff between carbon sequestration and ground water recharge.

While tree and forest removal is well known for raising the likelihood of floods, the corollary that the planting of trees and forests can reduce flooding, has been far more controversial (**Van Noordwijk and Tanika, 2016**).

Ravines are the network of gullies running parallel and discharging into rivers. India has 3.67 mha of ravine lands, which constitute 1.12% of the total geographical area of 328 mha. Very extensive degradation of land has occurred along some of the major river systems of the country in various states in the form of deep gullies (**NCA, 1976**).

The ravine lands are degraded by lands associated with several constraints for vegetation growth due to vicarious climate, poor soil fertility, low soil moisture, extreme variation in temperature, and heavy biotic pressure.

Ecological restoration is defined as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed, or it is the return of a damaged ecological system to a stable, healthy, and sustainable state (**Gaurav Mishra** *et al.*, **2014**).

GROWTH PERFORMANCE OF BAMBOO PLANTATION AT MANIKPURA WATERSHED (MPWS), AGRA

Mpws	Avg. Culm height (m)	Avg. Culm collar diameter (mm)	Avg. Crown size (m)	Number of culms per clump
April 2013	5.12	18.25	3.01	16.17
August 2013	6.42	23.75	4.56	21.05
December 2013	9.56	37.30	5.52	24.33
December 2014	10.46	40.23	6.03	26.50
July 2015	11.76	42.11	7.27	29.60

The growth performance over a period of time shows an increasing trend. The average culm height has increased twice its initial growth. The average culm collar diameter has increased threefold compared to initial planting (**Singh** *et al.*, **2017**). The plant growth of bamboo has contributed to decreased soil loss, which might have brought changes in moisture and silt retention owing to the growth of dense vegetative cover in the gully beds.

HYDROLOGICAL PERFORMANCE OF BAMBOO PLANTATION AT MANIKPURA WATERSHED (MPWS), AGRA

Year	Seasonal rainfall (mm)	Runoff from Bamboo planted area (mm)	Percent of Runoff	Soil loss t/ ha/yr
2010	456	44.0	9.65	4.27
2011	226	6.04	2.67	0.66

2012	531	14.50	2.73	0.78
2013	494	8.96	1.81	0.60

The results showed that the runoff, sediment behavior, under bamboo plantation based interventions absorbs more than 10 percent of rainfall. Due to influence of vegetation on soil, permeability of the soil was increased resulting in reduced surface runoff, soil loss, evaporation and better water penetration into soil as well as increased drainage capacity of soil.

The type of trees to be planted depends on the kind of soil in the concerned area. Recommended species for different soil types are as given in the table that follows:

Soil type	Suitable species
Clay soil	Azadirachta indica, Pongamia pinnata, Swietenia mahagoni, Pterocarpus marsupium, Terminalia tomentosa, Melia dubia, Dalbergia latifolia, Dalbergia sissoo (Any 4/5 species)
Red soil with 10ft minimum soil depth	Tectona grandis, Swietenia mahagoni, Pterocarpus marsupium, Terminalia tomentosa, Melia dubia, Dalbergia latifolia, Azadirachta indica, Santalum album and Pterocarpus santalinus (Each – 15%)
Red laterite soil with 5ft soil depth	Tectona grandis, Swietenia mahagoni, Santalum album, Pterocarpus santalinus, Dalbergia latifolia, Azadirachta indica, Melia dubia, Ailanthus excelsa (Each 20%)
Alluvial soil	Tectona grandis, Swietenia mahagoni, Pterocarpus santalinus, Terminalia tomentosa, Melia dubia, Dalbergia latifolia, Santalum album, Neolamarckia cadamba (Teak 60%, others 10%)

Uncultivable soil	Azadirachta indica, Albezia lebbeck, Dalbergia sissoo, Ailanthus excels, Pterocarpus santalinus (Each 20%)
Swampy soil	Terminalia arjuna, Casuarina junghuniana, Pongamia pinnata (100%)

5.2 COSTS INVOLVED IN THE FOREST MODEL FOR ONE ACRE OF FOREST LAND

In one acre of forest land, 250 native and endemic trees can be planted with spacing of 4 x 4m. The cost involved per acre of land would be:

No	Operations	Cost per Unit (Rs)	Cost (Rs)
1	Land treatment / preparation works	20,000	20,000
2	Sapling Cost* including gap filling (20%)	10	3,000
3	Pitting and planting	40	12,000
4	Manuring and mulching per year	12	3,000
5	Maintenance per annum (soil working, pruning, etc)	5,000	5,000
6	Drip Irrigation**	25,000	25,000
Total cost per acre of forest (Rs):			68,000

* Varies with species ** Optional

5.3 CREATING THE NURSERY INFRASTRUCTURE FOR THE REQUIRED NUMBER OF SEEDLINGS

Under forestry plantation, the total number of quality plant material required per stretch of 1000 kilometres of river is 8 crores. To produce the required QPM, 400 acres of land will be required. The capacity of nurseries in the state is to be strengthened. It is important to develop sufficient infrastructure to produce QPM by organic methods. This will be a critical element for successful implementation of the project. Unlike the horticulture nursery which requires a three year period given sapling grafting, the seedlings can be deployed in a year's time.

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ANNEXURE 7

SOIL REJUVENATION

Dr. Saravanan Kandasamy[1]

ABSTRACT

DECLINE IN SOIL PRODUCTIVITY

Despite significant growth in agriculture over the last four decades in India, most of our important soil-based production systems are showing signs of fatigue. The partial factor productivity of fertilizers during the last three and a half decades showed a declining trend from 15 kg food grains/kg NPK fertilizer in 1970 to 5 kg food grains/kg NPK fertilizer in 2005, as reported in the Vision 2030 document of Indian Institute of Soil Science (IISS, 2011).

DETERIORATION OF SOIL FERTILITY

The percentage of samples high in available soil phosphorus has risen five times from 4% to 20% during the period from 1969 to 2002, and the trend continues to rise due to non-judicious use of phosphatic fertilizers by farmers. Continuous use of such fertilizers possessing excessive nutrient loads, with an intention to boost crop yields, have not only increased the cost of cultivation but also led to nutrient imbalances in soil and eutrophication of surface water bodies. Analysis of more than 0.25 million soil samples revealed widespread deficiency of micronutrients: Zn (49%), S (41%), Fe(12%), Cu (3%), Mn (4%), and B (32% in some selected areas such as Bihar). The number of elements deficient in Indian soils increased from one in 1950 to nine in the year 2005-06, which might further increase by the year 2030 if the imbalanced fertilization continues. On the other hand, river canals, ponds, and lakes receive excessive nutrient inputs from fertilized farm lands through drainage suffer due to proliferation of aquatic weeds like water hyacinth and contamination by agrochemical residues.

The existing lacuna in soil chemical test based fertilizer recommendations coupled with poor soil management practices by farmers (intensive tillage, irrational use

[1] Soil scientist, former Assistant Professor, Tamil Nadu Agricultural University

of fertilizers, and neglect of organic matter addition to soil) continue to bring down the quality and potential utility of both soil and water.

SOIL DEGRADATION – STATUS, CAUSES AND REMEDY

Soil degradation is a severe problem in India, a land with high demographic pressure, supporting approximately 16% of the world's human population and 20% of the world's livestock population on merely 2.5% of the world's geographical area. The average soil erosion rate was estimated to be 16.4 ton/ha/year, resulting in an annual total soil loss of 5.3 billion tons throughout the country. Nearly 29% of the total eroded soil is permanently lost to the sea through the rivers, while 61% is simply transferred from one place to another, and the remaining 10% is deposited in reservoirs.

Various estimates on the annual direct cost of land degradation (in terms of loss in nutrients, production, chemical degradation, etc.) in India range from 75 to 448 billion rupees per annum.

The majority of the land degradation (86.31 %, 104.19 M ha) has happened on arable lands (under regular tillage) compared to 13.69 %, 6.53 M ha on open forest areas with < 40% canopy. Among the different types, soil loss due to water erosion (>10 tonnes/ha/yr) is the most dominant, recording 82.57 M ha (73.27 and 9.30 M ha affected under arable land and open forest respectively). Soil under the vegetation as that of open forests, with a canopy cover of 10-40%, suffers only 1/6 of degradation compared to arable land with regular tillage of soil, as practiced in conventional agriculture.

Area under desertification (land degradation in arid, semi-arid, and dry sub-humid regions of the country) has increased by 1.16 M ha from 2003-05 to 2011-13, as per the recent estimate in the Desertification and Land Degradation Atlas of India.

The main agricultural activities leading to soil degradation in different agro-climatic regions are:

- Imbalanced Fertilization
- Excessive Tillage and Use of Heavy Machinery
- Crop Residue Burning and Inadequate Organic Matter Inputs

- Poor Irrigation and Water Management
- Poor Crop Rotations
- Pesticide Overuse and Soil Pollution

Considering the influence of agroecology, it was found that the areas under crops with shorter growing period (< 90–150 days) cultivated with short duration crops viz., rice, wheat, millets, maize, chari (fodder), pulses, cotton, mustard, and gram (soils of Northern and Western plains and Central (Malwa) highlands) are more prone to soil degradation. The reason being lack of adequate vegetative cover during a major part of the year that would protect the soil against the forces of rain and wind, causing erosion. Whereas, agro-eco regions which possessed perennial vegetation/ crops with longer growing periods of 250+ days (Andaman-Nicobar and Lakshadweep), registered the least degradation.

These results indicate the nature of agricultural land use strategy that needs to be implemented in order to reduce the damage happening to the precious soil resource. Increasing area under long-duration and tree-based crops can effectively reduce soil erosion losses.

Moreover, a higher rate of decomposition of organic matter under Indian conditions, unlike in temperate climates, necessitates regular addition of crop residues and cattle excreta to maintain the soil's health. Only organic matter addition can lead to a balanced state of the soil's physical (structural development and movement of water and air), chemical (high nutrient holding capacity) and biological properties (microbial diversity).

Hence, cropping systems need to be redesigned from an exploitative mode to a conservative mode, considering the soil not just as a medium but an ecosystem. Based on already available evidence, the adoption of conservation agriculture (minimal tillage and crop residue mulching) in a diversified cropping system comprising horticulture crops (including fruit trees and vegetables), fodder crops (trees and grasses), and agroforestry, along with biological approaches of nutrient management and plant protection supported by livestock is recommended as a participatory resource conservation and management approach. The potential of such an integrated approach in achieving sufficient soil cover, erosion control, soil quality, biodiversity, food, nutritional security, net income, and conservation of natural resources needs to be demonstrated on a large scale for wider adoption.

1. DECLINE IN SOIL PRODUCTIVITY

Despite significant growth in agriculture during the last four decades in India, most of the important soil based production systems are showing signs of fatigue. The consumption of fertilizers (N +P_2O_5 + K_2O) in India has increased over the years from 1.98 million tonnes in 1970 to 26.8 million tonnes during 2015-16, according to the statistical database of the Fertilizer Association of India (FAI). However, the partial factor productivity of fertilizers is declining in intensive cropping systems in India. The partial factor productivity of fertilizers during the last three and half decades showed a declining trend, from 15 kg food grains/kg NPK fertilizer in 1970 to 5 kg food grains/kg NPK fertilizer in 2005, as reported in the Vision 2030 document of the Indian Institute of Soil Science (IISS, 2011).

In the urgency for higher production, no serious attention was given to long-term soil quality and sustained high productivity. As a consequence, the annual compound growth rate of major crops has declined from 3.36% in 1981-85 to 0.11% in 2001-05. A similar trend was registered in the case of pulses and oilseeds, while cotton even exhibited even a negative growth rate.

It has to be understood that soil is not just a medium for crop growth but a living system. The soil ecosystem is dependent on biotic diversity for its health, functioning, stability, and sustained productivity. Apart from the nutrients required for crop growth, it needs continuous nourishment with food for its biotic component, the macro fauna (earthworms, millipedes, mites, etc.) and micro fauna (bacteria, fungi, and actinomycetes).

The recycling of crop residues and animal excreta is indispensable for providing nourishment (organic matter at various levels of decomposition) to maintain their population and activities at different trophic levels. Each one of their roles is essential and interconnected. Only under these circumstances, through the improvement of the soil's biological properties, can the soil have ideal physical (structure, aeration, retention and movement of water and nutrients) and chemical (pH, accumulation of salts and nutrient transformation and availability) properties.

Only an overall improvement in all these properties can sustain soil health and thereby sustain productivity. The solid, liquid, gaseous, and biotic spheres of the soil are in a dynamic equilibrium, with change in one phase affecting the other. Hence the soil management strategies should shift towards a holistic approach.

2. TRENDS IN SOIL FERTILITY CHANGE

The first systematic soil fertility map of Indian soils, published in 1969 by Ramamurthy and Bajaj, showed that around 4% samples were high in available Phosphorus, which has increased to 20% in 2002 (Motsara, 2002). The increase in P status in some soils is due to non-judicious use of phosphatic fertilizers by farmers, which not only cost more but also lead to nutrient imbalances in the soil (IISS, 2011).

The deficiency of nitrogen in soil may continue to remain the same in Indian soils, as they are presently low to medium in organic matter content. Continuous reliance on the application of inorganic nitrogen fertilizers alone for augmenting crops cannot improve the soil's nitrogen reserves, as 70% of the applied fertilizer nitrogen is quickly lost within the crop period through water and gaseous routes. Only by increasing the organic matter content in soils through effective recycling of crop residues and animal excreta in combination with mulching techniques, can the status of organic matter and nitrogen in the soil be improved. More than 90% of the soil's nitrogen is stored in the form of organic compounds.

The three estimates (Ramamurthy and Bajaj, 1969; Ghosh and Hasan, 1980; Motsara, 2002) of soil fertility for K indicate an increase in the percentage of samples testing high over the years.

In the case of micronutrients, analysis of more than 0.25 million soil samples revealed widespread deficiency of Zn (49%), S (41%), Fe(12%), Cu (3%), Mn (4%), and B (32% in some selected areas such as Bihar).

As food grain production increased with time, the number of elements becoming deficient in soils and crops also increased. The number of elements deficient in Indian soils increased from one in 1950 to nine in 2005-06, which might further increase by the year 2030 if the imbalanced fertilization continues (IISS, 2011).

The fertilizer consumption in India has been grossly imbalanced from the outset, with the greatest part being N, followed by P. Further decontrol of phosphatic and potassic fertilizers resulted in more than doubled prices of phosphatic and potassic fertilizers. Thus, the already imbalanced consumption ratio of 6.2:4:1 (N:P:K) in 1990-91 has widened to 7:2.7:1 in 2000-01 and 7.5:3:1 in 2015-16 as against a favourable ratio of 4:2:1.

The problem is further accentuated by the fact that the current fertilizer nutrient use efficiency in India is quite low. It is 30-50% for N, 15-20% for P, 8-10% for S, 2-5% for Zn, and 1-2% for Fe and Cu. In this situation, productivity cannot be increased or sustained (IISS, 2011).

3. UNRESOLVED ISSUES IN SOIL FERTILITY MANAGEMENT

Even though soil tests and crop-based fertilizer recommendations are available, farmers continue to follow their own way of applying fertilizers, expecting higher yields, which contributes to nutrient imbalance in soil and emergence of multi-nutrient deficiencies. Most of the existing fertilizer recommendations are also based on individual crop requirements for a particular season alone and fail to address the nutrient budgets for a cropping system. Biological nutrient fixations in inter/mixed crop soil systems (e.g. cereal plus legume) are also not considered when calculating the fertilizer nutrient needs.

Unfortunately, most of the research experiments conducted in agricultural universities, including long-term experiments on soil fertility, focus mostly on assessing the nutrient status of the soil (chemical property), while neglecting the impact and interaction of physical and biological properties on sustaining the productivity of the soil. It is to be noted that the contribution of organic inputs in integrated nutrient management approaches is usually based on their nutrient content alone. This neglects the contribution of organic material towards enhancing soil fauna and micro flora, which consequently improve the solubilization of the soil's native nutrient reserves, apart from biological nitrogen fixation from atmosphere.

With high reliance on machineries, fertilizers, and other agrochemicals in the post green revolution era, most of the farmers have neglected the significance of livestock in Indian agriculture. Unlike in temperate climates that favour the accumulation of organic matter in the soil due to low decomposition rates, Indian soils need frequent replenishment of organic matter through the incorporation of crop residues and cattle manure. The high decomposition rates under high temperatures and intensive tillage necessitate regular addition of crop residues with animal excreta to maintain the soil microbial diversity.

Hence, cropping systems need to be redesigned to preserve soil health through a shift from the existing exploitative mode to a conservative mode. Without understanding and considering the soil's true nature as an ecosystem, continuous mono cropping on the same soil, relying mostly on inorganic fertilizer additions - as done in industrial manufacturing in style and scale - has led to a decline in its productive potential. Such practices lead to the continuous emergence of new nutrient deficiencies, in spite of the addition of newer fertilizers.

The addition of nutrients through organic inputs is therefore imperative for maintaining the sustainability of the system (IISS, 2011).

4. SOIL AND LAND DEGRADATION

"The nation that destroys its soil destroys itself." Franklin D. Roosevelt (1882-1945)

Soil is a part of the land, thus any deterioration in its quality, mass, or volume either singly or in combination, also results in the deterioration of the land.

Land degradation means reduction or loss of biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands, resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as:

- Soil erosion caused by wind and/or water;

- deterioration of physical, chemical and biological or economic properties of soil; and
- long-term loss of natural vegetation (UNCCD, 1994)

TABLE 1: STATUS AND SPATIAL DISTRIBUTION OF DEGRADED AND WASTELANDS OF INDIA (ICAR, 2010)

Degradation type	Arable land (M ha)	Open forest (<40% canopy) (M ha)	Total
Water erosion (>10 tonnes/ha/yr)	73.27	9.30	82.57
Wind erosion (Aeolian)	12.40	–	12.40
Chemical degradation (salt-affected soils,acidic soils)	17.45	7.23	24.68
Physical degradation (Mining and industrial waste, Waterlogging and surface inundation)	1.07	-	1.07
Total	104.19	16.53	120.72

(M ha: Million hectares) (Source: Indian Council of Agricultural Research, 2010)

Among the different types of land degradation, water erosion contributes to the highest share of 82.57 M ha out of the total 120 M ha, followed by chemical degradation and wind erosion (Table 1). It is to be noted that the majority of the degradation (86.31 %, 104.19 M ha) has happened on arable lands (under regular tillage) compared to 13.69 %/6.53 M ha on open forest areas with < 40% canopy. From the data presented above, it could be easily understood that soil under the vegetation as that of open forests, with a canopy cover of 10-40%, suffers only 1/6 of the degradation compared to arable land with regular tillage of soil, as practiced in conventional agriculture. Water and wind erosion happens mainly in agricultural areas, leading to land degradation due to the continuous loss of top soil.

4.1. AGRO-ECOLOGY AND SOIL DEGRADATION

To understand implications and role of climatic and edaphic resources in agricultural and allied sectors, the NBSS & LUP (National Bureau of Soil Survey and Land Use Planning, Nagpur) prepared an agro-ecological map, based on the physiography, soils, bioclimate, and length of growing period (GP) of crops. An Agro-Ecological Regions (AER) map was prepared by superimposing a bioclimatic cum growing period map over the base soil-scape map (soil plus physiography). The country has been broadly grouped into 20 agro-ecological regions (Sehgal et al., 1992).

The area estimates of degraded and wastelands in different AERs reveal that AER-4 (Northern Plains and Central Highlands including Aravallis, a hot semi-arid ecoregion with alluvium derived soils, and a GP of 90–150 days) is highly degraded, ranked at the top, with an area of 14.96 M ha.

Other AERs that have an appreciably high area under degradation are AER-2 (Western Plains, Kachchh, and a part of the Kathiawar peninsula, a hot arid ecoregion, with desert and saline soils, and a GP of <90 days; 13.913 M ha) and AER-5 (Central (Malwa) Highlands, Gujarat Plains, and parts of the Kathiawar peninsula, a hot semi-arid ecoregion with medium and deep black soils, and a GP of 90–150 days; 11.27 M ha).

Though all the AERs are affected, the least affected are AER-1 (the western Himalayas, a cold arid ecoregion, with shallow skeletal soils and a GP of <90 days; 0.019 M ha) and AER-20 (Islands of Andaman-Nicobar and Lakshadweep, a hot humid and perhumid island ecoregion, with red loamy and sandy soils, and a GP 210+ days; 0.077 M ha).

The above data clearly indicate that soil and land degradation is severe in hot semi-arid and hot arid ecoregions containing alluvium derived soils, desert soils, saline soils and medium and deep black soils (Northern and Western Plains, Central (Malwa) Highlands) with growing periods ranging from <90–150 days. Whereas the least degradation has happened either in cold arid eco-region (Western Himalayas) with low temperature (0-8°C), minimal soil depth and little agriculture, or in a hot humid and perhumid island ecoregion (Andaman-Nicobar and Lakshadweep), where the growing period is 210+ days (long duration and forest tree crops).

It is inferred that the areas (AER-4, AER-2 & AER-5) with a shorter growing period (<90–150 days), cultivated with short duration crops viz., rice, wheat, millets, maize, chari (fodder), pulses, cotton, mustard, and gram are more prone to soil degradation. The reason being lack of adequate vegetative cover during a major part of the year that would protect the soil against the forces of rain and wind to check erosion. It is to be highlighted that the natural forest cover in the AER-2 region (Western Plains) has decreased dramatically, from 15 per cent to almost 1 per cent, over the years, which additionally contributed to higher soil degradation.

The fact that regions like AER-20, which possessed perennial vegetation/crops with longer growing periods (250+ days), registered the least degradation indicates the nature of agricultural land use strategy that needs to be implemented in order to reduce the damage happening to the soil. **Increasing the area under long-duration and tree-based crops can effectively improve the soil cover for longer periods and thereby reduce soil erosion.**

The main agricultural activities leading to soil degradation in different agro-climatic regions can be summarized as follows (Bhattacharyya et. al., 2015):

- Low and Imbalanced Fertilization
- Excessive Tillage and Use of Heavy Machinery
- Crop Residue Burning and Inadequate Organic Matter Inputs
- Poor Irrigation and Water Management
- Poor Crop Rotations
- Pesticide Overuse and Soil Pollution

4.2. DESERTIFICATION

As per the United Nations Convention for Combating Desertification (UNCCD), desertification is defined as “land degradation in arid, semiarid and dry sub-humid areas resulting from various factors including climatic variations and human activities” (UNCCD, 1994). Here “land” means the terrestrial bio-productive system.

Recently, the Indian Ministry of Environment, Forest, and Climate Change has entrusted a national level project on "Desertification Status Mapping of India" to the Space Applications Centre, ISRO, Ahmedabad. This project has brought out the "Desertification and Land Degradation Atlas of India" (SAC, 2016).

Analysis of the information from the above project indicated the fact that there was an increase of 1.87 M ha of the area under land degradation (constituting 0.57% of the total geographic area of the country) from 2003-05 to 2011-13. The area under desertification (arid, semi-arid and dry sub-humid regions of the country) was 82.64 M ha in 2011-13, whereas in 2003-05, it was 81.48 M ha. Thus there was an increase of 1.16 M ha area under desertification in this period of time. Around 3.63 M ha productive land has degraded and 0.74 M ha land has converted from low-severity to high-severity degradation class during this period.

Thus there is a cumulative increase of 1.16 M ha area under desertification. The most significant processes of desertification in arid regions is observed to be wind erosion. In semi-arid and dry sub-humid regions, **vegetation degradation** and **water erosion** dominate. Among the process-wise changes in the desertification/ land degradation status, **vegetation degradation ranks at the top** with 1.02 million hectares from 2003-05 to 2011-13, followed by water erosion (0.49 M ha).

There are global efforts to combat desertification. India is signatory to the United Nations Convention on Combating Desertification (UNCCD) and is committed to achieving a neutral status of land degradation by 2030.

For a sustainable management of land that protects it from further degradation, a land use approach integrating soil, water, vegetation, and agriculture needs to be evolved and implemented urgently.

4.3. COSTS OF SOIL DEGRADATION

More than being a vital natural resource for our food, fibre, and shelter, soil is precious in the sense that it takes thousands of years for an inch depth of soil to form. Unlike water and air which can cycle very fast and get replenished quickly, the formation of new soil takes thousands of years. Hence a lot more emphasis on its conservation is required.

A major factor responsible for the degradation of the natural resources is soil erosion. In general, soil erosion is more severe in mountainous (sloping landscape) than in undulating and plain areas. Inappropriate soil management, unsuited to the location, such as tilling along the slope, lack of crop cover during heavy rainfall, etc. are responsible for accelerated soil erosion with consequent loss of land productivity.

Soil degradation is a more severe problem in countries like India with high demographic pressure. India supports approximately 16% of the world's human population and 20% of the world's livestock population on merely 2.5% of the world's geographical area. Soil erosion by water is one of the most serious forms of degradation in India. Based on first approximation analysis of existing soil loss data, the average soil erosion rate was 16.4 ton/ha/year, resulting in an annual total soil loss of 5.3 billion tons throughout the country (Dhruvanarayana, and Ram Babu, 1983). Nearly 29% of the total eroded soil is permanently lost to the sea, while 61% is simply transferred from one place to another, and the remaining 10% is deposited in reservoirs. This kind of soil degradation through the loss of topsoil, is one of the major factors of low and unstable crop yields in the rainfed semi-arid to sub-humid subtropics of India.

Soil degradation has become a serious problem in both rainfed and irrigated areas of India. India is losing a huge amount of money from degraded lands (Table 2). This cost is documented by declining crop productivity, land use intensity, changing cropping patterns, high input use, and declining profit (Joshi and Agnihotri, 1984; Parikh and Ghosh, 1995; Joshi et.al., 1996 and Srinivasarao et.al., 2013). Reddy (2003) valued the loss of production in India at Rs. 68 billion in 1988–1989, using the National Remote Sensing Agency (NRSA) dataset. Additional losses resulting from salinization, alkalinization, and waterlogging were estimated to be Rs. 8 billion.

TABLE 2: ESTIMATES ON THE ANNUAL DIRECT COST OF LAND DEGRADATION IN INDIA

Parameters	NRSA (1990)	Sehgal and Abrol (1994)
Area affected by soil erosion (M ha)	31.5	166.1
Area affected by salinization, alkalinization, and waterlogging (M ha)	3.2	21.7
Total area affected by land degradation (M ha)	34.7	187.7
Cost of soil erosion in lost nutrients (Rs. billion)	18.0	98.3
Cost of soil erosion in lost production (Rs. billion)	67.6	361.0
Cost of salinization, alkalinization, and water logging in lost production (Rs. billion)	7.6	87.6
Total direct cost of land degradation (Rs. billion)	75.2	448.6

In another comprehensive study made on the impact of water erosion on crop productivity, it was found that soil erosion due to water resulted in an annual crop production loss of 13.4 Mt in cereal, oil seeds, and pulse crops equivalent to ~USD 162 billion (Sharda. et.al., 2010).

4.4. MANAGEMENT OF SOIL DEGRADATION

Prevention and restoration of soil degradation is one of the major strategies suggested. For preventing and restoring soil degradation, controlling soil erosion and sedimentation will be the main issues. Once this is addressed, the associated risks of eutrophication of surface water and contamination of groundwater, combating desertification and enhancing soil carbon sequestration to improve soil quality/productivity and mitigating the greenhouse effect will all be taken care of.

The widely practiced monoculture system with short duration crops under intensive tillage, which is highly prone to soil degradation, needs to be replaced with a multi crop system, as present in an open forest system, to conserve the soil. An alternative cropping system with perennial horticultural or forestry tree components integrated with forage, green manure, and other food crops as mixed crops, grown under a conservation agricultural system (minimum or zero tillage) can be effective in preventing soil erosion and land degradation, due to an increase in canopy cover, mulching with crop residue, and improvement in soil structure. Combining biological approaches of nutrition and plant protection, the soil biodiversity can also flourish through regular addition of organic matter and thereby stabilize the soil ecosystem.

Conservation agriculture (CA), agroforestry and diversified cropping can be adopted as biological means of soil conservation and land degradation and mitigation Bhattacharyya et.al., (2015).

4.4.1. REFORESTATION, GRASSLAND, AND HORTICULTURE DEVELOPMENT

(a) The following horticultural crops were suggested for checking degradation in hilly soils (Bhattacharyya et.al., 2015):

  (i) Fruit trees in half-moon terraces (triangular system of planting) on contour;

  (ii) pineapple (*Ananas comosus* L.) in two rows planted closer together in contour bunds;

  (iii) vegetables like bean (*Phaseolus vulgaris* L.), cowpea (*Vigna sinensis* L.), guar or cluster bean (*Cyamopsis tetragonoloba* L.), pea (*Pisum sativum* L.), and good cover crops like sweet potato in the interspaces of the contour and

  (iv) ginger (*Zinziber officinale* L.) and turmeric (*Curcuma longa* L.) grown in the interspace area of contours.

(b) Tree plus fodder plus food crop system:

Comparing soil loss under different land use systems, Grewal (2000) found that soil loss was negligible (0.1 ton/ha) under a Eucalyptus-Bhabar grass (*Eulaliopsis binata*) system. All combinations of tree and grass/fodder crops resulted in a remarkable decrease in soil loss, run-off and nutrient loss compared to cultivated fallow. Compared to these mixed multi crop systems, soil loss, runoff, nitrogen loss, and potassium loss were up to 50 times, 23 times, 100 times, and 10 times higher under cultivated fallow respectively, indicating the huge benefits of mixed crop systems involving perennials as soil cover (Table 3).

TABLE 3: SOIL LOSS UNDER DIFFERENT LAND USE SYSTEMS IN SHIVALIKS
(SOURCE: GREWAL,2000)

Land Use Systems	No. of Years of Obser-va-tions	Soil Loss (ton ha^{-1})	Runoff (% of Total Rainfall)	Nitrogen (N) Loss (kg ha^{-1})	Potassium (K) Loss (kg ha^{-1})
Eucalyptus-Bhabar grass	6	0.1	0.1	0.5	0.9
Acacia catechu–forage grass	3	0.2	2.0	7.0	0.5
Leucaena-Napier grass	3	0.3	4.4	6.6	1.2
Teak - Leucaena-Bhabar	3	0.4	3.3	2.1	0.6
Eucalyptus-Leucaena-Tur-meric	5	0.6	2.6	2.5	0.7
Poplar-Leucaena-Bhabar	5	1.5	4.8	5.9	1.1
Sesamum - Rapeseed	3	2.7	20.5	42.5	3.0
Cultivated fallow	3	5.6	23.0	51.3	5.0

In forests, a high proportion of surface runoff percolates into the ground and becomes subsurface runoff, due to the high infiltration capacity of forest soils and leaf litter. As a result, runoff from forested areas, as compared with open ground, is more uniform, and usually forested watersheds are characterized by lower maximum and higher minimum water discharges (Shiklomanov, 2009).

During events of rainfall and melting of ice, such regulation of runoff by forest soils (with leaf litter on the surface) protects the soil from water erosion, and also water bodies like rivers and lakes from excessive loading with sediments.

4.4.2. VEGETATIVE BARRIERS AND THE USE OF NATURAL GEOTEXTILES, MULCHING, AND DIVERSIFIED CROPPING

Results from the Himalaya region indicate that vegetative barriers can decrease runoff by 18%–21% and soil loss by 23%–68% on slopes varying from 2%–8%. Vegetative barriers of *Guinea* grass, *Khuskhus* and *Bhabar* were effective (after 3–4 years) in reducing soil loss by 6–8 ton/ha/year and runoff by 33%–38% (CSWCR&TI, 2030).

Maize and wheat yield increased ~32% and 10%, respectively, due to conserved moisture in the hilly region (Ghosh, 2009). Pigeon pea (*Cajanas cajan*), because of its very good canopy cover (95%–98%), was effective, as a vegetative barrier, in reducing runoff (28%–29%) and soil loss (2.1 to 2.6 ton/ha), in a finger millet (*Eleusine coracana* L.)/kodo millet (*Paspalum scrobiculatum* L.)/lentil (*Lens esculentus* L.) cropping sequence. Pigeonpea improved SOC along with addition of 22 kg to 41 kg of N/ha in the soil. The practice increased maize yield by 5%–10% and wheat yield by 10%–15% in the hills.

4.4.3. AGROFORESTRY

Agroforestry systems are an appropriate management tool for both acid and salt-affected soils, because perennial woody vegetation recycles nutrients, maintains soil organic matter, and protects soil from surface erosion and runoff (Nair, 1993). Four multipurpose tree species were compared with a control plot (without tree plantation) for soil fertility status in an acid soil of India. The presence of trees improved the physico-chemical and microbial biomass parameters by storing greater SOC (Ramesh et. al., 2010).

Tree vegetation in an agroforestry system serves two major purposes:

(i) the fine root system holds soil in place, reducing susceptibility to erosion; and

(ii) plant stems decrease the flow velocity of runoff, enhancing sedimentation.

Nair (2011) stated three environmental benefits of agroforestry systems: water-quality enhancement, Carbon sequestration, and soil improvement. These benefits are based on the perceived ability of

(i) vegetative buffer strips to decrease surface transport of agrochemical pollutants;

(ii) large volumes of aboveground and belowground biomass of trees to store C deeper in the soil profile; and

(iii) trees enhance soil productivity through biological N_2 fixation, efficient nutrient cycling, and capture nutrients from depth.

(iv) legume-based agroforestry has the capacity to support biological N fixation to enhance subsequent soil N availability and therefore improve soil fertility and crop yields (Rosenstock et. al., 2014).

4.4.4. CONSERVATION AGRICULTURE (CA)

Conservation agriculture refers to a set of principles, grounded in sound science that is gradually being adopted globally. The concept includes:

(i) causing minimum disturbance to the soil surface by using no- or minimum-tillage;

(ii) keeping the soil surface covered all the time through practices such as retention of crop residue, mulching, or growing cover crops;

(iii) adopting crop sequences or rotations that include agroforestry in spatial and temporal scales; and

(iv) controlled traffic (FAO,2010)

Collectively, these practices lead to an increase in water stable aggregates, greater SOC concentrations, and protection from wind and water erosion. Conservation agriculture-based crop management technologies include zero tillage (ZT) with residue recycling; laser assisted precision land levelling, direct drilling into the residues, and direct seeding.

The results from a long-term experiment at ICRISAT, Andhra Pradesh, established that the biological approaches viz., use of plant biomass as surface mulch, agriculturally beneficial microorganisms, and other practices, have enhanced soil biological and chemical properties of a rainfed Vertisol in the semiarid tropical environment in southern India. Yields were comparable to the conventional system of crop production that used standard agrochemical inputs. In crop husbandry systems receiving only biological inputs, depending on the crops grown that year, stover yield ranging from 6.6 to 11.6 t/ha and grain yield ranging from 4 to 5.9 t/ha was harvested annually when there was > 627 mm of rainfall (Rupela, 2006).

An investigation on changes in soil organic carbon (SOC) under conservation agriculture (CA), after seven years of rice–wheat rotations in the eastern Indo-Gangetic Plains (IGP) of India, revealed that both zero tillage and permanent raised bed crop establishment methods which retained the crop residue in the soil increased SOC at 0–0.6 m depth by 4.7 and 3.0 t C/ha, respectively, whereas the conventional transplanted rice followed by conventional tillage wheat system resulted in a decrease in SOC of 0.9 t C/ha (Sapkota et.al., 2017).

Higher SOC concentrations in surface soils under zero tillage compared to conventional tillage system have been attributed to less disruption of macroaggregates that protected SOC against oxidation.

4.4.5. PARTICIPATORY RESOURCE CONSERVATION AND MANAGEMENT

A case study in Netranahalli Watershed (Karnataka) in southern peninsular India stressed the importance of involvement of communities for conservation of natural resources (mainly soil and water) and their management. Improvement in groundwater levels, soil and moisture conservation, development of irrigation facilities, water regeneration capacity, forestry and horticulture development, change in land use pattern and cropping pattern, improvement in animal health, employment, and income generation were noticed by Adhikari *et al.* [2013].

5. A REVIEW ON THE MAIN CAUSES OF SOIL DEGRADATION,

Research results documenting both soil on degradation and soil health improvement in various agricultural systems and potential solutions to improve soil health in different regions in India, leads to the following (Bhattacharyya et.al., 2015):

(i) With changing climate, land degradation is expected to further increase due to high intensity storms, extensive dry spells, and denudation of forest cover. Combating further land degradation and investing in soil conservation is a major task involving the promotion of sustainable development and nature conservation.

(ii) An integrated watershed approach should be given maximum attention to combat land degradation and environmental problems, particularly in fragile areas.

(iii) Sustainable agricultural intensification using innovative farming practices have tremendous potential of increasing productivity and conserving natural resources, particularly by sequestering Soil Organic Carbon (both labile and recalcitrant), and improving soil quality.

(iv) Conservation agriculture (CA) coupled with other technologies like micro-irrigation, fertigation, and management of problem soils using specific and necessary technologies hold great promise to increase productivity of crops and fruits, and reverse soil degradation.

(v) Novel CA practices include permanent broad bed with residue retention under maize/cotton/pigeon pea-wheat cropping systems and seasonal tillage alterations under rainfed and rice-based agro-ecosystems.

(vi) These practices need to be evaluated in micro-environments of different agro-climatic regions with different farming practices for wider adaptability on a watershed basis.

(vii) The non-edible (to animals) agricultural residues must not be burnt and should be used for mulching along with growing of cover crops, preferably legumes.

The contributions of Soil Organic Carbon (SOC) on physical, chemical, and biological properties of soils in sustaining their productivity are being appreciated since the dawn of human civilization. Restoration of soil quality through SOC management has remained the major concern for tropical soils. The most conducive soil–climatic environment for higher accumulation of SOC, thus helping in maintaining the soil quality, appears to be the one prevailing in forest ecosystem in hills and mountain areas. Hence, restoration of OC balance and efforts to enlarge the soil carbon pool by appropriate management techniques and also to encourage agro-forestry should form the strategic perspectives to sustain the health of Indian soils (Bhattacharyya et. al., 2000).

From the encouraging results obtained so far, it can be concluded that conservation agriculture practices with minimal tillage and crop residue mulching, growing of horticultural, forage, and forest tree crops as a mixed system should be judiciously combined, along with biological approaches (supported by livestock) of nutrient management and plant protection to achieve sufficient soil cover, erosion control, soil quality, biodiversity, food and nutritional security, and conservation of natural resources of the nation.

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ANNEXURE 8

CARBON FARMING SOLUTION

(Excerpts from *The Carbon Farming Solution: A Global Toolkit of Perennial Crops and Regenerative Agriculture Practices for Climate Change Mitigation and Food Security,* by Eric Toensmeier)

Carbon farming practices - a suite of crops and practices that sequester carbon while simultaneously meeting human needs. This, if widely supported, implemented, and developed on a global scale in conjunction with a massive reduction in fossil fuel emissions, could play a critical role in preventing catastrophic climate change by removing carbon from the atmosphere and safely storing it in soils and perennial vegetation. It could also return our atmosphere to the "magic number" of 350 parts per million of carbon dioxide. Carbon farming is successful when carbon gains resulting from enhanced land management and/or conservation practices exceed carbon losses.

Degraded soils give up much of their carbon to the atmosphere as carbon dioxide, a greenhouse gas.

Eg., Las Canadas in Veracruz, Mexico. The many sustainable practices employed by Ricardo Romero at Las Canadas, also sequester carbon, help mitigate climate change while producing food, fodder, materials, chemicals, and energy, thus fostering community self-reliance, creating jobs, improving biodiversity, and bringing degraded land back to life.

At present, the tropics have stronger carbon farming options compared to colder climates. Many of the agroforestry techniques that have the highest sequestration rates are largely confined to the tropics, at least at present, and most of the best perennial crops available today are also native to, or grown best in, the tropics.

Between 97 and 98% of climate scientists agree that climate change is real and is caused by human activity; namely, through land management practices and burning fossil fuels. Not all humans have contributed equally. Wealthy nations and wealthier people disproportionately drive the process through excessive use of energy and consumption of goods and services. It is those who have done the least to cause climate change who suffer the most and will suffer much more in years to come, unless a global movement arises to reverse the trend. These wrongs have led to the movement of climate justice, and activists argue that climate change is hardest not only on the poorest countries but also on the poorest within countries.

No one knows exactly how fast climatic changes might take place. We could hit 2°C (3.6°F) by 2030 or 2100. The faster the change, the harder it will be to adapt, and the less time there will be to respond. We are already seeing impacts of climate change on all continents and throughout the oceans. Permafrost is melting, and glaciers are shrinking. There is less fresh water available, and the fresh water that is available is declining in quality. Organisms are altering their range, seasonality, populations, and behavior. Coral reefs and Arctic ecosystems are declining rapidly. The number of Category 4 and 5 hurricanes almost doubled between 1970 and 2004. And farmers around the world report that the rains are coming at different times, throwing off the farming seasons. We are already seeing lower crop yields, except in some high-latitude regions.

Pushing global temperatures past certain thresholds could trigger abrupt, unpredictable, and potentially irreversible changes that have massively disruptive and large-scale impacts. Tipping points are points at which positive feedback loops would trigger additional warming. For example, when Arctic sea ice melts, we are left with more ocean water whose darkness absorbs more of the sun's heat, further contributing to warming. Currently, we have already crossed a global tipping point and are on the way to a point of no return. We have a narrow window of time, perhaps a few decades, in which to lower the concentration of greenhouse gases enough to prevent a catastrophe.

Emissions from agriculture, land clearing for agriculture, the food system, and food waste amount to roughly half of all anthropogenic emissions. The FAO of the UN estimates that methane and nitrous oxide from rice paddies, ruminant livestock, and poorly managed manure accounted for a whopping 76% of emissions from agriculture from 1990 through 2012. And then there are the fossil fuels that power our farms; the worst culprits are agrochemicals, plowing and subsoiling, harvesting with combines, and pumping water for irrigation. We burn fossil fuels to remove nitrogen from the atmosphere to manufacture fertilizer, much of which then off-gases as nitrous oxide from runoff and leaching. But agriculture's most damning contribution to climate change is the release of carbon held in the soil, primarily from deforestation and land clearing.

PROJECTED IMPACTS OF CLIMATE CHANGE

ENVIRONMENTAL IMPACTS

Storms that historically have occurred once in a century may come every 30 years by the 2050s, and every 4 years in the 2080s and beyond. Because warmer air holds more moisture, there will be not only more storms, but stronger storms. The intensity index of storms has already doubled as ocean temperatures have risen. Storms will also affect regions that have not previously experienced them. For example, in South America and the Mediterranean, historically unprecedented hurricanes have been projected. Some regions will see stronger droughts and become drier, while others will become more humid. Rainfall is likely come in the form of intense storms, causing flash floods and poor infiltration. "Super El Nino" effects could bring an end to the Indian monsoon rains, which provide critical rainfall for billions of people. The International Union for Conservation of Nature (IUCN) Red List documents 830 organism extinctions, with 29 more extinct in the wild and 4,735 critically endangered. Above 2ºC, there is a moderate chance that the Amazon will dry up and become a desert, resulting in a tremendous loss of biodiversity, stored carbon, and land inhabited by indigenous people. Heat can result in coral bleaching, and further increase could lead to widespread mortality of corals, resulting in loss of biodiversity. Carbon dioxide taken up by the oceans makes the water more acid. Subsequent warming will turn it toxic to organisms such as plankton, crabs, and shellfish. Plankton, being critical to oceanic carbon sequestration, their loss could lead to the spread of "marine deserts" devoid of the base of their food chain. Melting of Greenland and Antarctic ice caps can raise sea levels significantly and flood some of the cities. The loss of steady glacial meltwater would mean serious water shortages.

AGRICULTURAL IMPACTS

Due to increased temperatures, reduction in yields will result in increase in food price, and subsequent loss in agricultural productivity will lead to agriculture becoming impossible in some regions. Increased carbon dioxide could impact nutrition by changing the protein, mineral, and amino acid content of cereal grains. Fruits and vegetables will also suffer serious declines. Increasing aridity is projected to increase irrigation needs. Loss of glacial water will reduce river flows to agricultural areas, displacing tens of millions of people. The tropics may become too hot for most crops, while the subtropics may become too dry. The belt of habitability where farming as we knowtakes place, it is likely to move closer to the poles.

HUMAN IMPACTS

The range of diseases such as malaria will change, with projections from a decrease in 150 million to an increase of 400 million additional people exposed. Overall, hundreds of millions of people are expected to be exposed to new diseases and increased water stress. Existing habitats will become unsuitable for living and will lead to lot of migrations. Climate change is an important factor, threatening human security through 1) undermining livelihoods, 2) compromising culture and identity, 3) increasing migration that people would rather have avoided, and 4) challenging the ability of states to provide the conditions necessary for human security. Human rights to life, health, shelter, and food are fundamentally breached by the impacts of climate change.

There is still time to act, although the window is limited to just a few short decades. If we reduce greenhouse gas emissions, and sequester vast amounts of carbon dioxide from the atmosphere by adopting agricultural and forestry practices, we could avoid catastrophic changes. Thus agriculture can shift from being a contributor to climate change to becoming a major part of the solution.

AGRICULTURAL CLIMATE CHANGE MITIGATION AND ADAPTATION

When it comes to agriculture, climate change mitigation involves three broad areas: reductions of agriculture-related greenhouse gas emissions, agroecological intensification of existing farmland to prevent additional land clearing for agriculture, and carbon sequestration in soil and aboveground biomass.

REDUCING AGRICULTURAL EMISSIONS

We can reduce carbon emissions from soil by slowing or ending land clearing and wetland drainage for agriculture, preventing erosion and reversing the degradation of agricultural soils, and reducing tillage. We can reduce fossil fuel emissions by reducing the use of mechanized equipment and cutting back on chemical nitrogen fertilizers, which are energy-intensive to manufacture. We can replace fossil fuels with renewable sources of energy.

We can reduce methane emissions by changing the way we farm. Rice paddies emit substantial amounts of methane; letting paddies dry out can greatly reduce the impact. Emissions from livestock manure and the digestion of ruminant livestock such as cattle can also be reduced. We can reduce nitrous oxide emissions from chemical fertilizer by using fertilizer more efficiently with better timing and applying appropriate amounts, or by replacing it with manure or nitrogen-fixing plants such as legume cover crops or agroforestry support trees. Food supply with efficient transport and distribution, like central pickup sites, etc., can greatly reduce emissions.

AGROECOLOGICAL INTENSIFICATION

In order to meet our food needs without sacrificing more carbon-storing natural ecosystems, we will have to improve our yields on the farmland we already have – a challenge called agricultural intensification.

Industrial gains in yield have come at a huge social and ecological cost. This includes climate costs such as emissions from the manufacture and use of synthetic nitrogen fertilizers. Can ecological farming provide high enough yields to prevent further land clearing for agriculture? The answer varies considerably from system to system and site to site. Agroecological systems like polycultures, once established (which can take several years), often yield better than industrial agriculture.

CARBON SEQUESTRATION

Agricultural carbon sequestration involves removing excess carbon dioxide from the atmosphere and storing it in soil organic matter, and in the aboveground biomass of long-lived plants and trees (perennials). This natural part of the carbon cycle provides us with a powerful tool for climate mitigation.

Overall, an average of a third of carbon in agroforestry systems is held in aboveground biomass, though this varies by ecosystem and farming practices. The remaining carbon is held in the soil. Some soil carbon is in living roots, which are estimated at about 25 to 40% of the total weight of aboveground biomass.

The time period that sequestered carbon remains in the soil is called Mean Residence Time (MRT). Agricultural practices can have a profound impact on the MRT of carbon in the soil. Farming practices and crops that sequester and increase the MRT of carbon in the soil include perennial crops, mulching, non-flooded rice, reduced tillage, managed grazing, crop-livestock integration, and continuous cover through green manures or cover crops. In contrast, annual crops, tillage, and bare soils can quickly release soil carbon and return it to the atmosphere. The MRT in aboveground biomass and roots depends on the life span of the plant. Although some leaves and roots are shed every year, carbon in tree trunks, for example, can be sequestered for a long time.

ADAPTATION

Climate change has an impact on agriculture already, and this impact is likely to increase in the decades to come. Intense droughts and floods, unpredictable weather, and powerful storms will require us to change the way we farm. These changes are referred to as adaptation strategies. Many strategies serve dual purposes of adaptation and mitigation. For example, soils richer in carbon hold moisture longer during droughts and may survive floods better as well. Increasing soil organic matter builds the water holding capacity of the soil, increasing rainwater capture, and reducing runoff and flooding. High carbon soils are less vulnerable to erosion. They are also less likely to lose nutrients through leaching and have better fertility. Rainwater-harvesting earthworks and drip irrigation allow water conservation, among other water management strategies. Adaptation can mean switching crops to species that are more adapted to the new climate.

Soil-based strategies for adaptation include conservation agriculture (no-till, cover cropping, mulching), agroforestry and perennial crops, managed grazing, and silvopasture. Erosion control strategies such as terracing and contour planting are also adaptation tools.

Crop diversification means that even if some crop yields are poor in a given year, other crops may be producing well. In this way, farmers manage the risk, and food and income keep coming, even considering hurricanes, droughts etc. Biodiversity can create reservoirs for beneficial insects and other organisms that help with pest control. The deep root systems of trees move water from deep to shallower soils and vice versa in a process called hydraulic lift. This can make water available for adjacent shallower-rooted annual crops in agroforestry systems, though trees compete for water. With annual crops and livestock, breeding climate-hardy species is an important adaptation strategy that reduces climate risks. Integrating livestock and crop production is also important, including feeding livestock with crop residues and utilizing manure as fertilizer. Managed grazing increases vegetation cover and improves soil organic matter content and water filtration. Silvopasture has many adaptation benefits, from cooling pastures and livestock to windbreak and erosion control.

AGROFORESTRY AND PERENNIAL CROPS

The World Agroforestry Centre defines agroforestry as "a dynamic, ecologically-based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels. Agroforestry sequesters significant carbon and is more than the random incorporation of trees on farms; it is "intentional, intensive, integrated, and interactive."

Agroforestry has been divided into three broad classifications for the purpose of discussion. The first is tree intercropping systems, which integrate trees or other woody plants with annual crops to have better sequestration. This includes alley cropping and contour hedgerows, windbreaks, evergreen agriculture, and other practices.

The second classification is silvopastoral systems, which integrate trees or other woody plants with livestock and pasture understory.

The third classification is multistrata agroforestry systems, which consist solely of perennials or integrate trees or other woody plants with annual crops and livestock. This includes tropical homegardens and woody agriculture.

In addition to carbon sequestration, agroforestry systems provide people with food, fodder, fuel, and other important products. They also provide a range of important protective functions, such as windbreaks, erosion control, soil and moisture conservation, and shade for crops, livestock, and people.

Agroforestry systems may be low, medium, or high input (labor, fertilizers, financial capital, irrigation). This depends in part on whether they are intended for subsistence, commercial production, or even educational and recreational use. Although there are hundreds of agroforestry systems around the world, most are developed from a basic palette of roughly 20 practices. With this palette of practices as a foundation, individuals and communities can tailor an agroforestry system to reflect regional socioeconomic and environmental conditions. Such appropriate agroforestry systems have been developed for most of the world's climates.

TROPICAL HOMEGARDENS

Homegardens have been defined as "intimate, multi-story combinations of various trees and crops, sometimes in association with domestic animals, around the homestead. They are a small-scale, intensive type of multistrata agroforestry that typically occupies the size of the home yard.

The majority of homegardens are in the humid tropics. There are also some homegarden traditions in tropical highlands, as well as Mediterranean regions of Spain and South Africa, and some in arid tropical regions.

Homegardens have been characterized by leading agroforestry scientist P.K. Nair as " the epitome of sustainability" for their social and environmental impact, in the areas of "biodiversity conservation, gender equity, social justice, environmental integrity, appreciation of indigenous knowledge, preservation of cultural knowledge and so on." Nair goes on to state, specifically in terms of biodiversity: "A classification based on the production systems and species diversity ranked home gardens top, due to their having the highest biological diversity among all man-made ecosystems."

These remarkable systems also demonstrate some of the highest levels of carbon sequestration in agriculture. In some cases, carbon sequestration in homegardens is as good as or better than that of natural forests. According to agroforestry researcher B.M. Kumar, "Homegardens resemble young secondary forests in structure and biomass accumulation, and may be considered as a human-made forest... with considerable productive potential."

Tropical homegardens have a shared set of species, supplemented by regional crops, and useful native plants. Food plants being the most important products, homegardens also produce cash crops, medicinal, and other crops for materials, chemicals and energy.

The complexity and the uniqueness of each garden has slowed adoption of homegardens outside their core homelands, also hindered development efforts to promote their spread, and has made it relatively difficult for researchers to study them. Three priority areas have been identified to help realize the potential of homegardens to sequester carbon and meet human needs in a sustainable way: conserving existing homegardens; intensifying them by optimizing design, management and species selection, and finally, bringing more lands into homegardens.

Homegardens have not just been successful in the tropics, but also in humid temperate and boreal regions, arid and semi-arid temperate regions, in Mediterranean climates and arid tropics and subtropics.

NDHP CROPS

"Non-destructively harvested perennials" – plants that are not killed in the process of harvesting. Combining perennial crops with no-till and non-destructive harvest practices results in having plants that yield for many years and hold the soil (and its carbon) in place. While the perennial crops that probably come to mind for most people are those that provide fruits and perhaps vegetables, many NDHP crops can provide staple foods such as protein, oil, and carbohydrates. Others can replace petroleum for materials, chemicals, and, although not remotely enough, energy to meet our current use. Management of NDHP crops could be done according to their types.

A MULTIFUNCTIONAL SOLUTION

Multifunctional agriculture has a more general goal of valuing the positive effects of ecological agriculture beyond food production. This acknowledges "that agricultural activity beyond its role of producing food and fibre may also have several other functions such as renewable natural resources management, landscape and biodiversity conservation, and contribution to the socio-economic viability of rural areas.

Geoengineering or climate engineering is a still theoretical set of practices that aim to mitigate climate change through massive interventions in planetary systems at the global scale. Some strategies are solar radiation management, increasing reflective cloud cover, harnessing the power of ocean algae to sequester carbon, etc. A recent study found that even if such strategies were to be done at as large a scale as possible, and run for years, their mitigation impacts would be small. Some would propbably have extreme consequences and, once initiated, could not be stopped without triggering catastrophic climate change. Geoengineering fails to pass the multifunctionality test. It does not feed people, does not increase habitat or rainwater infiltration, and does not shrink the gap between rich and poor. That said, we might end up needing one or two of these strategies in order to keep a livable climate. But they should be a distant seventh or eighth line of defense after reducing emissions, switching to clean energy, overhauling transportation, reducing consumption, reforestation, and of course carbon farming.

AGROECOSYSTEM BENEFITS

- Soil improvement
- Preventing erosion and stabilizing slopes
- Reduced need for external inputs
- Water retention and microclimate creation
- Resilience and risk management
- Better yields

- Socioeconomic benefits
  - Products and revenue
  - Empowerment of female farmers
  - Food security
  - Food sovereignty
  - Climate justice and shrinking the wealth gap

DRAWBACKS, TRADE-OFFS, AND RISKS

Carbon farming is not a silver bullet. As we implement it, we must consider the serious risk that it comes with an expiration date. Climate change itself is an enemy of carbon farming. The increase in temperatures will result in soil and biomass becoming net emitters of carbon. This will limit and perhaps reverse hard sequestration work of farmers in those areas. This is not a strategy that can wait until things have gotten really bad; the time for carbon farming is now! Rapid implementation of carbon farming, in tandem with massive emissions reduction, can prevent this alarming situation from occurring.

SOME TRADE-OFFS/DRAWBACKS INCLUDE:

Lower yields

Some carbon farming practices yield less human food per hectare than an equal amount of industrial agriculture. This can happen because some of the growing area is taken up with support species that fix nitrogen, stabilize slopes, or provide mulch, but do not directly provide food.

Other greenhouse gas emissions

Although the sequestration potential of carbon farming is excellent, there are other greenhouse gases like methane and nitrous oxide that get emitted.

Water Use

In arid regions, trees may not be appropriate, because their transpiration can lower water tables and reduce stream flow, resulting in a negative impact on downstream agricultural yield and overall ecosystem health. These impacts are particularly potent with monoculture tree plantations.

Economic and Market challenges

Perennial crops often do not bear crops for several years, in some cases for decades. This creates an economic disincentive for farmers, who are already stressed financially in most cases, to adopt these practices.

Limitations in cold and arid climates

The humid tropics are excellently positioned for carbon farming. Colder and drier climates have a longer way to go.

These potential drawbacks of carbon farming are real, but most of them are manageable.

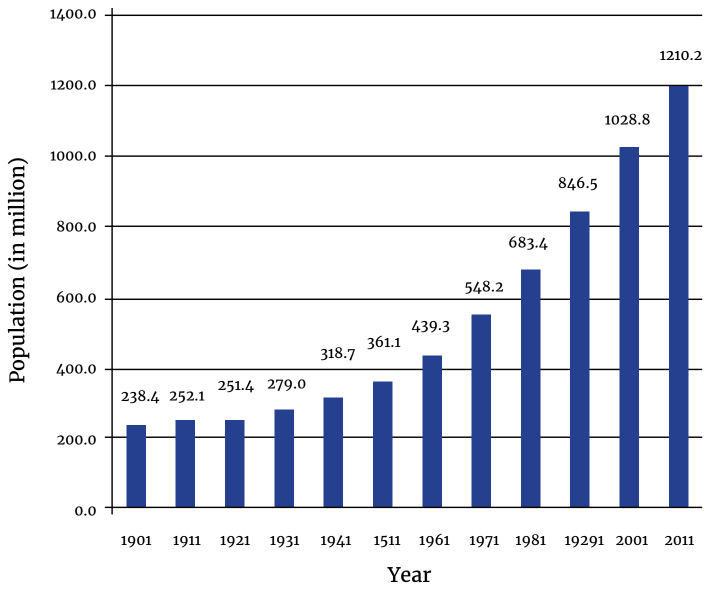
ANNEXURE 9

MICRO IRRIGATION

Netafim Irrigation India Pvt. Ltd. Vadodara, Gujarat

INDIAN WATER RESOURCES SCENARIO

Although India occupies only 3.29 million km^2 of geographical area, which forms 2.4% of the world's land area, it supports over 15% of the world's population. India supports about 1/6th of the world population, 1/50th of the world's land and 1/25th of the world's water resources. India also has a livestock population of 500 million, which is about 20% of the world's total livestock population. More than half of these are cattle, forming the backbone of Indian agriculture. The total utilizable water resources of the country are assessed as 1086 km^3. Recently, the National Commission for Integrated Water Resources Development estimated the basin-wise average annual flow in Indian River systems as 1953 km^3. The utilizable annual surface water of the country is 690 km^3. The annual potential natural groundwater recharge from rainfall in India is about 342.43 km^3, which is 8.56% of total annual rainfall of the country. The annual potential groundwater recharge augmentation from canal irrigation system is about 89.46 km^3. Thus, total replenishable ground-water resource of the country is assessed as 431.89%. After allotting 15% of this quantity for drinking, and 6 km^3 for industrial purposes, the remaining can be utilized for irrigation purposes. Thus, the available groundwater resource for irrigation is 361 km^3, of which utilizable quantity (90%) is 325 km^3.

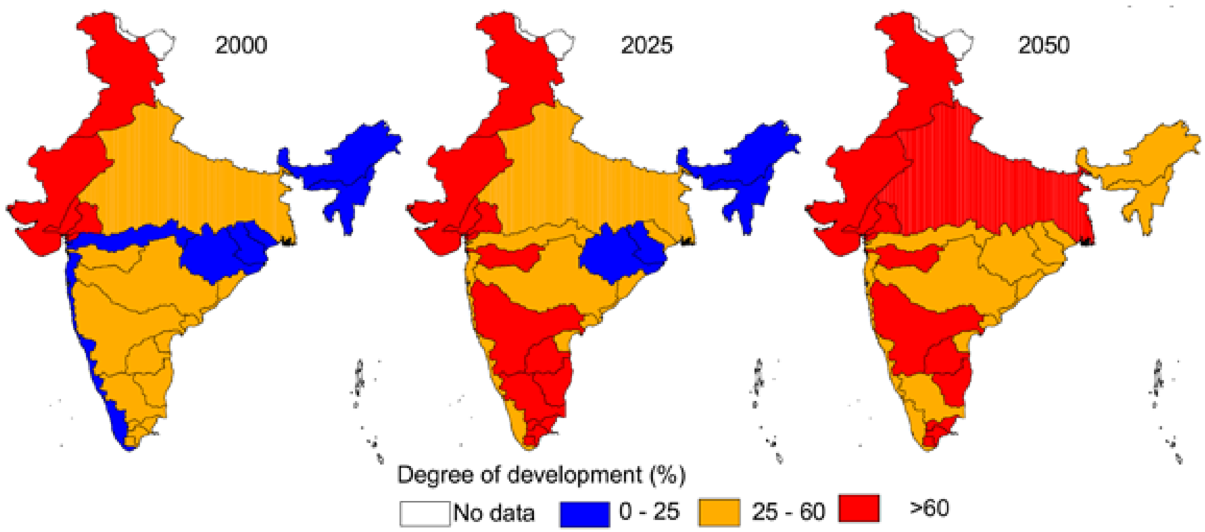


Source: Census 2011: Provisional Population Total - INDIA

Many river basins will be physically water-scarce by 2050. That is, these river basins will not have adequate freshwater resources for meeting future development without affecting the environment or other water users. The degree of development (the ratio of primary withdrawals to potentially utilizable water resources) of 10 river basins, home to 75% of the total population, will be well over 60% by 2050. (Source – International Water Management Institute)

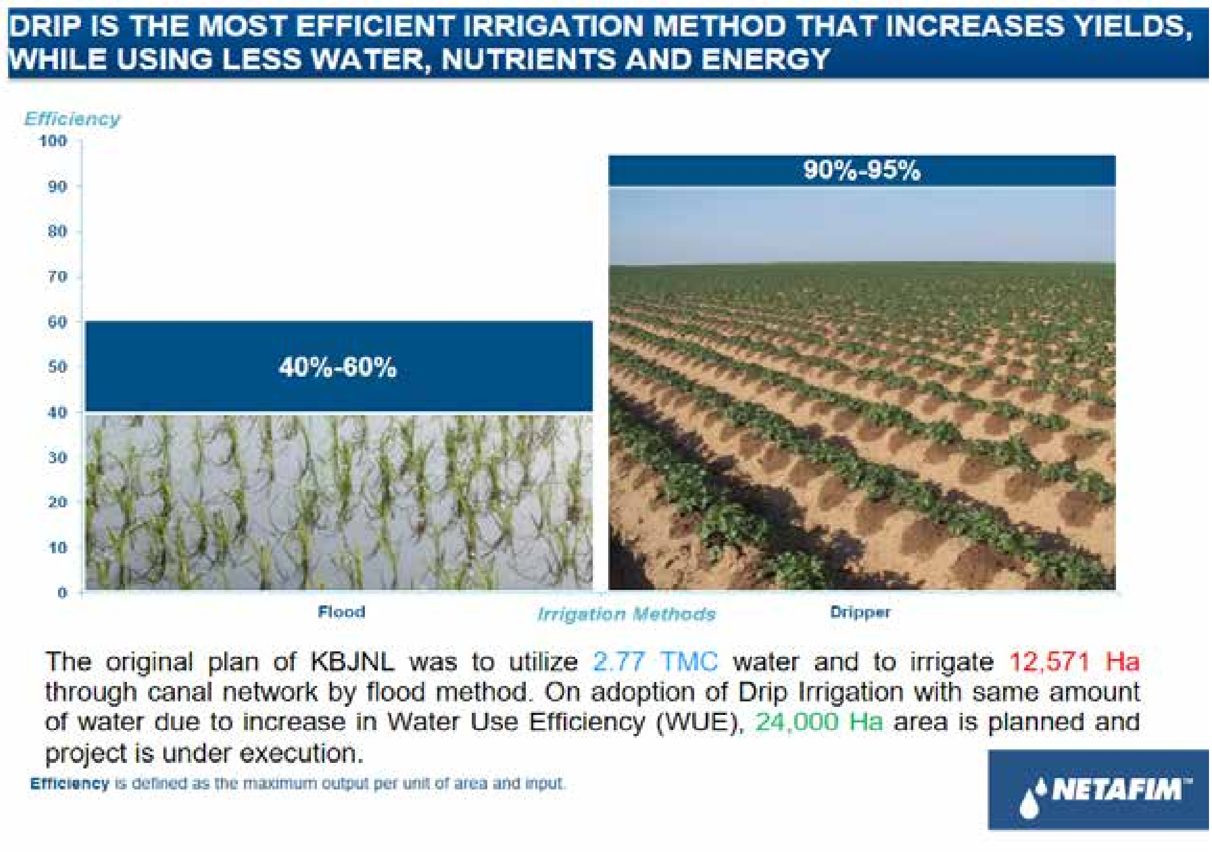
DEGREE OF DEVELOPMENT

The ultimate irrigation potential of India has been estimated as 140 Mha. Out of this, 76 Mha would come from surface water, mostly adjoining rivers, and 64 Mha from groundwater sources. The quantum of water used for irrigation by the last century was of the order of 300 km^3 of surface water and 128 km^3 of groundwater, total 428 km^3. The estimates indicate that by the year 2025, the water requirement for irrigation would be 561 km^3 for a low-demand scenario and 611 km^3 for a high-demand scenario. These requirements are likely to further increase to 628 km^3 for a low-demand scenario and 807 km^3 for a high-demand scenario by 2050. As day by day the world population is increasing at a very fast rate, to meet the food requirement of the increased population, it becomes essential to increase the food production at the same rate. To enhance the food production more land should be brought under cultivation & irrigation, so efficient use of available water resources is becoming unavoidable. To tackle this issue, the adoption of a micro-irrigation drip system is the best solution.



DRIP IRRIGATION

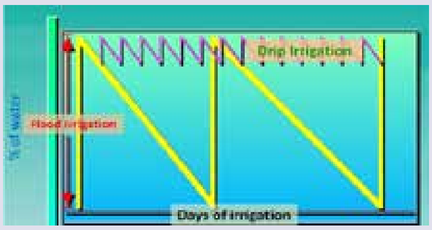
Drip irrigation is an advanced method of irrigation wherein water is delivered directly at the root zone of crops at frequent intervals in a controlled manner through a close-conduit pipe network. In drip irrigation, generally irrigation is given on a daily basis to fulfil the day-to-day crop water requirement. As water is conveyed through the network of pipes & delivered precisely only at the root zone of crops, the conveyance losses or infield application losses are almost nil, enabling an overall application efficiency as high as 90-95%. While in conventional flood irrigation, water is allowed to flow through open canals and field channels and to spread in the entire area of irrigation, irrespective of cropped and uncropped area / root zone. As this is uncontrolled water application through porous soil media, most of the water gets lost due to evaporation, run-off, deep percolation, etc, resulting in overall irrigation efficiency as low as 40-60%.



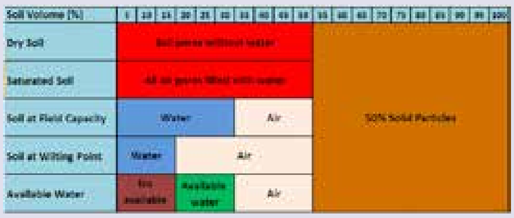
PRINCIPLE OF DRIP IRRIGATION

- Drip irrigation involves dripping water onto the soil at very low flow rates from a system of small-diameter plastic pipes fitted with outlets (drip emitters).
- The basic concept underlying the drip irrigation method is to supply the amount of water needed by the plant within a limited volume of soil and as often as needed. Water is applied directly at the plant root zone.
- The volume of soil irrigated by each drip emitter and the water flow along the soil profile is a function of the characteristics of the soil (texture and hydraulic conductivity) and the discharge rate of the drip emitter.
- Applications are usually as frequent as daily to provide a favorable moisture level for the plants to flourish.

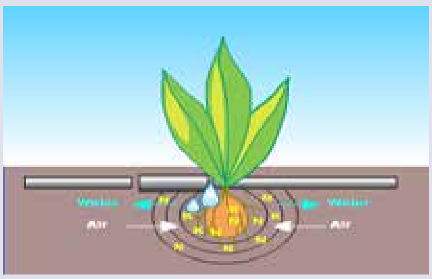
Irrigation frequency



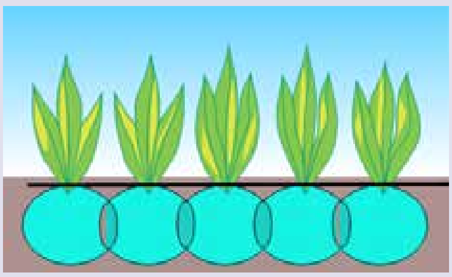
Soil moisture content



Soil composition under drip



Uniform wetting pattern



DIFFERENCE B/W CONVENTIONAL FLOOD IRRIGATION & DRIP IRRIGATION

- In the conventional flood irrigation method, it is a general practice to apply water to the soil once in week or so.
- In such irrigations, soil moisture content reaches saturation on irrigation and recedes to wilting point before the next instance of watering.
- In these situations, most of the time plant roots suffer either due to saturation or moisture stress, which results in monotonous plant growth and yield.
- On the other hand, in drip irrigation with daily water application to the root zone of the crop, the effort is to maintain the soil moisture nearly at field capacity.
- Due to the frequent application and optimum moisture levels in the root zone, i.e. having favorable moisture conditions all the time, the plant grows well and yields good produce with excellent quality.
- In addition to this, drip irrigation wets only the root zone volume of soil mass, which enhances repellence and creates hostile conditions to most pests and diseases.

Particular	Conventional Flood Irrigation	Drip Irrigation
Water use efficiency	Less than 40%	Above 80%
Fertilizer use efficiency	Very low	Excellent
Labor requirement	High	Low
Weed emergence	Very high	Rare
Leaching and deep percolation	Very high	Nil
Surface runoff and soil erosion	Liable	Nil
Uniform crop growth	Rare	Consistant
Uniform yield and crop quality	Rare	Consistant

Maintenance	High	Very low
Intercultivation	Not possible on irrigation	At any time
Land leveling and shaping	Essential	Not necessary
Suitability to soil type	Not suitable for heavy soils	Suitable to any soil
Automation	Not possible	Possible
Emergence of pest and de-cease	High	Low
Soil moisture at root zone	High level of variation between saturation and wilting point	Always nearly at field capacity
Irrigation frequency	Once a week (approx.)	Daily

ADVANTAGES OF DRIP IRRIGATION

- Improves crop yield and quality as compared to conventional irrigation method.
- Minimized fertilizer/nutrient loss due to localized application, reduced leaching.
- Reduced weed growth
- High water application efficiency
- Leveling of the field not necessary
- Ability to irrigate irregularly shaped fields
- Allows safe use of recycled water
- Maintains moisture in root zone nearly at field capacity
- Soil type plays less important role in frequency of irrigation
- Avoids soil erosion
- Highly uniform distribution of water
- Lower labor cost

- Variation in supply can be regulated by regulating the valves and drippers
- Fertigation with minimum waste of fertilizers
- Foliage remains dry thus reducing the risk of disease
- Usually operated at lower pressure than other types of pressurized irrigation, reducing energy costs.
- Automation is possible with irrigation controllers.

Crops	Water saving (%)	Increase in yield (%)
Banana	45	52
Cauliflower	68	70
Chilly	68	28
Cucumber	56	48
Grapes	48	23
Groundnuts	40	152
Pomegranate	45	45
Sugarcane	50	99
Sweet Lime	61	50
Tomato	42	60
Watermelon	66	19

Source: National Committee on Plasticulture Applications in Horticulture (NCPAH)

INDIAN RIVERS

Water resources and their development are pivotal to growth of any civilized society. India with 2.4% of the global geographic area supports 17.5% of the human population through 4% of the world's fresh water resources. India is among the foremost countries in the world in exploiting its river water resources after independence for irrigation, generation of hydro-power and water supply. Being an agrarian society, irrigation had acquired increasing importance in agriculture. India has the highest irrigated land in the world but surprisingly most of land is still under conventional flood irrigation where overall irrigation efficiency is very low and there is huge potential to further increase area under irrigation by adoption of advanced irrigation methods like drip irrigation.

Currently most of the Indian rivers are overexploited to the extent that even the perennial rivers are going dry for a few months every year. (Source – A. Narayanamoorthy & P. Alli). A recent study by Mekonnen and Hoekstra (2016) of the University of Twente, Netherlands, warns that two-thirds of the global population lives with severe water scarcity for at least one month every year, and nearly half of those people live in India and China. More alarming is the estimate of the World Bank that by 2030, India's per capita water availability may shrink to half from the 2010 level of 1,588 cubic meters per year, which will push the country from the "water scarce" category to the "water stress" category. The World Bank in its latest report (2016), High and Dry: Climate Change, Water and the Economy, has cautioned that countries that lack a sufficient amount of water could see their GDPs decline by as much as six per cent by 2050. Shouldn't we take these warnings seriously?

Some of the major worrysome issues of Indian rivers are as follows –

- Perennial rivers such as the Ganga, Godavari and Krishna have dried up at various locations.
- Overexploitation of water and depleting ground water table.
- Reduction in storage capacities due to erosion at uplands & siltation in river beds / dams which further results in frequent severe floods.
- Over-irrigation whenever and wherever abundant water is available
- Violation of the Right of Equitable Distribution of Water
- Soil salinity at places of over-irrigation – degradation of soil health
- Excess usage of fertilizers & agro chemicals – leaching resulting in river water pollution
- Chemical leaching resulting in imbalance of river biodiversity
- Unnecessary growth of aquatic plants and depletion of fish and other native species

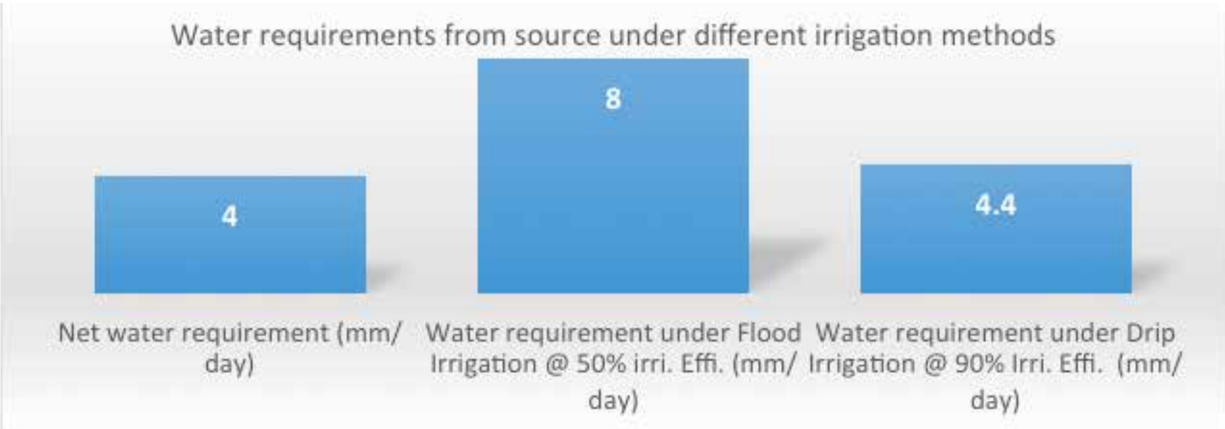
• The following table shows the total lengths of major rivers in India, according to the basin. The total length of these rivers is more than 15,000 Km. Most of the Indian rivers are forest-fed. When it rains, water percolates into the soil, it saturates soil and later slowly leaches out to form rivulets, streams & rivers. For river rejuvenation, our suggestion is to have plantation cover for at least 1 km on either side of the rivers. For government lands, the plantation can be forestry plants and on private lands it can be horticultural crops. In this way, we can enhance the income of farmers and revive the rivers. This can be done in a systematic way by the adoption of drip irrigation for these plants, which will support in the establishment of dense plantations with almost a 50% saving of irrigation water, which can be used to increase the irrigation area or can be made available for other commercial activities.

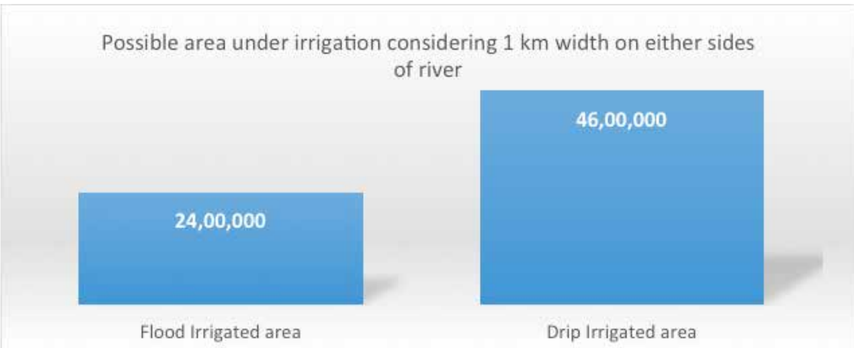
Major river lengths, acc. to basin	
Name of basin	River length in India (Km)
Indus basin	1114
Ganga basin	2525
Brahmaputra basin	916
Barak and others	564
Godavari basin	1465
Krishna basin	1400
Cauvery basin	800
Subernarekha Basin	Subernarekha – 395 Burhabalang – 164
Brahmani and Baitarni Basin	Brahmani – 799 Baitarni – 355
Mahanadi Basin	851
Pennar Basin	597
Mahi Basin	583
Sabarmati Basin	371
Tapi Basin	724
Narmada Basin	1312
West flowing rivers from Tapi to Tadri	Many independent rivers with short lengths
West flowing rivers from Tadri to Kanyakumari	
East flowing rivers between Mahanandi and Pennar	
East flowing rivers between Pennar and Kanyakumari	
West flowing rivers of Kutch & Saurashtra including Luni	
Minor rivers draining into Myanmar & Bangladesh	
Area of Inland Drainage in Rajasthan	
Area of North Laddakh not draining into Indus	
Drainage area of Lakshadweep Islands	
Drainage area of Andaman & Nicobar Islands	

Source: Central Water Commission (CWC)

With reference to the above table, the total length of the major rivers in India is more than 15,000 km. Considering 1 km on either side of river, the area that can be brought under plantation is around 30,00,000 ha. As most of the river originates at hills, we consider around 20% (approx. 6,00,000 ha) of the total area will be natural forests or hills. So, the area to be targeted for plantation is around 24,00,000 ha.

As previously mentioned, the overall irrigation efficiency in flood irrigation is about 50% while the same is over 90% in drip irrigation. Accordingly, assuming daily net crop requirement is 4 mm/day and considering irrigation efficiencies, to satiate crop water requirement in Flood & Drip Irrigation method, we need to apply about 8 & 4.4 mm/day in Flood & Drip method respectively. Meaning in Drip irrigation there is saving of about 45% water. So in this example, for Net irrigation under Flood & Drip, the irrigation water requirement is about 628, 1257, & 691 TMCft respectively (considering 180 days irrigation). Drip irrigation for proposed area can save 565 TMCft water which can be further utilized to irrigate additional 22,00,000 ha area or can be made available for other commercial activities. Apart from this, the adoption of Drip Irrigation will yield better farm produce in terms of quality & quantity and hence returns will be very impressive as compared to





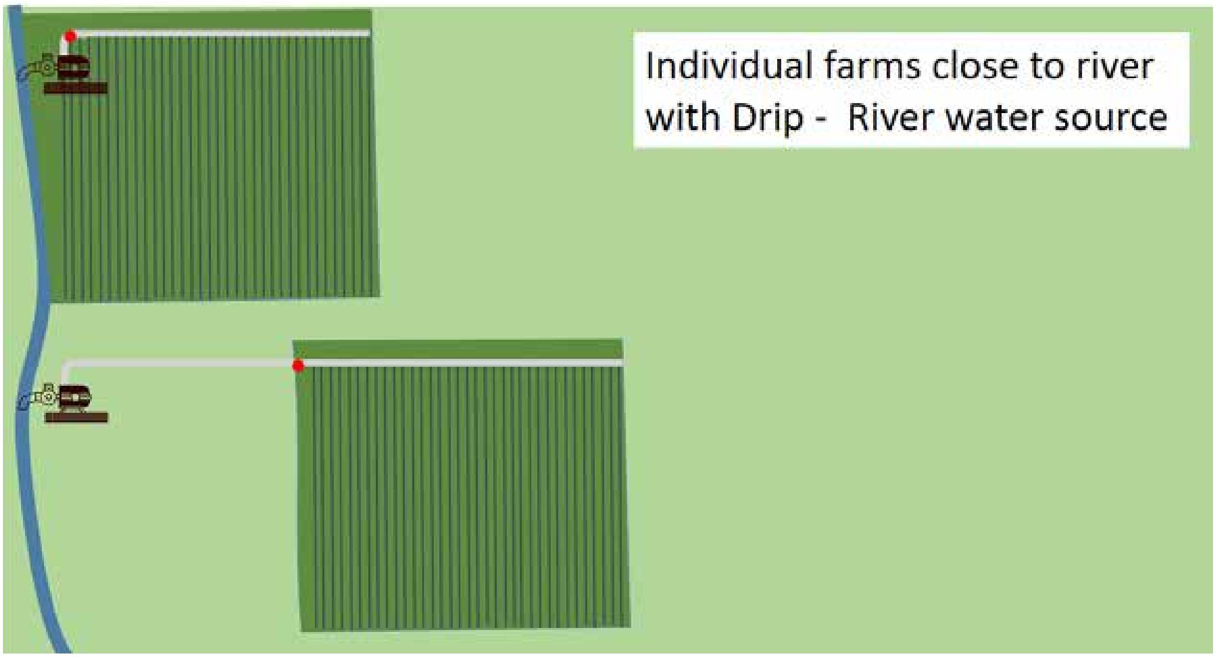
conventional flood irrigated crops.

POSSIBLE MODELS TO ADOPT DRIP IRRIGATION IN RIVER ADJACENT AREAS

Considering the land ownership & holdings, types of plantations, available resources like electricity in close vicinity, there could be 4 major models for adoption of Drip Irrigation as follows:

1. Individual farmers with own Lift Irrigation infrastructure.
2. Individual farmers with own water sources (open / bore wells) in adjoining areas.
3. Co-operative lift irrigation schemes like Bambavade / Gotkhindi LI schemes in Maharashtra.

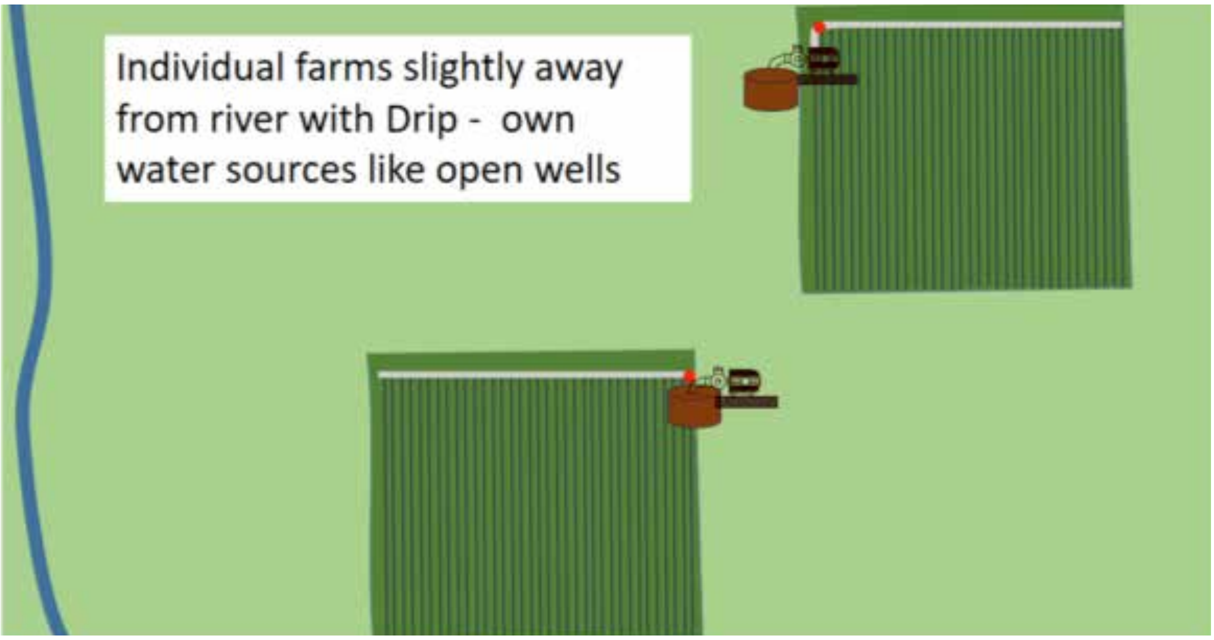
MODEL 1.
INDIVIDUAL FARMERS WITH OWN LIFT IRRIGATION INFRASTRUCTURE



4. Govt. Lift Irrigation Projects like Ramthal Drip Irrigation Project in Karnataka.

In the first model, private land owners have their own water lifting infrastructure to irrigate their farms adjacent to rivers. The majority of these farms are very close to rivers or just next to them because the water conveyance system holds the majority of the cost and most of the farmers cannot afford it. This small number of farmers lifts large amounts of water to irrigate a small extent of land and in some places due to over-irrigation, lands are being turned saline and going out of cultivation. Drip Irrigation should be promoted in such private lift irrigation schemes in an aggressive way by making it mandatory by distribution of financial

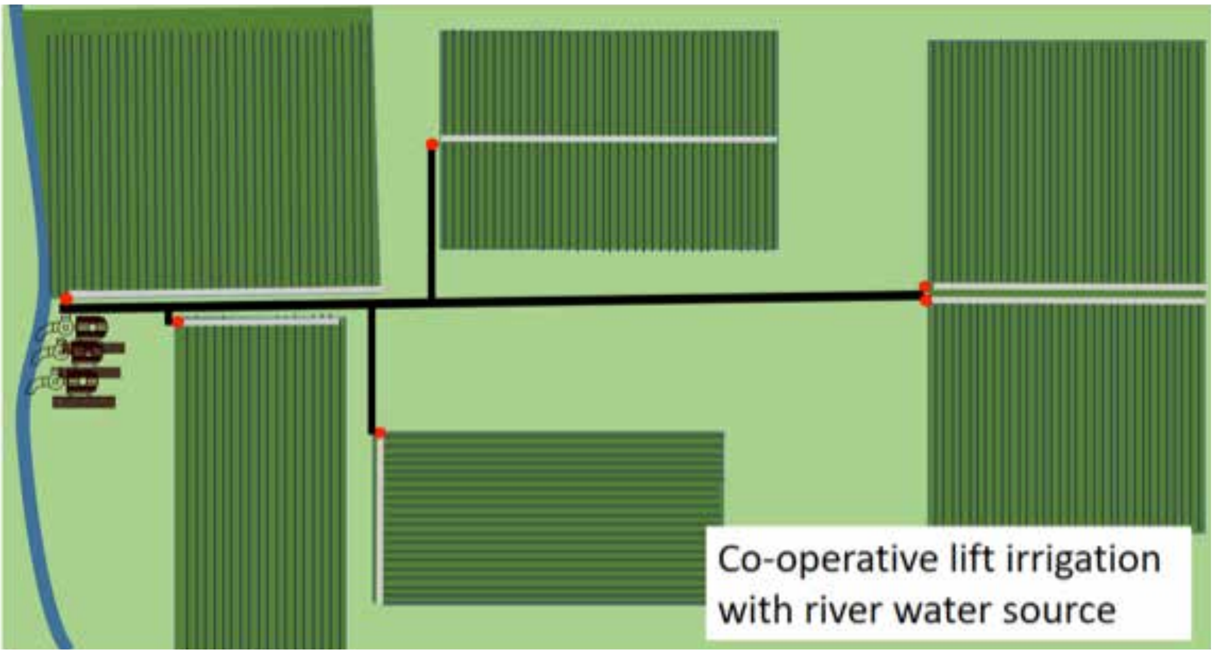
MODEL 2.
INDIVIDUAL FARMERS WITH OWN WATER SOURCES (OPEN / BORE WELLS) IN ADJOINING AREAS



assistance. This can avoid overexploitation of water and saved water can be made available for activities.

In second model, farmers use their own water sources like wells to irrigate their fields. Usually these wells receive water from aquifers fed from the nearby rivers. In the first model, farmers using their own water sources also lift more water than their actual necessity causing an unfair advantage over fellow farmers whose wells do not get enough water to irrigate their fields. Drip Irrigation can be made more popular in these areas by educating farmers and creating awareness. Also, the process of financial assistance in the form of subsidy should be made more flexible, reliable and user friendly so that most of the farmers opt for that.

MODEL 3.
CO-OPERATIVE LIFT IRRIGATION SCHEMES LIKE BAMBAVADE / GOTKHINDI LI SCHEMES IN MAHARASHTRA



The third model is very popular in parts of Western Maharashtra & Northern Karnataka where farmers' cooperatives lift water from rivers to irrigate their lands with shared infrastructure. The old cooperative lift irrigation schemes use conventional flood irrigation methods for infield water applications. But recently active schemes have come ahead to adopt Drip Systems for an entire command area. In such schemes, water lifting infrastructures like pump houses, distribution networks and others are common and the infield water application system is owned by farmers. Depending on the interest of farmers / members of co-operative society, the area covered for irrigation in such a scheme may not be continuous and can be scattered.

Looking at the superiority of the concept, the government should make it mandatory to adopt Drip Systems in command areas of every new farmer's cooperative and should encourage existing schemes to convert their schemes under micro-irrigation. Conversion of these large areas into drip irrigated schemes can save a huge amount of water. Due to the fact that drip irrigation needs only 50% water as compared to flood irrigation, new lift schemes can be designed for an efficient cost. In Western Maharashtra, there are a few success stories for cooperative drip irrigation schemes where on a pilot basis, the government has given special assistance to promote the drip irrigation in these areas. The Gotkhindi & Bambavade farmer's cooperatives are the ground breaking

MODEL 4.
GOVT. LIFT IRRIGATION PROJECTS LIKE RAMTHAL DRIP IRRIGATION PROJECT IN KARNATAKA.

schemes which have made remarkable works in revolutionizing concept of lift irrigation. The details for these two success stories are given in the annexure.

The forth model is about Government Lift Irrigation Projects wherein instead of conventional canal networks & flood irrigation, advanced Automated Drip Irrigation through close conduit network is proposed. The main objective to go for such Lift & Drip Irrigation Projects is to avoid permanent land acquisition which is becoming more difficult & costly, equitable distribution of water, doubling irrigation area with same limited available water, to decrease gap between Irrigation Potential Created (IPC) & Irrigation Potential Utilized (IPU).

Under this type of Govt. sponsored community irrigation schemes, generally areas under irrigation will be continuous throughout the proposed command area irrespective of farmer interest / land holdings. In this segment of Community Micro-Irrigation, Karnataka state is the pioneer & leader. Karnataka has executed few integrated Lift & Micro Irrigation Projects like Ramthal Drip Irrigation Project whose details are given in the annexure.

INDICATIVE INFRASTRUCTURE COST FOR DIFFERENT DIS MODELS

The cost of irrigation infrastructure depends on the type of model of Drip Irrigation as described above. As per Operational Guidelines of Per Drop More Crop (Micro-Irrigation) Component of PMKSY, the indicative costs of Drip Irrigation System for various spacing's and areas are as follows.

Indicative cost of Drip Irrigation System for calculation of subsidy (Cost in Rs.)						
Spacing	0.4 Ha	1 Ha	2 Ha	3 Ha	4 Ha	5 Ha
12x12	15,853	21,643	34,417	53,437	66,480	84,653
10x10	16,419	23,047	37,171	57,647	72,205	91,806
9x9	16,826	24,035	39,145	60,610	76,238	96,852
8x8	17,351	25,332	41,650	64,500	81,527	103,459
6x6	19,096	30,534	51,045	82,472	100,016	125,498
5x5	20,674	34,664	59,154	85,484	108,635	145,964
4x4	21,414	36,562	64,084	99,965	130,884	155,778
3x3	23,055	42,034	72,759	112,065	140,936	176,457
2.5x2.5	31,156	60,065	109,345	167,011	234,396	286,297
2x2	36,358	73,138	141,957	206,232	286,504	351,667
1.5x1.5	41,369	85,603	163,137	243,633	336,484	414,002
2.5x0.6	30,810	63,145	116,042	177,345	246,276	302,318
1.8x0.6	37,845	80,599	152,551	229,637	312,784	389,511
1.2x0.6	40,000	100,000	200,000	323,019	435,788	545,181

For the first & second model of Drip Irrigation system as discussed above, the cost of the drip system can be taken from above table. For other models, tthe otal cost of irrigation infrastructure depends on the nature of lift infrastructure required, extent of area & distribution network, level of automation, crop type etc. The third & fourth model of Drip Irrigation is community-based, so other costs like training & capacity building, requisite training hall, electrical infrastructure, adds some more cost to DIS which depends on factors as described earlier. Average cost of the lift infrastructure for the third & fourth model is about Rs. 150,000 & Rs. 250,000 / ha.

FEASIBILITY EVALUATION

Considering the utilization of the same amount of water that is presently being used for irrigation in river adjacent areas, about 50,00,000 ha area can be brought under irrigation in a strip of 1 km on both sides of major rivers. Out of this area, assume about 5% area is already under high commercial value crops like Sugarcane, Banana, etc. The balance area may be brought under other Horticultural crops like Mango, Sapota, Pomegranate, Tomato, Chillies, Potatoes, Cabbage, Cucumber, Onion, Beetroot etc. Just for elaboration, we have assumed some percentage of areas under different common horticultural crops as follows and calculated the net returns & financial indices like Benefit Cost ratio / payback period as follows.

Area proposed under different models for adoption of DIS				
Particular	% area	Extent of area (Ha)	App. Cost / Ha	Total cost (Cr)
Current area under DIS	5%	250,000	100,000	2,500
Individual area (type 1 & 2)	15%	750,000	100,000	7,500
Type 3 - Co-operative societies	30%	1,500,000	250,000	37,500
Type 4 - Govt CMI projects	50%	2,500,000	350,000	87,500
Total	100%	5,000,000		135,000

Proposed area & Net income under different crops				
Crop	% area	Area (Ha)	Net income (Rs/Ha)	Total income (Cr)
Sugarcane	3%	150,000	209,950	3,149
Banana	2%	100,000	148,200	1,482
Papaya	10%	500,000	197,600	9,880
Sapota	10%	500,000	123,500	6,175
Pomegranate	10%	500,000	123,500	6,175
Tomato	10%	500,000	200,000	10,000
Chilies	10%	500,000	300,000	15,000
Potato	10%	500,000	197,600	9,880
Cabbage	10%	500,000	150,000	7,500
Carrot	10%	500,000	200,000	10,000
Onion	10%	500,000	100,000	5,000
Beetroot	5%	250,000	150,000	3,750
Total	100%	5,000,000		87,991

BENEFIT COST RATIO

Benefit Cost (BC) Ratio										
Years	1	2	3	4	5	6	7	8	9	10
Total cost of project (Crores)	135,000									
Net Income (Crores)	70,393	70,393	70,393	70,393	70,393	87,991	87,991	87,991	87,991	87,991
NPV of costs (@12%)	₹ 120,535.71									
NPV of benefits (@12%)	₹ 433,732.43									
BCR (@12%)	3.60	: 1								

With the above calculations, the payback period for this project will be 2 years.

RECOMMENDATIONS

Looking at the superiority of the concept to increase water use efficiency, to increase the irrigated area with available limited resources and for river rejuvenation, it is suggested that Policy makers in the field of Environment & Water Management should step forward to initiate the necessary action to revive the rivers and bring back water prosperity. To address this mission, we recommend the following measures which can help to achieve the gigantic task of river transformation.

- Form a policy to make DIS mandatory in river adjoining areas
- Mandatory use of Water Meters on all (private / co-operative / Govt) irrigation projects
- Irrigation / domestic water charges based on a volumetric basis
- Central assistance / subsidy for infield drip system & common lift infrastructure
- Promote horticultural crops (less water intensive), food processing activities, etc.
- Incorporation of basic water management studies in primary school curriculum to increase water literacy.
- Model village programme should be addressed more effectively with the incorporation of "Per Drop More Crop" component by development of at least one model village in each constituency of the state assembly.
- Corporate companies may be motivated to sponsor Community Micro-Irrigation schemes under CSR.
- It should be made mandatory to treat Industrial / urban waste water before releasing it into the river.

ANNEXURES

GOTKHINDI DRIP IRRIGATION PROJECT

The first large scale Community Drip Irrigation Project in India took place at Gotkhindi village in Walwa Tal, Sangli Dist. The lift scheme was established in the 1980’s to irrigate about 608 Ac (347 farmers) from Krishna river (about 6 km from MDC). Lift infrastructure was designed for 24 hours/day but recently due to load sharing electricity is available only for 12 hours/day. So the entire planned area was not being irrigated satisfactorily and the irrigation cycle was as long as about a month resulting in inequitable distribution of water, poor crop quality & yield. In 2010, Netafim proposed to adopt a Community Drip Irrigation for the entire command area under the scheme. A fully automated Gotkhindi Drip Irrigation Project was installed & commissioned in 2011 and it has been running successfully since then. The project beneficiaries are very happy with the performance of the system and are enjoying improved crop quality & increased crop yields with a reduced cost of cultivation.

Watch Gotkhindi Project at – https://www.youtube.com/watch?v=r8Fl_Tegb90

BAMBAWADE DRIP IRRIGATION PROJECT

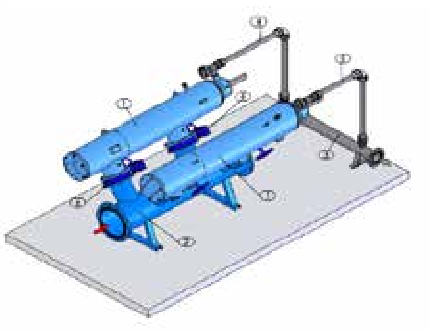
Established in 2014 with nearly 575 farmers and for an area of 750 acres under irrigation. The uniqueness about this scheme is that the lift is designed considering Drip Irrigation for the entire planned command area. The Lift scheme is sponsored by Kranti Agrani G.D.Bapu Lad SSK Ltd. Kundal, Tal. Palus, Sangli Dist. Major salient features of the project are as follows:

- Two filtration units: 1000 M3 (50 x 20) & 600 M3 (50 x12)
- Gravel filter as the primary filter with automatic Back Flush System controlled by NMC Pro.
- Amiad Scan-Away Semi-automatic filters as Secondary filter
- Automation with NMC XL & Radio Net Wireless System

Water Source	Krishna River
Pump HP	450 (150 x 3 Nos)
Pump Type	V.T. Pumps
Water Available	350 LPS
Pumping Hours	16 Hrs.
Total Area	750 Ac
Major Crop	Sugarcane
Design with Available Water	6.4 mm
Rising Main Length	6700 M
Size of Rising Main	600 mm (24 “) PSC
Lateral Spacing	1.52 Mtrs
Dripper discharge	1 LPH
Dripper Spacing	40 cm

ERRAVALLI DRIP IRRIGATION PROJECT

It's part of ambitious model village project of Govt. of Telengana under entire cultivation area under two villages viz. Erravalli & Narsannapet is brought under Community Drip Irrigation. Total project area is 1116 Ha with 1024 farmers.
Its integrated community drip irrigation project which includes water lifting, distribution with piped network, infield water application with drip irrigation system, centralized fertigation, wireless automation etc. Entire project is centrally operated, controlled & monitored from zone control rooms with state of the art wireless automation and fertigation units.



RAMTHAL DRIP IRRIGATION PROJECT

Ramthal Drip Irrigation Project is 2nd stage of Ramthal Project which is part of Upper Krishna Project (UKP) in Northern Karnataka executed by Krishna Bhagya Jala Nigam Ltd (KBJNL). The original plan of KBJNL was to irrigate 12,571 Ha area utilizing 2.77 TMC Water but when Netafim approached KBJNL and convinced on the adoption of Drip System, with same amount of water about 24,000 Ha area is planned and project is under construction. The key highlights of the project are as

- Mega Community Drip Irrigation Project for area of 24,000 and 100% financed by Govt. of Karnataka
- Total beneficiaries in project are about 14,000 farmers
- Project execution time is only 18 months including monsoon
- Detailed scope of work includes Engineering survey, design, installation & commissioning of lift infrastructure from MDC, Electromechanical works at pump house, power transmission line & sub-station, Bulk Water Supply (BWS) System and distribution network, O&M of all system components for 5 years after commissioning, training & capacity building of all project associates, formation of Water User Association (WUA) & marketing support for farm product.

Cost Benefits	Ramthal, with Integrated Drip Irrigation	Flood Irrigation through Canals	Benefits with Drip Irrigation
Area (Ha)	24,000	12,571	90% increase in area
Water Requirement	2.77 TMC	2.77 TMC	Same amount of water
1 TMC	8,664 Ha	4,538 Ha	90% increase in area
Total Cost	750 Crs	307.9 Crs	
Cost / Hectare	3.13 Lakhs	2.5 Lakhs	25% increase in cost/Ha
Water distribution	Equal distribution among all beneficiaries	Uncontrolled & inequitable water distribution	Increased benefits to more no beneficiaries
Project execution period	Only 18 months	Could have been many years	Very short execution period
O & M	Min. annual O& M	Routine O&M is more	Less O&M in Drip
Overall water use effi. (WUE)	>90%	<50%	More than 40% increase in WUE

Watch Ramthal Project movie at - https://www.youtube.com/watch?v=_VphpHqF4NE

ANNEXURE 10

PANCHAYATI RAJ INSTITUTIONS AND GOVERNANCE OF NATURAL RESOURCES

Rajesh Ramakrishnan[1]

ABSTRACT

Panchayati Raj Institutions (PRIs) are well placed to govern and manage natural resources as they have a statutory status, are democratically elected, and provide institutional continuity or sustainability. Grassroot people's institutions have their own salience and function best when appropriately nested within statutory institutions like Gram Panchayats, which can act as overarching governance institutions. Following the 73rd Amendment, the Eleventh Schedule was added to the Constitution, specifying 29 subjects over whom PRIs have jurisdiction. State governments were required to devolve functions, functionaries, and funds to PRIs for these subjects. Eleven of these 29 subjects are related to natural resources. These subjects are also critical to rural livelihoods. The Panchayats (Extension to the Scheduled Areas) Act, 1996, applicable to Schedule V Areas, defined local self-governance for communities living in Schedule V Areas and recognised their traditional rights over natural resources. A village in the Schedule V Areas was defined as consisting of a habitation or a group of habitations or a hamlet or a group of hamlets, comprising a community and managing its affairs in accordance with traditions and customs. The Gram Sabha or village assembly was recognized as the basic unit of governance.

Panchayati Raj Institutions play a key role in developing village-agriculture plans through a decentralised planning process that is in tune with the local needs and aspirations. The Gram Panchayat Development Plan (GPDP) reinforces people and stakeholders' participation in the local planning processes. The development plan matches people's needs and priorities with available resources. The focus is on local development issues, local perception of need and priority, local analysis of problems and solutions, local resources management, all within a collective local

[1]Development professional – natural resources management and livelihoods; Isha volunteer

vision. Almost all the states have also devolved watershed development functions to PRIs. In Maharashtra and Rajasthan, Panchayats have demonstrated successful models of land management. The Rajasthan Common Land Policy, 2010, laid down additional norms for devolution of management of common lands to Panchayats. There are examples in Maharashtra of Gram Panchayats undertaking social forestry and tree planting.

The key challenges to the management of natural resources by Panchayats is inadequate and inconsistent devolution, e.g. 'Activity mapping', through which the roles and responsibilities of each PRI tier are defined, is not clear and not based on the nature of the resource to be governed. The unique definition of 'village' and Gram Sabha in PESA, as a self-governing unit in accordance with customs and traditions, has not been adhered to by a number of states in their legislation. Many states are yet to frame rules under PESA and the state and central laws relating to mines and minerals, forests, and land acquisition are not yet compliant with PESA.

PANCHAYATI RAJ INSTITUTIONS AND GOVERNANCE OF NATURAL RESOURCES

Due to high variability in climate, topography, and nature of natural resources, local strategies and solutions are required for the management of natural resources. The participation of local communities and institutions, using the acute knowledge and skills that they have developed through long association with local conditions, becomes very important. This is the rationale for decentralized governance over natural resources. India has a long history of local communities deciding on the governance and management of natural resources, be it water, forest or common lands. One of the challenges of governance by the state has been the involvement and participation of people and communities in planning, implementation and monitoring of government programmes pertaining to natural resources. This is where Panchayati Raj has an important role to play. Panchayats are probably better placed to govern and manage natural resources as they have a statutory status, are democratically elected, and provide an institutional continuity or sustainability which is missing from the numerous parallel bodies that have been created by various government departments under various schemes. But natural resources are also issues of scale where institutional structures and processes are required at different scales to deal with issues of boundary, access, market economics and environmental sustainability. A decentralisation approach would require such institutions to exist at each level to undertake planning and implementation. Grassroot people's institutions have their own salience and function best when appropriately nested within statutory institutions like Gram Panchayats, which can act as overarching governance institutions.

THE ELEVENTH SCHEDULE AND NATURAL RESOURCES MANAGEMENT

The 73rd Amendment to the Constitution in 1993 paved the way for a three-tiered institutional structure of local government at district, block and village levels. The Eleventh Schedule was added to the Constitution specifying 29 subjects over which PRIs have jurisdiction. State governments were required to devolve functions, functionaries, and funds to PRIs for these subjects. Eleven of these 29 subjects are related to natural resources. These are listed in Table 1 below.

TABLE 1: SUBJECTS RELATED TO NATURAL RESOURCES MANAGEMENT IN THE ELEVENTH SCHEDULE (ARTICLE 243G)

S. No.	Subjects
1	Agriculture, including agricultural extension
2	Land improvement, implementation of land reforms, land consolidation, and soil conservation
3	Minor irrigation, water management, and watershed development
4	Animal husbandry, dairying, and poultry
5	Fisheries
6	Social forestry and farm forestry
7	Minor Forest Produce (MFP)
8	Drinking water
9	Fuel and fodder
10	Non-conventional energy sources
11	Maintenance of community assets

These subjects are also critical to rural livelihoods. Most of the subjects fall under the sector of agriculture and allied activities. The Centre and the states have been provided legislative, financial, penal, and other administrative powers over all these natural resources. Whereas land and water resources fall within the states' jurisdiction, forest resources are in the Concurrent List. Institutions below the state level viz. district, intermediate, or village level have only those powers of control over natural resources as have been delegated by the state governments to them (Vani, 2002).

PANCHAYATI RAJ INSTITUTIONS IN SCHEDULE V AREAS

The Scheduled Areas have a preponderance of tribal population and the Constitution provides for separate laws for the administration of these areas. Two categories of Scheduled Areas exist in India – Schedule V Areas or Scheduled Areas found in nine states of central, western, eastern, and southern India, and Schedule VI Areas or Tribal Areas in five states in North East India. The 73rd Constitutional Amendment was not automatically applicable to these areas. Instead, a new Act, the Panchayats (Extension to the Scheduled Areas) Act, 1996, applicable to Schedule V Areas, was passed, making a number of modifications to the73rd Amendment. The PESA Act, as it has come to be known, defined local self-governance for communities living in Schedule V Areas, and recognised their traditional rights over natural resources. A village in the Schedule V Areas was defined as consisting of a habitation or a group of habitations or a hamlet or a group of hamlets, comprising a community and managing its affairs in accordance with traditions and customs. PESA recognises the Gram Sabha or village assembly as the basic unit of governance (ELDF, 2004).

PESA empowers the village community to plan village development, manage natural resources, and resolve conflicts in accordance with traditional customs and practices (ibid.). The powers and rights conferred on the Gram Sabha that are relevant to the management of biodiversity include: ownership of minor forest produce, prevention of land alienation, planning and management of minor water bodies, the right to be consulted before acquisition of land for development projects and before resettling or rehabilitating persons affected by such projects, and mandatory recommendation before the granting of prospecting licences or mining leases for minor minerals.

PANCHAYATI RAJ INSTITUTIONS AND DECENTRALIZED PLANNING FOR AGRICULTURE[1]

Panchayati Raj Institutions play a key role in developing village-agriculture plans through a decentralised planning process that is in tune with the local needs and aspirations. To strengthen this concept, the government has taken new policy initiatives. The Gram Panchayat Development Plan (GPDP) is one such effort that reinforces people and stakeholder participation in the local planning processes. The GPDP should ideally match people's needs and priorities with available resources. It should be prepared through a fair, inclusive, transparent, and participatory process. The focus should be on local development issues, local perception of need and priority, local analysis of problems and solutions, and local resources management – all within a collective local vision.

THE GRAM PANCHAYAT DEVELOPMENT PLAN PROCESS:

- Establishes GP as a local government
- Brings out people's needs and priorities and incorporates them into the plans
- Addresses local development issues
- Promotes demand-based convergence of resources
- Builds confidence in people for finding solutions
- Utilizes local human resources and natural resources more efficiently
- Provides space for integration of people's knowledge and wisdom into local development
- Responds to differential needs of different groups (Antyodaya)
- Activates Gram Sabha and promotes responsive governance
- Facilitates holistic understanding of local level development

- Ensures value for money by focusing on felt needs
- Has the potential of feeding into plans of higher tiers of governance

The following steps can be taken to develop a decentralised Panchayat level agriculture plan:

Formation of planning team and its capacity building

The first step involves consultation with the local community for the formation of a planning team to be constituted by the Gram Panchayat. Youth, women, government officials, and PRI members should be participants of this group. After the formation of the planning team, intensive capacity building exercises should be organised on the different aspects of decentralised planning such as vision building, data collection, etc.

Development of vision

In this step, the urgent needs and long-term development requirements of the village should be discussed, keeping in view a certain time frame with due consultation of community and concerned line departments/stakeholders. This vision document must be discussed with Technical Support Institutions (TSI), Block Agriculture Planning Unit (BAPU), and District Agriculture Planning Unit (DAPU) for qualitative inputs if required, so that the Panchayat level vision statement can be aligned with block and district level vision to fulfil the state level vision.

Data collection, analysis and identification of sectors

After the development of vision statement, the process of data collection starts, which includes socio-economic status of households, literacy rate, caste group, land use pattern, source irrigation, major crops and their average yields, and traditional agricultural practices. This practice of data collection should be done by a trained team of planning members. Data analysis by the team members should be the next step. During the process of data collection and its analysis, Panchayat should take the services of experts so as to improve the quality of data and its analysis. After the analysis of data, findings should be shared with the community members so that collective developmental strategies can be decided.

Developing options for identified sectors

- After the data analysis, the following areas of intervention should be identified, as applicable:
- Soil and water conservation activities to control soil erosion.
- Promotion of water harvesting.
- Maximization of irrigation use efficiency by increasing use of micro-irrigation technology.
- Promotion of integrated crop management practices.
- Promotion of quality seeds.
- Promotion of allied sectors such as dairy, poultry, etc.

This will be developed by the planning team with due consultation of the community, experts, and block and district administration. The Panchayat should also take the services of experts from research institutions, subject matter specialists, etc. As a result, a design for sector wise development will come out vetted by the experts of different sectors. After the finalisation of the thematic sector, broader level discussions should be done for more suggestions and clarity of the strategies.

Identification of resources and matching with needs

The next step is resource identification. Resources can be identified from different central and state sponsored schemes, tied and untied funds, MP/MLA funds, locally available natural resources, special purpose grants etc. After resource identification, the planning team should sit together and match the needs with the identified resources. In the process of the resource mapping and matching exercise, the Panchayat should take the help of block and district administration, as well as technical support institutions.

Approval of plans by the Gram Sabha

After the preparation of the village agriculture plan, it should be discussed in the Gram Sabha for approval. If any changes are suggested by the Gram Sabha, the Panchayat should modify the plan as per suggestions and resubmit it to the Gram Sabha for approval.

Integration of the Panchayat plan with the Block and District level plan

After the approval by the Gram Sabha, the plan should be submitted to the block for technical validation, compilation, and aggregation at the block level. After the compilation of the Panchayat plan at the block level, the same should be forwarded to the district for compilation and aggregation in the district plan. The idea is that the Gram Panchayat plan will be consolidated at the block level. The plan prepared by all the blocks will be consolidated at the district level, and the plan of the different districts will be consolidated at the state level.

Submission to the Zila Panchayat for approval

After the compilation and preparation of the district level plan, it should be presented to the District Planning Committee (DPC) for approval. If DPC suggests any changes, the district plan will be resubmitted in the DPC after incorporating the suggested changes by the committee.

Monitoring

Once the plan is approved and taken for implementation, it is essential to closely monitor the progress. For this purpose, the Gram Panchayat should constitute the monitoring committee to monitor the work and present physical and financial progress at the Panchayat level. The same should be presented in the Gram Sabha meeting from time to time.

Social Audit

The social audit should be organised by the Gram Panchayat at regular intervals so as to provide an opportunity for the Gram Sabha to assess the quality of work done and inspect the records. Before organising the social audit, wider publicity of the same should be done by the team members to inform the local people, which can help towards ensuring increased participation of all sections of the society.

PANCHAYATS IN WATERSHED DEVELOPMENT

According to the Common Guidelines for Watershed Development (2008), the GP would perform the following important functions:

a) Supervise, support, and advise the Watershed Committee, which implements the watershed development project and is elected by the Gram Sabha, from time to time.

b) Authenticate the accounts/expenditure statements of the Watershed Committee and other institutions of the watershed project.

c) Facilitate the convergence of various projects/schemes to institutions of the watershed development project.

d) Maintain asset registers under the watershed development projects with a view to manage assets after the watershed development project is over.

e) Provide office accommodation and other requirements to the Watershed Committee.

f) Allocate usufruct rights to deserving user groups/Self-Help Groups (SHGs) over the assets created.

Almost all the states have devolved watershed development functions to PRIs. In Gujarat, PRIs are trained on watershed development and are involved in selecting beneficiaries, planning, implementing, spending funds and monitoring. In West Bengal, the Watershed Committee oversees the entire project work, while funds are routed through the GP. The GP Pradhan, being a member of the Watershed Committee, ensures the linkage between the Panchayats and the Watershed Committees. The assets created are maintained by the GP. It also charges the users who are getting benefits from the assets created.

SUCCESS STORIES OF NATURAL RESOURCE MANAGEMENT BY PANCHAYATS

Devolution of management of natural resources has led to several cases of successful management of natural resources. For example, in Maharashtra and Rajasthan, Panchayats have demonstrated successful models of land management (Box 1).

BOX 1: Land management by Panchayats

Hivre Bazar Panchayat in Ahmednagar district, Maharashtra, has full control over the wasteland and forestland in its jurisdiction and has brought the entire area under watershed management and afforestation. It has introduced incentives for the protection of trees and soil moisture conservation.

Gopalpura Panchayat in Churu district of Rajasthan has involved its residents in the protection of common lands and forest lands. The Panchayat opposed the grant of mining leases on Panchayat and forest land to private entities and approached the High Court. It also prepared a land-use plan. Gopalpura Panchayat inspired people in villages of 20 Panchayats to unite and protect their common lands.

Source: GoI, 2009.

The Rajasthan Common Land Policy, 2010, laid down additional norms for the devolution of management of common lands to Panchayats. A Standing Committee for natural resource and biodiversity management has been constituted at the Gram Panchayat level and a Grazing Land Development Committee at village/habitation level. The Policy envisages provision of ‘a ready platform for other institutions such as Watershed Development Committees, Grazing Land Development Committees, Biodiversity Committees, Committees for Management of Minor Irrigation Tanks, etc. to converge and strengthen local governance of natural resources.’ Ward Sabhas are envisaged to identify community rights on the village common lands. The Policy also provides for leasing of ‘waste lands’ to Panchayats and compensation in cases where pasture lands are used for other public purposes.

The state of Gujarat involves PRIs at all levels for the implementation of watershed projects. Members of PRIs are trained on watershed development and are involved in selecting beneficiaries, planning, implementing, spending funds, and monitoring (TARU, 2011a). In West Bengal, funds for watershed development are routed through the Gram Panchayat. The head of the Gram Panchayat, the Pradhan, is a member of the Village Watershed Committee, thereby ensuring linkage between the Panchayat and the Watershed Committee. The Gram Panchayat maintains assets created by the watershed development project and charges users (TARU, 2011b).

There are examples in Maharashtra of Gram Panchayats undertaking social forestry and tree planting (Box 2).

BOX 2: Natural resource management by Panchayats in Kolhapur and Nandurbar districts, Maharashtra

In Kolhapur district of Maharashtra, Panchayats have engaged in tree plantation drives and watershed development. Forest protection and conservation committees have been formed in villages. Jambur Gram Panchayat, for example, has worked on soil and water conservation, and planted trees. It has also adopted a resolution banning cutting of trees and free grazing. In Nandurbar district, Panchayats have planted a million trees and are implementing watershed development projects. Soute and Padvalwadi Gram Panchayats are taking steps to stop land degradation and cutting of trees.

Source: SOPPECOM, 2011.

KEY CHALLENGES TO MANAGEMENT OF NATURAL RESOURCES BY PRIS

Inconsistent Devolution

The 73rd Constitutional Amendment made it imperative for the state governments to devolve functions, functionaries, and finance to the various tiers of PRIs besides amending existing laws and rules related to subjects like agriculture, irrigation, and forests, in line with their respective Panchayati Raj legislation. While states have made mention of devolution of many of these subjects, overall, the ground situation remains challenging in terms of the actual role played by PRIs in the management of natural resources. Natural resources continue to be considered in piecemeal fashion and not as requiring integrated planning and implementation (Vani, 2002). As a result, in several cases, the management strategy or rules have been designed for maximizing exploitation of resources rather than sustainable management (ibid.). Furthermore, microlevel information that is needed for integrated planning is not available at the ground level.

While various Panchayat Acts include sections pertaining to the devolution of management of natural resources, there are sectoral laws that have a larger bearing on the way natural resources are governed. These sectoral laws have remained largely unchanged, making the provisions of devolution in Panchayati Raj Acts ineffective. Existing laws on forests, land resources, irrigation, drinking water supply, soil and water conservation, and fisheries have accorded 'line agencies' a monopoly over control and management of natural resources (*ibid.*). 'Activity mapping', through which the roles and responsibilities of each PRI tier are defined, is not clear and not based on the nature of the resource to be governed. For example, forests have significance at national/global (carbon sequestration, genetic diversity), regional (markets for Non-timber Forest Products (NTFP), species migration, landscape-based approaches) and local (community dependence for provisioning) levels. Devolution to different levels should stem from the nature of the resource as above.

In short, while many State Panchayat Acts mention the role of different tiers of PRIs, their actual functioning is limited due to lack of effective devolution, multi-sectoral coordination, capacity, and information. Further, in some states like Jharkhand, Chhattisgarh, Arunachal Pradesh, and Odisha, traditional institutions for the management of natural resources are still active and take key decisions. The relationship between PRIs and traditional institutions needs further clarity

The challenges of implementing PESA

The implementation of PESA in states with Schedule V Areas has been extremely variable. The unique definition of 'village' and Gram Sabha in PESA, as a self-governing unit in accordance with customs and traditions, has not been adhered to by a number of states in their legislation. In many states, enabling provisions for the Gram Sabha's control over the prospecting of minor minerals, planning, and management of water bodies, control of minor forest produce, and right to be consulted before land acquisition are not yet in place.

A grey area in the PESA legislation is the option it offers to empower either the Gram Sabha or 'Panchayat at appropriate level'. Most states have chosen to empower the latter, thereby diluting the overall spirit behind the legislation to strengthen the self-governing village community. Further, many states are yet to frame rules under PESA and the state and central laws relating to mines and minerals, forests, and land acquisition are not yet compliant with PESA (MoPR, 2010).

Notwithstanding all these challenges, PRIs are best placed to govern natural resources as they have a statutory status, are democratically elected, and provide institutional continuity. Panchayats have potential as overarching governance bodies under which various resource user committees can work.

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ANNEXURE 11

COMMUNITY FORESTRY ON FOREST LANDS AND VILLAGE COMMON LANDS, AND AGROFORESTRY

Rajesh Ramakrishnan[1]

ABSTRACT

Community forest resource rights in forest lands: Community forest rights and community forest resource (CFR) rights provided by the Forest Rights Act are most important for collective access to forest resources, community living, and the ability and power to conserve forests. At least 40 millha of forest lands are eligible for CFR rights recognition across the country. At least 150 million people, including almost 90 million Adivasis, live in communities which would benefit from CFR rights recognition. At least one fourth of the villages in the country (170,000) are eligible to claim CFR rights, based on forest land within their revenue village boundaries. Districts with a high number of villages having forest lands are located in regions that have an Adivasi majority. Community forest rights and forest resource rights have the potential for transforming forest governance and forest-people relations; creating space for democratic, community-based forest governance; livelihood security, poverty alleviation and development; and food security.

But between 2006 and 2016, CFR rights have been granted only on 3 percent of the potential area. The reasons for poor progress include the widespread portrayal of the FRA as legislation for individual rights over land; lack of baseline information on the existence of rights, and existence of customary practices relating to management, use and protection; and lack of clarity among communities and officials on how to determine and verify CFR. No guidance and support systems exist for CFR management and governance by the Gram Sabha, except in areas where civil society organizations are working.

[1]Development professional – natural resources management and livelihoods; Isha volunteer

Community Forest Resource rights have been recognized in a few pockets of the country where civil society organizations and local district administration have taken initiatives. Villages in Gadchiroli district and Narmada district (Gujarat) have traded in bamboo from their forests, creating large community incomes. Agroforestry: There are a number of studies from different parts of the country suggesting that agroforestry is more profitable to farmers than agriculture or forestry for a particular area of land. In recent times, the ecosystem services rendered by agroforestry systems have been widely recognized. Agroforestry systems also have the potential for being an effective tool in climate change mitigation and adaptation steps. Estimates of the total area under agroforestry in India vary from 11.54 mha to 25.32 mha. Traditional agroforestry systems conserve the soil by improving its fertility levels and erosion; provide quality water for local consumption, fodder for livestock, fuel and timber for use as energy and construction materials, and traditional crops for food security. Commercial agroforestry is estimated to be practised over 5 mha. Commercial agroforestry is estimated to produce 100 million cubic metre timber/pulpwood for industrial and domestic use and 150 million tonnes firewood, and generate employment of 4000 million person days/ annum in nursery and plantation activities.

The major highlights of the National Agroforestry Policy (2014) include: establishment of an institutional set-up at the national level within the Ministry of Agriculture to promote agroforestry; simplify regulations related to harvesting, felling and transportation of trees grown on farmlands; access to quality planting material; institutional credit and insurance cover to agroforestry practitioners; and increased participation of industries dealing with agroforestry produce. Various programmes, schemes, missions on various elements of agroforestry functioning in various departments of agriculture, forestry and rural sectors of the government, are being brought under the National Agroforestry and Bamboo Mission. The Central Agro-Forestry Research Institute (CAFRI), Jhansi) is being upgraded as a nodal centre with agro-ecology-based regional centres in various parts of the country. This step will promote value chains, climate-resilient technology development and pave the way for region-based marketing linkages in agroforestry.

Commons or common pool resources form critical components that supplement and support rural communities dependent on agriculture, livestock and forests in large parts of India, but especially the dryland and tribal areas. Access to the commons provides stability and security in an unpredictable environment, especially critical for landless households. The extent of common lands in India is estimated at 23.97 percent of the total land mass by the Department of Land Resources. Despite the important contribution of the commons to the rural livelihood complex, a significant decline in their extent and quality has been registered over a period of time. This decline has been recorded by several studies. Poor families are usually at the losing end, either by denial of access to these resources mainly because of privatization of the common pool resources by a few, or by diversion of these resources to alternative uses.

THE FOREST RIGHTS ACT AND NATURAL RESOURCES MANAGEMENT

The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA) recognises and grants rights to Scheduled Tribes and other communities, who have traditionally been living in or depending on forest land for their legitimate livelihoods. The Forest Rights Act confers several rights on communities, the Gram Sabha[2] and even individuals.

It broadly provides for two sets of rights – land rights, both private and common, and community rights over forest resources. The former include the 'right to hold and live in forest land under individual or common occupation for habitation or for self-cultivation for livelihoods'. The latter include rights for collective management of community forest resources, rights over common property resources such as water bodies, grazing rights for both settled and nomadic communities, and ownership rights over NTFPs (Springate-Baginski et al., 2008; also see Annexure 1).

2 The Forest Rights Act uses a very expansive definition of `village', ranging from what is defined as `village' in any State law related to Panchayats in non-Schedule V states, to "habitation or a group of habitations or a hamlet or a group of hamlets comprising a community and managing its affairs in accordance with traditions and customs " in Schedule V areas; the traditional village, by whatever name called, in states that do not have Panchayats; and "forest villages, old habitation or settlements and unsurveyed villages, whether notified as village or not". Following from this, the Gram Sabha means a village assembly which shall consist of all adult members of a village (MoTA & UNDP, 2014).

The Forest Rights Act also has special provisions for protected areas with provision for declaring `critical wildlife habitats'. These are important wildlife areas that are to be kept inviolate, i.e. no human activity that is scientifically and objectively shown to damage wildlife is permissible in these areas. Although this implies that some livelihood activities of forest dwellers could be modified or restricted in these areas, the process through which this is to occur is transparent and consultative. Even in protected areas from where forest dwellers are to be resettled, it has to be done with prior, informed consent of the affected persons. Additionally, the Act states that the critical wildlife habitats cannot subsequently be used for purposes other than wildlife conservation (Kothari et al. 2009).

The actual implementation of the FRA, or more specifically the recognition of rights via claims, occurs through a multilayered process conducted by various authorities (Box 1). These range from the Gram Sabha to committees at the sub-district, district and state level. The Act relies heavily on the Gram Sabha to drive the claims process forward. Although the power of final decision on the validity of a claim lies with the district committee, it is the Gram Sabha that starts the process to determine the nature and extent of individual or community forest rights (Kalpavriksh, 2008 and MoTA & UNDP, 2014).

BOX 1: Institutions and processes for implementation of FRA

The Forest Rights Act lays out a series of procedures, and creates or authorizes institutions at various levels, for its implementation.

At the grassroots level, Gram Sabha is the authority to initiate the process of determination of rights which include receiving, consolidating and verifying claims. A Forest Rights Committee (FRC) at Gram Sabha level is constituted and authorized by Gram Sabha to assist it in its functions to collate, verify, and approve claims to rights.

A Sub-Divisional Level Committee (SDLC) examines the Gram Sabha resolutions on rights claims and maps related to these claims, and provides its opinion on them to the next level of authority, the District Level Committee.

The SDLC provides necessary support to the Gram Sabha and FRC to support the process for determination of rights.

A District Level Committee (DLC) examines the claims it receives, and accepts or rejects them. The DLC is also required to ensure that necessary support is provided to Gram Sabhas to carry out their functions.

A State Level Monitoring Committee (SLMC) assesses whether FRA is properly implemented. The nodal agency in the state is the Tribal Department, and the state appoints a nodal officer.

At the national level, Ministry of Tribal Affairs is the nodal agency.

The FRA and its rules lay out the composition, functions, and processes of these institutions, and the relations amongst them.

Source: MoEF and MoTA (2010).

COMMUNITY FOREST RIGHTS AND COMMUNITY FOREST RESOURCE RIGHTS UNDER FOREST RIGHTS ACT

The provisions of the FRA on community forest (CF) rights and community forest resource (CFR) rights are extremely important for supporting community conservation where it is already happening, and also where communities are willing to take part in conservation and management of common resources. Community forest rights and forest resource rights are far more numerous than individual forest rights in the Act, and much more important from the point of view of collective access to forest resources, community living, and the ability and power to conserve forests. The provisions are crucial for changing the governance of forests towards more decentralization and site-specificity, while providing for a possibility of collective livelihood security to communities (Box 2) (Kalpavriksh, 2010; MoEF and MoTA, 2010; and MoTA & UNDP, 2015).

BOX 2: Community forest rights and forest resource rights in the FRA

Community forest (CF) rights are the various rights under Section 3(1) which are vested and recognised in a village community, and exercised together as a community. This would include nistari rights, the right to minor forest produce, fishing and grazing rights, right to conversion of forest villages into revenue villages, right to access biodiversity and intellectual property rights and so on.

The Community Forest Resource (CFR), however, is defined under Section 2(a) as under:

Section 2(a) of FRA defines a community forest resource as 'customary common forest land within the traditional or customary boundaries of the village or seasonal use of landscape in the case of pastoral communities, including reserved forests, protected forests and protected areas such as Sanctuaries and National Parks to which the community had traditional access'.

The CFR is therefore the customary common forest which harks back to the traditional or customary boundaries of the village, and includes seasonal use of pastoralists.

This forest right finds articulation in Section 3(1) i of FRA, which provides:

The 'right to protect, regenerate or conserve or manage any community forest resource which they have been traditionally protecting and conserving for sustainable use'.

This is a unique opportunity for forest-dependent communities to claim and manage forest resources in order to achieve the twin objectives of forest and biodiversity conservation and sustainable livelihood.

Section 5 of FRA addresses the powers and duties of forest rights holders. It provides for a legal option/right/responsibility to protect wildlife, forests and biodiversity while empowering Gram Sabha to regulate access to community forest resources and to stop any activity that may adversely affect the same.

The recognition of CFR rights empowers forest dwellers with the authority over decision-making and forest governance with access to and use of funds available under various government programs for management of their CFRs.

The provisions for CFR rights in the FRA are reinforced by provisions within the Forest Rights Rules.

Every village with any forest dwellers residing in it should receive a title to a Community Forest Resource (Section 12(B)(3) of the Forest Rights Rules) unless reasons for not being able to do so are recorded by the authorities.

Rule 4 (e) of FRA states that communities which claim rights under the Act have a right to 'constitute committees for the protection of wildlife, forests and biodiversity, from amongst its members, in order to carry out the provisions of Section 5 of the Act'.

The CFR right, therefore, is much wider than the various community rights delineated under Section 3(1) in that it extends over a geographical area where the community traditionally and customarily had access, and also vests important responsibilities and powers in the Gram Sabha to ensure the CFR area, and the wildlife, water sources, forests, and biodiversity it comprises, is protected from harm.

Source: Kalpavriksh, 2010; MoEF and MoTA, 2010; MoTA & UNDP, 2015; and RRI et al., 2015.

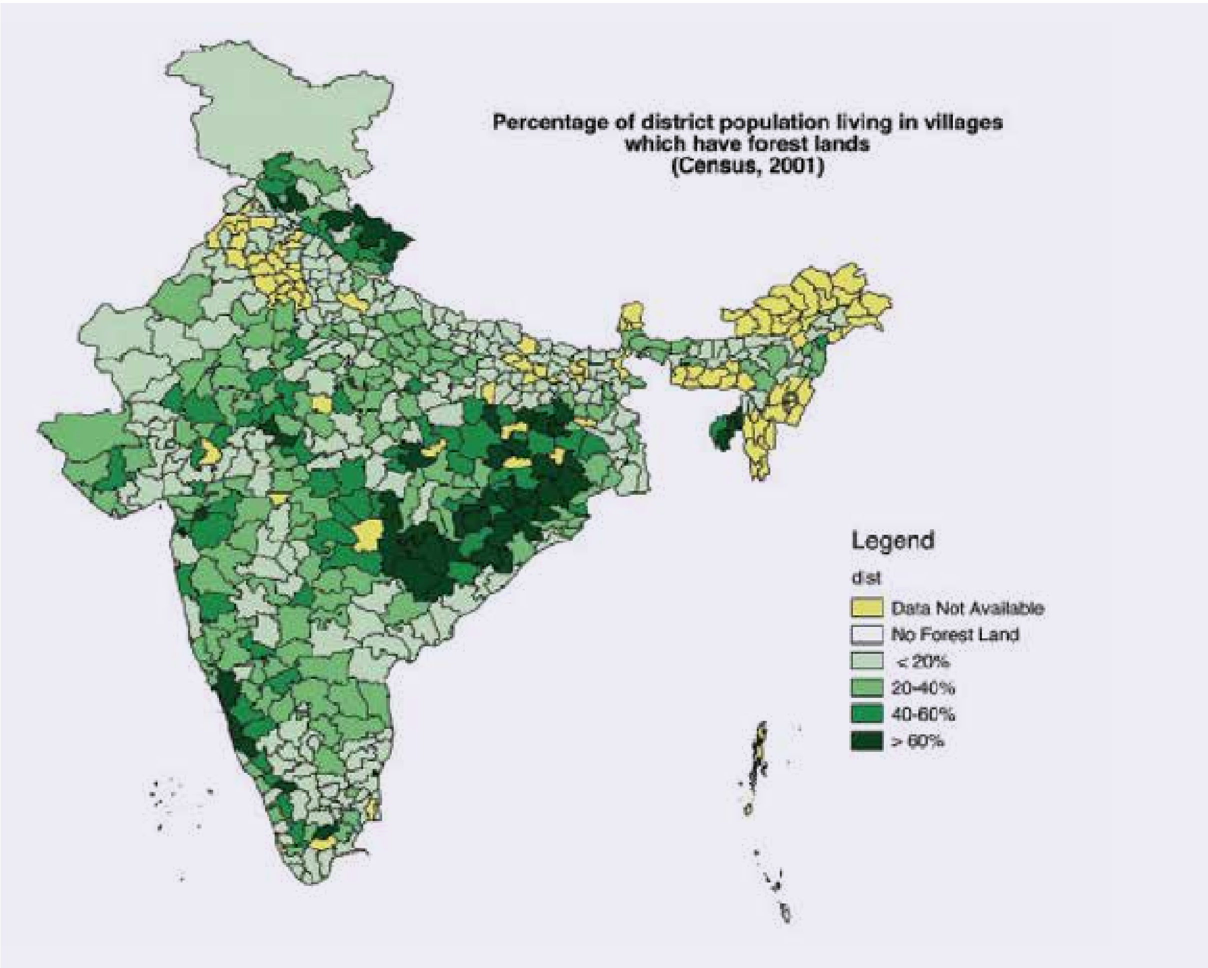
POTENTIAL FOR COMMUNITY FOREST MANAGEMENT

A study found that there is enormous potential for community forest management through community forest resource (CFR) rights under FRA.

At least 40 mha of forest lands are eligible for CFR rights recognition across the country. This estimate includes 32.198 mha of forest land identified by the Forest Survey of India 1999 as located within village boundaries and at least 8 mha of community forests in North-Eastern States, but not forest areas customarily used by forest-dwelling communities lying outside revenue village boundaries. To that extent, this is a conservative estimate.

At least 150 million people, including almost 90 million Adivasis, live in communities which would benefit from CFR rights recognition. There are 120 districts, mostly located in the Adivasi areas of central India, where more than 40 percent of the population live in villages that have forest land and which are eligible for CFR rights recognition (Fig. 1).

FIGURE 1: PERCENTAGE OF DISTRICT POPULATION LIVING IN VILLAGES WHICH HAVE FOREST LANDS

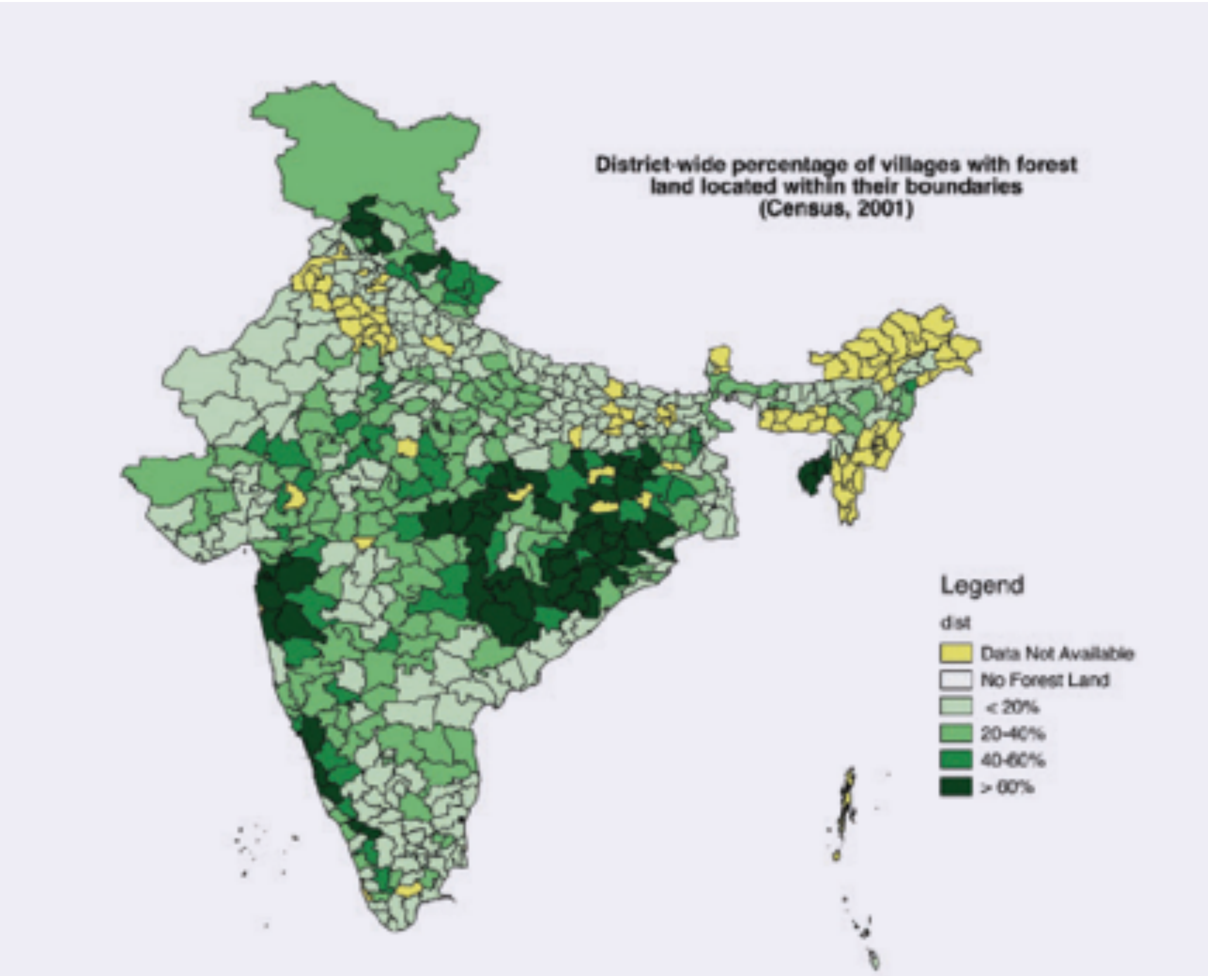


Source: RRI et al., 2015

At least one fourth of the villages in the country (170,000) are eligible to claim CFR rights, based on forest land within their revenue village boundaries. Nine states have more than one-third of their total villages eligible for CFR rights recognition.

Districts with a high number of villages having forest lands are located in regions that have an Adivasi majority (Fig. 2).

FIGURE 2: DISTRICT-WIDE PERCENTAGE OF VILLAGES WITH FOREST LAND WITHIN THEIR BOUNDARIES



Source: RRI et al., 2015

Community forest rights and forest resource rights have the potential for:

Transforming forest governance and forest-people relations: Studies show that people develop a connection with forests because of everyday proximity. They develop special ecological knowledge and, often, use it to devise low-cost, efficient and powerful forest management interventions. Innumerable community conservation efforts across the country show that communities are quite skilled at devising governance institutions for effective conservation and management of natural resources.

Creating space for democratic, community-based forest governance: Community forest resource rights support local adaptive forest governance. Transfer of jurisdiction of CFRs to the Gram Sabha will boost creativity and leverage dispersed local knowledge of forest dwellers to effectively manage, govern and restore forests at a low cost. While only a small percentage of the potential CFR area has been recognized till now, effective forest governance by the Gram Sabha is already being practiced in hundreds of villages.

Livelihood security, poverty alleviation and development: Individual and community forest and resource rights through the Forest Rights Act have extraordinary potential for ensuring livelihood security and poverty alleviation through sustainable and community-based management of forests. The Act offers opportunities for poverty alleviation through forest product harvesting, processing and forest enterprises, and transfer payments to the Gram Sabha for reforestation, carbon sequestration and provision of ecological services. A significant opportunity lies in the convergence of FRA with development programmes such as MGNREGA and IAY.

Food security: Food from forests and tree-based systems is likely to continue to form an essential part of household strategies to eliminate hunger and achieve nutritionally balanced diets. Food from forests provides micronutrients and contributes to dietary diversity. It also provides nutritional sufficiency and a "safety net" during periods of other food shortages caused by crop failure and during seasonal crop production gaps. Individual and community forest and resource rights have the potential to improve the status of food security of millions of forest-dwelling poor and tribal communities by recognizing their age-old tenure and occupational rights of land and forest products. Individual Forest Rights, through recognizing occupancy rights and allowing investments on the recognized land, can contribute to the food security of marginalized forest dwellers. Similarly, recognition of traditional and sustainable shifting cultivation practices support food security. The transfer of forest governance responsibility from forest department to the communities also creates potential for sustainably managing forest landscapes for food, nutritional production and livelihoods.

Meeting Sustainable Development Goals: The Forest Rights Act's potential to enhance local livelihood and ensure conservation through community forest resource rights makes it a good legal instrument to address SDGs, especially the goals of eliminating poverty and achieving ecological sustainability. The Act presents one of the most important legal instruments available to the government of India to secure the rights and livelihood of Scheduled Tribes and other traditional forest dwellers living in the forested landscapes of India having one of the largest concentration of poor and marginalized in the world, and thereby achieve its commitments under the SDGs.

Meeting national and international conservation goals: The Convention on Biological Diversity (CBD) is amongst the most important international treaties on biodiversity conservation. Recognition of individual and community/community resource rights and Gram Sabha empowerment, both inside and outside protected areas, enable the meeting of CBD goals of conservation with full and effective recognition and respect of rights, protection of traditional knowledge and knowledge systems and participation in conservation governance.

Climate change mitigation: Following the 2015 COP Paris Agreement on Climate Change, India has made ambitious plans as part of its Intended Nationally Determined Contributions (INDC) to sequester an additional 2.5 billion tonnes of carbon. Effective implementation of CFR rights should be a critical part of the strategy of carbon sequestration through checking forest degradation and enhancement of forest stocks. Community forest resource rights can potentially channelize the creative energies of over 170,000 villages in the country for this task.

(CFR-LA, 2016)

PROGRESS AND CHALLENGES TO THE IMPLEMENTATION OF COMMUNITY FOREST MANAGEMENT

For the whole country (excluding the five north-eastern states and J&K), only in 3 percent of the potential area have CFR rights been granted in the 10 years between 2006 and 2016 (*ibid.*).

At the Centre, the nodal agency for FRA, the Ministry of Tribal Affairs, is understaffed and has various responsibilities other than overseeing the implementation of the Act. It has organized training programmes and consultations for state officials, brought to the notice of states violations or poor or non-implementation of FRA, and issued guidelines and directives for effective implementation from time to time. The statutory SLMCs for FRA are non-functional in most states. SLMCs do not meet quarterly as required by the law. The Act requires SLMCs to address petitions and complaints filed by Gram Sabhas and forest rights holders. However, most of the petitions filed to SLMCs remain unaddressed. The state tribal welfare departments (nodal agencies at the state level) have not been provided the human and financial resources to implement FRA (*ibid.*).

Formation of DLCs and SDLCs has been delayed in several states. In many cases, the composition of DLCs/SDLCs violates the statutory requirement. Meetings of DLCs/SDLCs are not regular. The legal authority of the Gram Sabha for determining the nature and extent of rights, and governance of forests is often seriously undermined. In many states, Gram Sabhas are being organized at the panchayat level, although FRA mandates village/hamlet level gram sabhas. There is lack of awareness and capacity building of the Gram Sabha and FRCs on FRA (*ibid.*).

The reasons for poor progress in the implementation of CF and CFR rights include: (i) the widespread portrayal of the FRA as legislation for individual rights over land, as distinct from usufruct rights and other forms of rights; (ii) inadequate information collection and follow-up at higher levels in the government on CF and CFR rights; (iii) confusion at the field level on the distinction between claims for development facilities and claims on forest resources; (iv) lack of baseline information on the existence of rights, and existence of customary practices relating to management, use and protection; (v) lack of clarity among communities and officials on how to determine and verify CFR; (vi) omission of the right to protect or manage community forest resources in the claim form; and (vii) open-access status of community forest resources (MoEF and MoTA, 2010).

Community Rights, and development rights under Section3(2), have been reported as CFR rights due to lack of clarity at all levels of implementation agencies. Even where Gram Sabhas have filed large numbers of CFR claims, these are not mentioned in the official reports or are pending at SDLCs and DLCs without any response. Customary boundaries delineated by the Gram Sabha are not accepted or are arbitrarily changed by Government functionaries during field verification. CFR claims are pending due to objections raised by SDLC or DLC. Where recognized, the CFR rights are yet to be incorporated in the Record of Rights as required by law. No guidance and support systems exist for CFR management and governance by the Gram Sabha, except in areas where civil society organizations are working (CFR-LA, *op. cit.*).

CASE STUDIES OF SUCCESSFUL COMMUNITY FOREST MANAGEMENT

Community Forest Resource rights have been recognized in a few pockets of the country where civil society organizations and local district administration have taken initiatives. These include Gadchiroli and Nandurbar districts in Maharashtra; Kandhmal and Mayurbhanj districts in Odisha and Narmada district in Gujarat. Implementation in districts like Gadchirolli and Kandhmal provides real time substantiation of the potential of CFR rights recognition, with large areas of forests being recognized as CFRs (RRI et al., *op. cit.*). Maharashtra has emerged as a leading state in the recognition of CFR rights in the country. By November 2016, a total of 5741 CFR rights claims had been recognised over an area of 7260.58 sq km in the state. This is largely due to Gadchiroli, where over 60 percent of the potential CFR rights area has been recognized (Maharashtra CFR-LA, 2017).

Dramatic examples of major livelihood improvement arising out of CFR rights recognition are emerging. Villages in Gadchiroli district have traded in bamboo from their forests, creating large community incomes (Box 3). Similarly, over 20 villages who have received titles under the FRA in Narmada District, Gujarat, have harvested and sold bamboo to paper mills, generating incomes in tens of lakhs of rupees to individual villages. In 2013, with support from CSOs, 18 gram sabhas in Gadchiroli, Gondia and Amravati districts collected and sold tendu leaves worth crores of rupees from their CFR areas (Box 4). In Andhra Pradesh, Sirsanapalli village sold Rs. 26 lakhs worth of bamboo after receiving CFR rights, decided to spend half of the income on improving the forests and want to develop their village into a model village using income from forests. In Biligiri Rangaswamy Temple (BRT) Tiger Reserve in Karnataka, five Gram Sabhas, which have received CFR titles, have established a honey value-addition center. In Shoolpaneshwar wildlife sanctuary in Gujarat, sustainable bamboo harvest by communities from their CFR areas have yielded large incomes and wage employment. Rights recognition could potentially wipe out persistent poverty from the forested heartlands of India (CFR-LA, *op. cit.*).

BOX 3: Mendha Lekha's Experience: Bamboo Ownership and Trade

Mendha Lekha, a tribal forest village in Gadchiroli inhabited by the Gond tribe, is renowned for holding regular Gram Sabhas and for arriving at community level decisions in a transparent manner. The village was one of the first in the district to have its community rights over NTFPs recognized under Section 3(1) i of FRA. Thereafter, the Gram Sabha worked on conservation of the existing biodiversity in the areas where the rights had been recognised. A committee was formed by the Gram Sabha under Section 4(1) e of FRA for this purpose. Having created a People's Biodiversity Register way back in 2004, the Gram Sabha worked closely with Professor Madhav Gadgil for the development of a management plan for the community forest resources whose rights have been recognized. Professor Gadgil is one of the many subject matter specialists who are frequently consulted by the Gram Sabha.

Mendha Lekha created history in 2011 by being the first village in India to harvest and sell bamboo through its Gram Sabha. Earlier, the management of the trade- tendering process, negotiations with contractor, fund management and issue of transit passes was done by the Forest Department with the community working as wage labourers in bamboo harvesting.

In January 2010, the Mendha Lekha Gram Sabha wrote to the Forest Department regarding harvesting bamboo from its CFR recognized area and followed this with a meeting on the subject with senior officials of the Forest Department at the district level. However, the Forest Department responded only in February 2011, denying permission for bamboo harvesting. A year was lost in bureaucratic delays.

Immediately after this letter was received, the Mendha Lekha Gram Sabha communicated to the Forest Department of its decision to harvest the bamboo on its own using the working plan of the Forest Department. The bamboo was harvested in April-May 2011 and sold to a private contractor. Of the total sales of Rs. 21.96 lakhs, the Gram Sabha paid Rs. 8 lakh as wages and Rs. 12.56 lakhs was deposited as 'Gram Sabha Nidhi'. The Gram Sabha decided to allocate 50 percent of the Gram Nidhi funds for forest conservation and development and 50 percent for community based innovative development projects.

For the 2012 harvesting, the Gram Sabha initiated work well in advance. It invited tenders for the bamboo, harvested and sold bamboo to a private contractor, got the proceeds in its bank accounts and issued its own transit pass for bamboo transportation from the village. The Gram Sabha earned a record rate at Rs. 8,151 per notional tonne (weight of a 2,000-m end-to-end chain of green bamboo) for long bamboo, which was 2.5 times more than the highest rate received by the Forest Department in the preceding year . The Gram Sabha was able to offer wages to the community to the tune of Rs. 37.66 lakhs and an income of Rs. 49.04 lakhs was deposited as Gram Nidhi. After this, the Gram Sabha stopped bamboo harvesting for the stock to regenerate. Seeing the success of Mendha Lekha, 28 villages in Gadchiroli harvested and sold bamboo through Gram Sabhas with the support of the forest and the revenue department.

Source: `From state to community ownership in Gadchiroli'; NR Management Consultants, New Delhi, unpublished draft.

BOX 4: Collection and sale of tendu leaves by Gram Sabhas in Vidharba

Tendu leaves are a major source of livelihood for over 450,000 families in rural eastern Maharashtra. The state Forest Department was managing collection and sale of tendu leaves under "Maharashtra Forest Produce (FP) (Regulation of Trade) Act, 1969 and Maharashtra FP (Regulation of Trade in Tendu Leaves) Rules, 1969. This process continued even after FRA came into force in 2006. In 2013 the Forest Department was planning for tendu leaf collection in seven forest circles. Some of these were Gram Sabhas which had already received their CFR rights. NGOs like VNCS and KHOJ working with these villages brought this to the notice of the then State Principal Secretary of Forests, who called a meeting under Chairmanship of the State Chief Secretary at Mumbai in February 2013, including officials from the Department of Tribal Development, Revenue and Law & Judiciary. It was agreed that tendu leaves should be collected and sold by Gram Sabhas and contradictory rules obstructing this would be accordingly amended. A letter was issued by Deputy Secretary (Forests) in May 2013 recognizing Gram Sabhas as the Agent (Abhikarta) of the FD to collect tendu. Gram Sabhas refused to work as the Agents of FD when they had complete rights to collect and sell under the FRA. Eighteen Gram Sabhas then decided to collect and sell tendu leaves from their CFR and other areas, from where they have been traditionally collecting the leaves.

Following this a group of Gram Sabhas (GGSs) was formed based on their traditional areas of collection of tendu leaves, dividing 18 villages into 4 units. A Technical Advisory Committee was set up comprising two members each from the 18 Gram Sabhas, representatives from VNCS and KHOJ, Chief Conservator of Forests, District Conservator Forests, and a Technical Adviser, the representatives of lead banks were nominated as the members of this committee to guide and monitor the process. Tender document was prepared through a joint consultation of Technical Experts, VNCS team, members of the Gram Sabhas and finally signed and issued by the representatives of the

Gram Sabhas. This was then published in major newspapers and was also uploaded on the website of Chief Conservator Forests, Gadchiroli.

The Ttibal Development Corporation (TDC) provided Rs. 70,00,000 as an advance to the Gram Sabhas from time to time. However, after the leaves were plucked, dried and packed the TDC refused to pay Rs. 3500 per standard bag being asked by the Gram Sabhas. With help from VNCS and KHOJ the leaves were then sold in the open market at Rs 3600 to 3200 per standard bag depending on the quality of leaves. Gram Sabhas of Dhamditola Unit in Gondiya became the first few villages to return Rs. 28,00,000 advance that they had received from the TDC, having covered all their costs and profits.

Based on the bundles of tendu leaves deposited by the pluckers and approved by the checker/Phadi Munshi and representatives of Gram Sabhas, payments for collection of tendu bundles were deposited in the bank account of respective Gram Sabha of that center by the group of Gram Sabhas from their main account. Gram Sabhas disbursed collection charges at Rs. 195 per 100 bundles (Rs. 1950 per standard bag) to the pluckers. Collectively the leaves were sold for Rs.69,82,502 and Rs. 41,55,816 was paid to 1449 families as collection charges. It was decided that the balance after deducting plucking charges and management cost will also be paid to the plucker as bonus. Accounts were audited by an external auditor. These audited statements were presented in all the respective Gram Sabhas in front of individual families involved in plucking. This is a great leap with respect to Gram Sabhas empowering themselves both economically and politically by claiming their right over the NTFP.

Source: Wasudeo Kulmethe and Rajesh Prasad, VNCS, Nagpur; cited in Maharashtra CFR-LA, 2017.

AGROFORESTRY AND FARM FORESTRY[3]

POTENTIAL GAINS FROM AGROFORESTRY AND FARM FORESTRY

Agroforestry is a judicious integration of tree species with agricultural crops and/or animals, which has been traditionally practiced across the world in both the tropics and temperate regions. It provides the inter-dependent benefits of the three components, viz. trees, crops and livestock, in addition to the 6Fs, i.e. food, fruit, fodder, fuel, fertilizer and fibre. The nutrient cycling exchange and positive spill-off effects of each component brings sustainability to farm production mechanisms. Most of the agroforestry systems are part of indigenous traditional knowledge of local communities. These systems vary from one part of the country to another due its diverse climatic conditions.

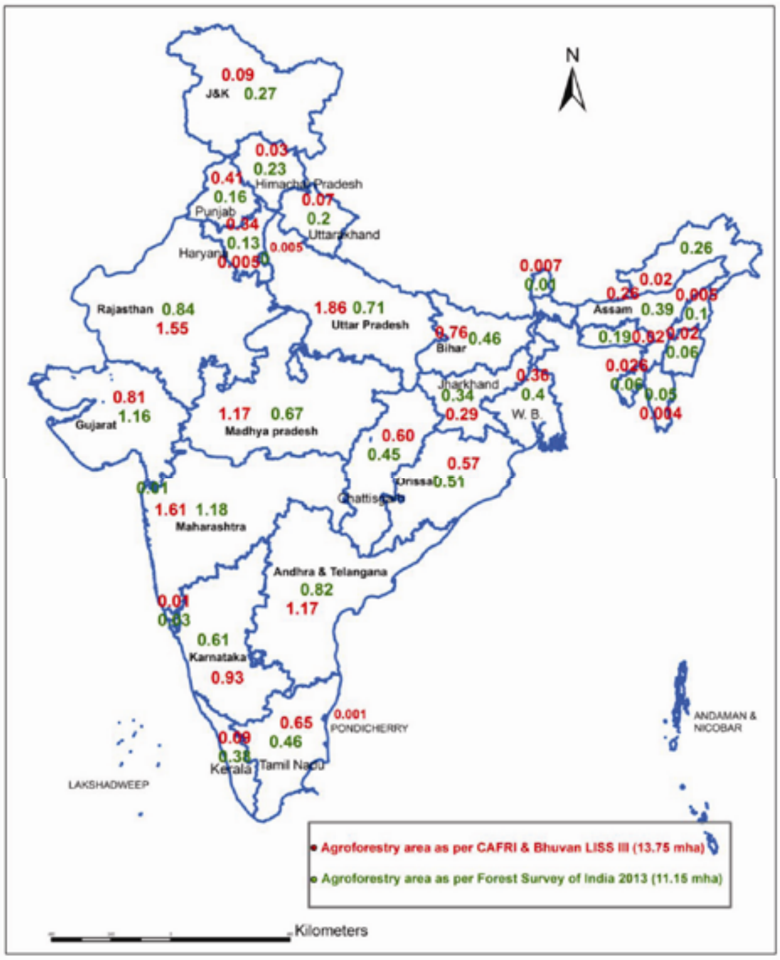
There are a number of studies from different parts of the country suggesting that agroforestry is more profitable to farmers than agriculture or forestry for a particular area of land. A comprehensive analysis indicated economic viability with internal rate of return (IRR) ranging from 25 to 68 and B:C ratio of 1.01 to 4.17 for 24 agroforestry systems from different agroclimatic regions of the country. A 13-year study of aonla-based agroforestry system in marginal lands under rainfed conditions found a B:C ratio of 3.28 (on discounted rate it was 2.61), which indicated its profitability. Agroforestry systems have the potential to generate employment opportunities of 450 man-days per hectare per year. Current estimates show that about 65 percent of the country's timber requirement is met from the trees grown on farms. Agroforestry is perhaps the only alternative to meeting the target of increasing forest or tree cover to 33 per cent from the present level of less than 25 per cent, as envisaged in the National Forest Policy (1988).

Conventional economic analysis largely looks at input and output costs in material terms. In recent times, the ecosystem services rendered by agroforestry systems have been widely recognized. These services include microclimate moderation, biodiversity conservation, carbon sequestration, protecting water sources, soil erosion and pollution control. Agroforestry is mentioned by IPCC as one of the instruments to fight climate change. Agroforestry systems have the potential for being an effective tool in climate change mitigation and adaptation steps.

3 This section is excerpted from Chavan et al. (2015).

Area under agroforestry: Lack of uniform methodology adopted by different agencies results in varying estimates of the total area under agroforestry. The current approximate area under agroforestry is estimated to be **25.32 mha**, or 8.2 percent of the total geographical area of the country according to Dhyani (2014). Based on data from Central Agro-Forestry Research Institute (CAFRI), Jhansi and remote sensing data of Bhuvan LISS III, the area under agroforestry is **13.75 mha**. However, India State of Forests Report 2013 by Forest Survey of India estimated the area as **11.54 mha**, which is 3.39 percent of the geographical area of the country. Maharashtra, Gujarat and Rajasthan rank high in state-wise area under agroforestry. The latter two estimates are depicted in Figure 3.

FIGURE 3: ESTIMATES OF AREA UNDER AGROFORESTRY IN INDIA



Source: Chavan et al., 2015

Traditional agroforestry systems and ecosystem services: Across the diverse agro-climatic regions there are various traditional agroforestry systems that have co-evolved with livelihood activities of local communities. Such systems include homegardens in Kerala and North East India, kangayam tract in south India, khejri-based in the northwest, *Acacia nilotica*-based in the central parts, alder-based in the Himalayas and so on (Table 1). Traditional systems are one of the best examples of ecosystem services providing several goods and services. Such systems conserve the soil by improving its fertility levels and erosion; provide quality water for local consumption, fodder for livestock, fuel and timber for use as energy and construction materials, and traditional crops for food security. A comparison of soil loss under various land use systems shows that cardamom-based agroforestry in North-East India shows the least soil loss (30 kg/ha) compared to forest-based (74 kg/ha), horticulture-based agroforestry (145 kg/ha) and rainfed agriculture (477 kg/ha). Standard methodologies have not been developed to quantify various ecosystem services from agroforestry. Methodologies for carbon sequestration (regulating services) have been framed clearly and the overall carbon sequestered in agroforestry systems ranges from 0.5 to 2.0 mg/ha/year.

Commercial agroforestry systems: Commercial agroforestry is gaining momentum due to large-scale demand from pulp and paper industries. In order to meet the requirement of paper mills, industry requires around 2.5 million ha of land for pulpwood plantation. Currently, the commercial agroforestry is estimated to be practised over 5 million ha with tree species belonging to Eucalyptus, *Populus, Casuarina, Leucaena, Ailanthus, Melia, Anthocephalus, Acacia, Bombax*, etc. (Table 1). Commercial agroforestry is estimated to produce 100 million cubic metre timber/pulpwood for industrial and domestic use and 150 million tonnes firewood, add approximately 15 million tonnes organic matter through leaf fall, sequester 60 million tonnes carbon annually in tree components (excluding in soil and that locked in the wood products), and generate employment of 4000 million person days/ annum in nursery and plantation activities. The value of wood/pulpwood produced is estimated to be around Rs 10,000 billion and that of firewood as Rs 30,000 million annually.

TABLE 1: AREA UNDER TRADITIONAL AND COMMERCIAL AGROFORESTRY SYSTEMS IN INDIA

Type of agroforestry system	State	Area ('000 ha)	Species
Traditional agroforestry			
Alder-cardamom	North East India	34	Alnus nepalensis
Kangayam agroforestry	Tamil Nadu	384	Acacia leucophloea
Homegardens	Kerala	1330	Mixed tree species
Khejri-based agroforestry	Rajasthan	1586	Prosopis cineraria
Commercial agroforestry			
Pulpwood agroforestry (paper)	Punjab, Haryana, Uttar Pradesh, Andhra Pradesh, Gujarat and Tamil Nadu	657	Eucalyptus, poplar, casuarina and subabul (Acacia nilotica)
Timber-based agroforestry (furniture)	Kerala, Maharashtra, Tamil Nadu and Madhya Pradesh	1700	Tectonia grandis
Willow-based agroforestry (bat industry)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand	137	Salix species

Source: Chavan et al. (2015)

POLICY ENVIRONMENT FOR AGRO-FORESTRY AND FARM FORESTRY

Agroforestry finds mention in the National Agricultural Policy, 2000, where it is stated that 'farmers will be encouraged to take up farm/agroforestry for higher income generation by evolving technology, extension and credit support packages and removing constraints to development of agroforestry'. Other major policy initiatives, including the National Forest Policy (1988), Planning Commission Task Force on Greening India (2001), National Bamboo Mission (2002), National Policy on Farmers (2007) and Green India Mission (2010), emphasize the role of agroforestry for efficient nutrient cycling, organic matter addition for sustainable agriculture and for improving vegetation cover. The Government of India (GoI) has launched several schemes/projects like the National Bamboo Mission (NBM) under the Ministry of Agriculture, Rashtriya Krishi Vikas Yojana (RKVY), National Horticulture Mission (NHM), National Biofuel Policy, etc. wherein integrating forestry components on farmlands has been given the much needed thrust. The National Bank for Agriculture and Rural Development (NABARD) provides financial and banking institutional support for social forestry, farm forestry and afforestation of wastelands. Similarly, the National Medicinal Plants Board (NMPB) under the AYUSH Ministry has emphasised integrating medicinal plants and trees along with agricultural crops. Establishment of silvi-pastoral systems and fodder blocks/banks has been envisaged in various schemes operated by the Animal Husbandry Department. The National Afforestation and Eco-development Board (NAEB) under the Ministry of Environment, Forests and Climate Change, is also promoting agroforestry practices on farm and wastelands. In addition to these schemes, State Governments also have schemes/projects that promote agroforestry.

However, the lacuna of not having an exclusive policy for agroforestry at the national level has hampered its adoption on a wider scale. In addition, agriculture is a State subject and forestry falls under the Concurrent list. The complicated and cumbersome legal procedures and hurdles involved in growing, felling, transportation and marketing of tree species have acted as barriers. Markets and market information about tree components are not well established in all places

Lack of uniformity in legal and financial provisions across various states of the country also makes it difficult for many farmers to integrate trees into their cropping systems.

National Agroforestry Policy (NAP), 2014: The major highlights of the Policy are: establishment of an institutional set-up at the national level within the Ministry of Agriculture to promote agroforestry; simplify regulations related to harvesting, felling and transportation of trees grown on farmlands; ensuring security of land tenure and creating a sound base of land records and data for developing a market information system (MIS) for agroforestry; investing in research, extension and capacity building and related services; access to quality planting material; institutional credit and insurance cover to agroforestry practitioners; increased participation of industries dealing with agroforestry produce, and strengthening MIS for tree products. The policy identified 20 important multipurpose tree species at the national level to be exempted from all restrictions related to harvesting, transportation and marketing if grown under agroforestry systems.

One of the objectives of NAP, 2014 was to bring together various programmes, schemes, missions on various elements of agroforestry functioning in various departments of agriculture, forestry and rural sectors of the government under one platform. This has been achieved in July 2017 through expanding the remit of the National Bamboo Mission, renaming it the National Agroforestry and Bamboo Mission, under the Department of Agriculture and Co-operation (DAC), Ministry of Agriculture. The Central Agro-Forestry Research Institute (CAFRI), Jhansi) is being upgraded as a nodal centre with agro-ecology-based regional centres in various parts of the country. This step will promote value chains, climate-resilient technology development and pave the way for region-based marketing linkages in agroforestry. The Policy also suggests massive extension programmes in order to broadcast the outcomes of intensive R&D activities in the field of agroforestry.

CHALLENGES TO BE ADDRESSED

Regulatory regimes for agroforestry: The restrictions imposed on harvesting, transportation and marketing of agroforestry produce play a significant role in the minds of the farmer looking to adopt agroforestry. There are many common species which grow naturally in the forest areas and are well adapted to local regions and are also grown by farmers under agroforestry systems. There is an urgent need to remove these regulatory restrictions at least for those species which are widely adopted under agroforestry systems and providing raw material to the wood-based industries. The Bansal Committee (constituted by the Ministry of Environment, Forests and Climate Change in July 2011 to study the regulatory regime, felling and transit regulations for tree species grown on non-forest/private lands) recommended relaxation in transit and felling permission for the species preferred by farmers and agroforesters. Implementing this will encourage active participation of farmers and help in achieving 33 percent forest cover ensuring raw material to wood-based industries as well as environmental security. In November 2014, MoEFCC issued guidelines for liberalizing felling and transit regime for tree species grown on non-forest/ private land (Box 3).

BOX 3: Guidelines for liberalizing felling and transit regime for tree species grown on non-forest/ private land

These guidelines were issued by the Ministry of Environment, Forests and Climate Change in November 2014. The main points were:

- *Preferred tree and bamboo species under agroforestry by farmers and not naturally available in neighbouring forests are to be invariably exempted from the transit permit and felling rules.* An indicative list was enclosed, with freedom for State/UT Governments to include other species as required, based on their own local conditions. States were asked not to place any requirement of permission for felling of trees and transit permits in case of important timber species like Teak (*Tectona grandis*), Shisham (*Dalbergia sissoo*), Padauk (*Pterocarpus dalbergioides*) and pines etc. in the States and Union Territories where these species are not found in natural forests, but farmers and private land owners raise plantations of such species. The Revenue and other State Acts/ Regulations/ Rules which inhibit tree felling and free movement of timber need to be liberalized.

- *Preferred tree and bamboo species in areas where they are found in the neighbouring forests may be brought under limited restrictive provisions for felling and transit to safeguard trees from such forests.* The concerned Gram Sabha or equivalent institution at the village level, may be authorized to regulate felling and transit of trees/timber of these species grown under agro-farm forestry on private or communal lands. The Forest Department should issue permits based on the certificate of origin issued by authorized representative of such Committees of Gram Sabha/ JFMC.
- *The permission for felling and transit wherever required may be given in a time-bound manner and this provision should be well publicized.*
- *Facilitation of interstate movement and setting up of regional coordination mechanism.* Interstate movement of timber derived from agroforestry plantations or trees from non forest lands/private lands needs to be facilitated for benefitting tree growers to get best market price. Felling and transit permits may not be required for exempted species grown on non forest/private/ farm lands and logs/ timber/ pulpwood of these species. The produce/ timber obtained from non forestlands/private lands, which is to be transported from a State to other States may be covered under an appropriate mechanism through mutual consultation such as Nationally Valid Permit. There is an urgent need to move towards one simple and uniform nationally adopted transit permit system on electronic format.
- *Recording of agroforestry plantations.* Transparent and simple methodology for maintenance of records of tree plantation on private land needs to be worked out by the state government. Such records will help in de-centralizing issuing of transit permits and facilitate harvesting of trees. Registration of plantations should also be encouraged. All the records in

respect of planting of trees, felling and transit of timber may be placed on website or other such computerized public record system.

- *Preparing manuals on agroforestry in local and official languages of the States for public awareness.* Manuals/brochures on growing preferred tree species along with relevant information on procedure for harvesting, transporting and marketing in simple local language may be prepared and made available to farmers/people. The State Forest Departments should bring out a list of all the trees exempted from the requirements of felling and transit permission in the concerned State at the beginning of planting season for public information and publicise it through appropriate media.

Source: http://www.moef.nic.in/sites/default/files/Guidelines%20for%20felling%20and%20transit%20regulations%20for%20tree%20species%20grown%20on%20Non-forest%20or%20private%20lands%2018.11.2014.pdf. Accessed on 31 August 2017.

Quality planting stock and certification: Only 10% of quality planting material reaches the resource-poor remote regions. Quality assurance of genetically improved planting stock, particularly for long-rotation timber species is crucial for safeguarding the interest of farmers and industries.

The projected annual requirement of planting stock is 6160 million seedlings of different tree species and to fulfil this, research institutions, private organizations and forest departments must come together to establish good linkages among farmers for the production of planting material for 20 identified species in the National Agroforestry Policy. National and state-level research institutions, forest departments and universities should enter into a convergence mode to cater to the needs of superior planting stock. There is a challenge to develop a mechanism for certification of nurseries and planting material. A suitable mechanism for laboratory and nursery accreditation is to be developed. Agencies involved in certification services in the forestry sector in the country need to be learnt from. Well-evolved agroforestry systems can turn out to be self-sustained production systems wherein zero external inputs like fertilizers and pesticides are used. These kinds of agroforestry systems can also be subjected to organic farming certification at the national and international level to bring in additional income and incentives.

Financial and insurance sector: Farmers practicing tree-based farming are devoid of facilities of insurance and credit from financial institutions and an organized marketing structure. This is a major hurdle in boosting agroforestry among resource-poor farmers. The recommendations for tree insurance/credit cover mentioned in NAP will encourage involvement of farmers in expanding the area under agroforestry. To provide financial assistance to agroforestry farmers, bankable projects need to be formulated in agroforestry as in the case of agriculture and other allied subjects such as horticulture, animal husbandry, etc. A few tree insurance schemes are already operational (Box 4).

BOX 4: Examples of tree crop insurance schemes

'Agroforestry Plantation Insurance' by United India Insurance, Chennai, ensures financial protection against natural calamities (flood and cyclone), wild animal damage, and pest and disease for the species that are widely cultivated in the state, including casuarina, eucalyptus, *sissoo*, *G. arborea*, *M. dubia*, *A. excelsa* and subabul. Similarly, in Kerala, insurance scheme for coconut and rubber is in existence. For mature and immature plantations of rubber, compensation on account of natural calamities will be provided with replacement cost plus future returns of present value arising out of loss or death of the plant. Agricultural Insurance Company India Limited is providing biofuel tree/plant insurance for the species such as *Jatropha curcas, Pongamia pinnata, Azadirachta indica, Bassia latifolia, Callophyllum inophyllum and Simarouba glauca* at the premium cost of 125–150% of the input cost.

Source: Chavan et al. (2015)

Public private partnership (PPP) based model for expansion of agroforestry: Agroforestry has expanded in a big way wherever it has been supported by the private sector due to assured market for the growers. The private sector has established many successful agroforestry models like pulp and paper mills in Tamil Nadu (Tamil Nadu Newsprint Ltd), Andhra Pradesh (ITC Paper Board), Gujarat and Odisha (JK Paper Mills), Uttar Pradesh (West Coast Paper Mill); plywood industries in Haryana and Punjab (Yamunanagar) and Uttarakhand (Rudrapur); other wood-based industries (WIMCO Ltd) in the Indo-Gangetic region; gums and resins in Chhattisgarh, Jharkhand; tendu in Madhya Pradesh; cardamom in North East India and homegardens in Kerala are regional-specific models that have identified marketing linkages with farmers through contract farming. There is a need to develop strong linkages between different institutions and clients on the PPP model and ensure a complete value chain of agroforestry produce. PPP in development of agroforestry as envisaged in NAP 2014 has immense potential to provide opportunities in the production and supply of quality planting materials, land development activities, buy-back schemes of farm produce, research and extension activities, etc.

CASE STUDIES OF SUCCESSFUL AGROFORESTRY

Box 5: From subsistence farming to agroforestry and prosperity

"We have found our treasure in trees," declares Ramanathan, a 70-year-old farmer of Pudukottai district in Tamil Nadu. Farmers in his locality have found prosperity in agroforestry, the practice of growing trees and crops in farmlands, instead of just cultivating crops. Agreeing with Ramanathan, Jesuraj shows his rice field juxtaposed against a grove of coconut, banana and jackfruit trees.

Pudukottai is considered a dry area. In spite of being close to the Cauvery delta, and in spite of Pudukottai's Aranthangi taluk falling under the Cauvery delta, the district does not receive water from the river. Even as the delta farmers are financially distressed, reeling under a severe drought, the farmers in the southern taluks of Pudukottai district have not been affected. The farmers attribute their success to agroforestry, though they rely solely on deep borewells for irrigation.

Elderly farmers recall the *mummaari* days, when they had three rainy seasons in a year. The period that the monsoons became irregular was also the time bore wells were introduced. Many farmers recall that bore wells were first sunk in their region in 1972. Ramanathan recalls the initial days of euphoria. Suddenly there seemed to be plenty of water. Combined with the green revolution practices of using chemical fertilizers and pesticides, farmers enjoyed good farm income for the first time. However, their success was short-lived. After a decade, their expenditure on the farm inputs increased. Beyond a point, the yield not only did not increase but started decreasing.

Most of the farmers grew two crops. Those with more acreage grew more number of crops such as groundnut, pigeon pea, and black gram. Yet, it was limited to two cropping seasons and the farmers found it hard to make a living out of farming. The present shift to agroforestry seems to have happened by chance. Ramanathan was one of the first converts to agroforestry, followed by many villagers. An unplanned agroforestry system does not work. The trick is to have a tiered tree planting plan, according to Ramanathan, that is, plant a mix of saplings that will bear fruit in five years, 10 years and so on. "Teak can be used after 10 years, mahogany after 15 years. Include fruit trees such as mango, guava, gooseberry and pomegranate that will give an annual yield. And also follow inter-cropping and multi-cropping," he points out.

"When you plant, you leave a gap of 6 feet between tree saplings. For the next three years, before the saplings grow to full height, you can do inter-crop in the gap between the saplings. You can grow groundnut, sesame, pulses or vegetables like tomato and okra in the gap. You will be able to harvest a minimum of five inter-crops in three years". After the trees reach full height, shade-loving crops such as pepper are grown.

This systematic approach has worked well for the farmers. Parimalam, a diploma holder in electronic engineering, quit his job and got back to farming. He earns Rs 5 to Rs 6 lakh per year, way more than what his job paid. "I have eight acres. In one portion, I have red sanders, mahogany and teak trees. In another plot, I grow cashew, mango and banana, which give yearly income. In the rest of the area, I grow maize, black gram and the like, that are harvested after three or four months, depending on the crop," he adds.

Kaspar grows lemon, coconut and jackfruit, besides rice and vegetables. Sampath who grows coconut, neem and jackfruit in four acres says that jackfruit never fails to give good returns. "I have 200 jackfruit trees. Even if I lease it out for the minimum of Rs 1000 per tree, I get Rs 2 lakh," he adds. In addition to the trees, he grows sugarcane in three acres, maize and paddy in two acres each. As the soil in this region is suited for all types of crops, farmers grow a range of crops.

Chinnappa grows black gram, chilly, groundnut and vegetables, not only as inter-crops but also as stand-alone crops. Even small farmers who own three or four acres, divide the lands and grow trees and multiple crops. A group of farmers grows flowers such as jasmine, roses and sweet lilies that bring them daily income too.

In times of necessity, the farmers fell a tree and sell the timber or use it for themselves. “When I built a house, I found out that a single door frame cost Rs 50,000. I cut one jackfruit tree and made all the doors and windows with the wood,” says Sampath. The farmers are unable to quantify the difference agroforestry has made in monetary terms. But they show their new houses, personal and farm vehicles and their ability to send their wards to professional courses, as proof of their prosperity.

Source: `From subsistence farming to agroforestry and prosperity’, by Jency Samuel. May 5, 2017. https://www.villagesquare.in/2017/05/05/subsistence-farming-agroforestry-prosperity/ Accessed on 1 September 2017

Box 6: Wadi model: a livelihood programme

Wadi programme initiated by BAIF Development Research Foundation in south Gujarat in the 1980s, further expanded to different tribal regions of India. It is an agri-horti-silvi model spread over Maharashtra, Gujarat, Karnataka, Uttar Pradesh, Uttarakhand, Rajasthan, Madhya Pradesh, Chhattisgarh, Bihar, Andhra Pradesh and Jharkhand. For example, horticulture crops such as amla, mango (10 x 10 spacing), and cashew (7 x 7 spacing) with intercrops grown in these spaces and trees like *glyricidia*, subabul planted in closer spacing in the border in an area of 0.4–

1.0 ha. So far, BAIF has assisted over 1.81 lakh families to establish 68,586 ha wadi. This concept is a comprehensive programme for natural resource management; adoption of sustainable farming practices, and uplifts the rural communities providing livelihood security.

Women’s self-help groups (SHGS) set up in BAIF-Wadi projects are engaged in a diverse range of income-generation activities including: nurseries for mango grafts, and multi-purpose tree species saplings; backyard or Wadi plot cultivation of vegetables; manufacture of vermicompost; trading in foodgrains; making leaf cups; making papads; manufacture of brooms; fisheries; and group farming by taking land on lease. The main source of funds for these activities is the savings generated by SHG members themselves.

The story of Anita Jadhav, of Jadhavwadi, in Igatpuri tehsil of Nashik, Maharashtra, is illustrative. Her family owns 4 acres of rainfed land, which is cultivated only in the kharif season. The family had no other regular source of income. In 2003-04, she joined the Wadi programme, and started cultivation of guava in a 1-acre plot. Till the trees reached maturity, she grew tur, chana, and other pulses in the spaces between trees. Using improved agriculture practices promoted by BAIF-MITTRA, she earned annual net income of around Rs 5000.

In 2006-07, the guava trees bore first fruit, fetching net income of Rs 6000, followed by Rs 7000 at second fruiting (generally, guava trees produce fruits twice a year, in the rainy season, and in winter). In 2007-08, the income from first fruiting of guava was Rs 13,000. Anita used the money to buy a buffalo of `Mahuda' breed, which yielded 7 litres of milk a day. From the milk earnings, she bought a crossbred cow. In 2008-09, net income from sale of milk amounted to Rs 60,000, which was in addition to Rs 32,000 earned from sale of guavas. Thus, in a short span of 6 years, Anita's family rose above the below poverty line to nearly attain `lakhpati' status.

Source: Chavan et al. (2015); http://baifwadi.org/index.php/field-reports/98-livestock-income-through-wadi; and http://baifwadi.org/index.php/field-reports/96-income-generation-activities-of-women-shgs. Accessed on 1 September, 2017.

COMMUNITY FORESTRY ON COMMON LANDS

Definition of common lands: Commons or common pool resources are defined as resources accessible to the whole community of a village and to which no individual has exclusive property rights. In the dry regions of India, these include village pastures, community forests, wastelands, common threshing grounds, waste dumping places, watershed drainages, village ponds, tanks, rivers/rivulets and riverbeds (Jodha, 1986). Commons or common pool resources form critical components that supplement and support rural communities dependent on agriculture, livestock and forests in large parts of India, but especially the dryland and tribal areas. Access to the commons provides stability and security in an unpredictable environment, especially critical for landless households, but also important for large rural landowners (Nagendra et al., 2013).

Estimates of common lands: Estimates of common lands in India are based on the estimates of total land and land use. There are wide differences not only on the estimates of common lands but also on the estimates of total land area. The extent of common lands in India is estimated at 23.97 percent of the total land mass by the Department of Land Resources, Ministry of Rural Development (SAPPLPP, 2011).

Livelihoods from commons: A recent study documents the dependence of rural livelihoods on the commons. Conducted in seven states – Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Odisha – this comprehensive study spanned 3000 households in 100 villages in arid, semi-arid and sub-humid parts of the country. Dependence on the commons was very high, with 98% of households accessing the commons for different types of use, including for grazing, fodder collection, agriculture, food, fuelwood, and non-timber forest products. Dependence on forests and on community sources of water was especially high. Resources from the commons contributed to a substantial proportion of household income, about 31% of net income, for the landless (FES, 2010).

Traditional institutions for commons management: India has a long history of a variety of traditional and indigenous institutions for commons management, including van panchayats, gramya jungles and community forestry. Van panchayats are long-standing village forest institutions in Uttaranchal, with a documented history of existence over a century, that have been successful in many parts of the Kumaon hills in protection and sustainable management of village forests. Gramya jungles are village forest institutions recognized in the state of Odisha, consisting of village forest areas managed for communal and developmental purposes within the village boundary. Similarly, there are a variety of long-standing indigenous community institutions that have evolved locally to manage forests in different parts of the country, such as the Mundari Khuntkatti in Chotanagpur, indigenous Community Forest Management in Odisha and Maharashtra, sacred groves (Devara Kaadus and Gunda Thopus) in Karnataka, and similar institutions in many other states. In most instances these have been insufficiently recognized by formal administrative rights.

Decline of commons: Despite the important contribution of the commons to the rural livelihood complex, a significant decline in their extent and quality has been registered over a period of time. This decline has been recorded by several studies. The NSSO data of 1999 estimates a decline of 0.38 percent per annum in common pool resources at an all-India level. The qualitative and quantitative decline in the common pool resources has intensified the conflict over resource use, with the poor families usually at the losing end, either by denial of access to these resources mainly because of privatization of the common pool resources by a few, or by diversion of these resources to alternative uses (FES, op. cit.).

Large parts of common lands have either been encroached or allocated by the government as a welfare measure in the past few decades. The Report of the Committee on State Agrarian Relations and Unfinished Task of Land Reform constituted by the Department of Land Resources in 2009 said, "CPRs are threatened due to encroachments by resource-rich farmers. Over-exploitation of CPRs definitely leads to poor upkeep of these resources. This also points to the fact that traditional institutions have either weakened or disappeared and have failed to enforce norms. Also, Revenue Department control has never been interested in productivity, being too remote to manage and with lack of funds to develop it as their major role has been more of a record keeper rather than that of developer. The complex nature of land administration has only worked to the disadvantage of the rural poor" (cited in SAPPLPP, 2011).

CASE STUDIES OF REJUVENATION OF COMMONS:

Common land development in Rajasthan and Madhya Pradesh[4]

The work of two organizations, Foundation for Ecological Security (FES) and BAIF Development Foundation, on supporting rejuvenation of common lands in Rajasthan and Madhya Pradesh, show positive results in vegetation regeneration and fodder availability.

In the study locations, the commons constitute an average of 56 percent of the total geographical area in Rajasthan and 38 percent in Madhya Pradesh. The initiation of common land development across these villages involved two distinct processes. In the first, a stretch of common land was demarcated and tenurial rights given to the village institution. The facilitating organisation provided monetary support to the institution to regenerate the plot through fencing, seeding, plantation and soil and moisture conservation. The second process built on the evolving institutional arrangements and traditional practices so as to frame rules and regulations which restrict encroachments, tree felling and harmful lopping and also provide support to natural regeneration and protection of trees on other common lands in the village. In Rajasthan, three different land categories, viz. forestland, grazing land and revenue wasteland, were brought under institutional arrangements for commons development. In Madhya Pradesh, it was largely revenue wastelands.

The results of the interventions by FES and BAIF showed healthier vegetative composition on the regenerated commons as compared to the unprotected areas. The increase was visible across tree, shrub and grass coverage. The increase in the number of trees per ha on protected patches ranged from 100 to 350 trees per ha in Rajasthan as against 28 to 80 trees per ha where there had been no similar work. In case of Madhya Pradesh, the increase in number of trees per ha ranged between 100 and 120 trees in comparison to around 19 trees per ha on the ungoverned/ unprotected commons. The governed areas provided protection to natural rootstocks for regeneration, as also support to the natural process of seed germination – the success of these measures showing in the growing numbers of regenerating trees.

4 Based on FES et al., 2009

Acacia nilotica was widespread across the regenerated commons and was highly valued for its use as an animal feed as well as for timber and medicinal purposes. It serves as a major feed for animals, especially sheep and goats, in arid and semi-arid regions where there is a scarcity of feed and fodder. Besides, it is traditionally appreciated for its high nutritive value and for its beneficial impact on reproductive processes. The improved water availability through soil and water conservation measures also helped *Butea Monosperma* gain dominantly in the vegetative growth across most of the villages. Leaves of *Butea* are used to feed cattle and buffaloes and are traditionally accepted as boosters of milk production and fat content. Shrub density had also increased. They help arrest soil erosion and indirectly support biomass growth on the commons. With their low height, relatively tender stems and high foliage, they are an important feed and fodder resource for livestock. Grass cover and production per ha had also significantly increased. Grass on regenerated patches showed a greater diversity and higher palatability in comparison to that on the unprotected commons. More palatable species like *Apluda mutica, Heteropogon contortus, Cenchrus setigerus, Stylosanthes hamata, Iseilema laxum, Chloris barbata,* and *Cynodon dactyon* were replacing the earlier not-or-partially palatable species like *Aristida Spp., Tephrosia purpurea.* Thus a process of positive ecological succession could be seen in the watersheds/ study villages, with an increasing number of plant species dressing the denuded areas. In Rajasthan, an increase of almost 450 percent in the total availability of palatable fodder is seen in the regeneration patches. Villages in Madhya Pradesh also show similar trends, with an average increase of around 300 percent on regenerated patches. On an average, the total biomass on the regenerated commons came to around 62 tonne per ha in comparison to an average of 23 tonne per hectare on the non-regenerated commons.

In Rajasthan, the monetary values of biomass on regenerated commons ranged from Rs.18.6 thousand per ha to Rs.460 thousand per ha across villages. In comparison, the monetary values of biomass per hectare on non regenerated/ unprotected commons ranged from Rs.3.9 thousand to Rs.216 thousand per ha. In Madhya Pradesh, the estimated monetary value of biomass came to an average of Rs.59 thousand per ha on the protected commons while in comparison the values on non-regenerated commons came to around Rs.12 thousand per ha.

ANNEXURE 1

Rights conferred on communities, Gram Sabhas and individuals by the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

- Right to hold and live in forest land under individual or common occupation provided that
    - The land must be for the purpose of habitation or cultivation to provide for livelihoods needs
    - The land should be under occupation prior to 13 December 2005
    - The land claimed is restricted to the area under actual occupation
    - The land cannot be more than four hectares.
    - Community rights such as nistar (user rights) or those community rights used in erstwhile princely states of India
- Right to own, collect, use and dispose of minor forest produce which has been traditionally collected within or outside the village. Minor forest produce includes all NTFP of plant origin (including bamboo, brushwood, stumps, cane, honey, wax, tussar, cocoon, lac, tendu or kendu leaves, medicinal plants, herbs, roots, and tubers).
- Other community rights of use or entitlement, such as rights to fish and other products of water bodies, grazing or traditional seasonal access to natural resources by nomadic or pastoralist communities.
- Community tenure of habitat for particularly vulnerable tribal groups and pre-agricultural communities.
- Rights in or over lands under any categorisation in any State where there are any disputes regarding claims to such lands.
- Rights to convert leases or grants issued by any local authority or any State Government on forest lands to titles (ownership deeds).
- Rights to convert the following types of habitation into revenue villages: forest

villages, old habitations, unsurveyed villages and other villages in forests.

- Rights to protect, regenerate, conserve, or manage any community forest reserves which the individual or community has been traditionally protecting and conserving for sustainable use.
- Rights that are recognised under any of the following kinds of law: State laws, laws of any autonomous district council, rights of tribals as accepted under any traditional or customary law.
- Right of access to biodiversity, and community rights to intellectual property in traditional knowledge related to biodiversity and cultural diversity.
- Any other traditional rights enjoyed which are not mentioned above. However, this excludes the traditional right of hunting or trapping or extracting a part of the body from any species of wild animal.
- Rights to rehabilitation on the individual's or community's currently occupied land or alternative land, in cases where they have been illegally evicted or displaced from forest land without receiving their legal entitlement to rehabilitation.
- Rights to development facilities. The Central Government will use forest land to provide for the following facilities to be managed by the Government, and these lands and facilities will be exempted from the operation of the Forest Conservation Act: schools, dispensaries or hospitals, fair price shops, electric and telecommunication lines, tanks and other minor water bodies, drinking water supply and water pipelines, minor irrigation canals, water or rainwater harvesting structures, non-conventional sources of energy, skill up-gradation and vocational training centres, anganwadis (pre-school centres), roads, community centres. However, the use of forest land can be allowed only if the forest land to be used is less than one hectare in each case, not more than seventy-five trees are felled per hectare and the clearance of such developmental projects is recommended by the Gram Sabha.

Source: Kothari et. al. 2009

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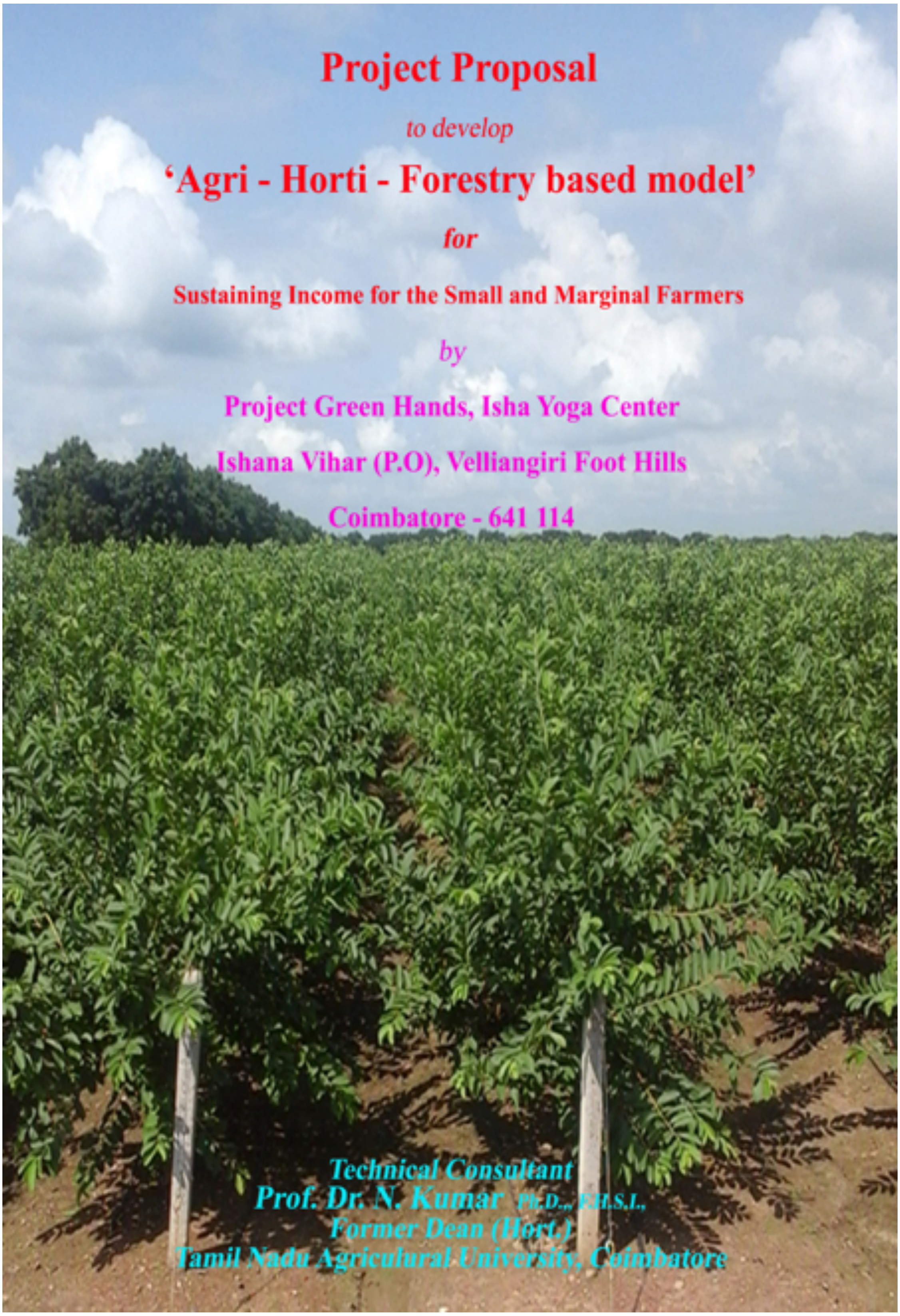
ANNEXURE 12



Project Proposal

to develop

'Agri - Horti - Forestry based model'

for

Sustaining Income for the Small and Marginal Farmers

by

Project Green Hands, Isha Yoga Center

Ishana Vihar (P.O), Velliangiri Foot Hills

Coimbatore - 641 114

Technical Consultant
Prof. Dr. N. Kumar *Ph.D., F.H.S.I.,*
Former Dean (Hort.)
Tamil Nadu Agricultural University, Coimbatore

PROJECT PROPOSAL TO DEVELOP 'AGRI-HORTI-FORESTRY BASED MODEL' FOR SUSTAINING INCOME FOR THE SMALL AND MARGINAL FARMERS.

1.BACKGROUND

Agriculture still supports the livelihood of more than 2.6 billion people in the world, living mostly in rural areas. In low-income countries of Africa and Asia, potential for non-farm employment is limited, viability of subsistence agriculture of smallholders is under stress, and inequity is widening. The extraordinary progress in food production in the past half century was also accompanied by unsustainable levels of consumption in some countries and hunger and malnutrition in some other countries, largely in South Asia and Africa, leading to poor health, reduced earning capacity and degradation of environment. The fast emerging phenomenon of climate change is putting more pressure on the natural resources we depend on, and the safe space for operation within the planetary boundaries of earth's resource system is shrinking. A profound change in the global food and agriculture system will have to be incorporated, if we are to feed today's 925 million hungry people, of which 230 million live in India. About 2 billion people are expected to be added to this category by 2050, mostly in developing countries, if corrective measures are not applied. On the brighter side, food security and sustainable agriculture are now on top of the global development agenda (UN, 2012). Sustainable agriculture is central to everlasting development and the judicious application of science and technology can help to achieve "zero hunger" goal even much before 2050.

AGRICULTURE SCENARIO IN INDIA

Currently, the agriculture sector in India contributes only about 13.7 per cent to the national GDP (compared to 30% in 1990), though agricultural production in 2013 was at all-time high of 264 million tonnes. High dependence on agriculture for livelihood support (more than 50% population) is the main factor responsible for the high share of poverty in rural population. The agricultural economy that grew at an average rate of 3.7 per cent per year during 2007-2012, is projected to grow annually at 4.0 per cent during 2012-2017, with growth in national GDP estimated at 8 per cent. However, it must be remembered that the GDP estimates do not take into account the costs of environmental degradation. According to Mr. Y.C.Deveshwar,the Chairman of ITC LTD, agriculture consumes around (90 %) of the country's renewable fresh water, a fifth of total electricity, and significant part of government subsidies.Yet, this sector contributes less than 15 % to GDP. It is therefore; not surprising that farmer's percapita income is less than one-fifth of country's average (The Hindu, 2017).

Further, agriculture places considerable load on environment in the process of production of goods and services. Further, India is predominantly small farm agriculture. According to 2010-11 Agriculture Census, the total number of operational holdings was 138.35 million with average size of 1.15 ha. Of the total holdings, 85 per cent are in marginal and small farm categories of less than 2 ha (GOI, 2014). These small farms, though operating only on 44 per cent of land under cultivation, are the main providers of food and nutritional security to the nation, but have limited access to technology, inputs, credit, capital and markets.

Climate change presents a major risk to longterm food security as it may have multidimensional debilitating effects on agriculture. The climatic impacts could lead to a dramatic scarcity of freshwater in the northern and peninsular regions of the country, fuelling the existing internal or interstate conflicts and heightening the competition among different users. Increasing seawater acidity and rising river water temperature will affect fish breeding, migration and harvest. Irrigated wheat and maize yields may decline by 5-10 per cent by 2050. Rain-fed agriculture, which covers 60 per cent of all the cultivated land in India, will be particularly hard hit. It would require technological innovations to make them adapt to climate extremes.

Declining/degrading land resource is another concern. India is a land-scarce country with only 0.13 ha land/cap (in 2010-11), which stands to get reduced to 0.09 ha/cap by 2050, simply due to increase in population. Further, land is getting polluted with toxic waste waters and there is a large-scale degradation due to water and air erosions. Besides, annually, India is losing 0.8 Mt of N, 1.8 Mt of P and 26.3 Mt of K. Growing nutrient deficiency and declining factor productivity are the matters of great concern. Overall, the land balance for India is negative, i.e. land classified as not suitable, is being made productive through human intervention and the most productive land is being lost to the urban and industrial sectors. Much of the remaining land suffers from constraints such as ecological fragility, low fertility, toxicity, and would require high input-use and management skills, and prohibitively high investments.

According to Government's Economic Survey, agricultural sector's consumption of renewable fresh water far surpasses the 60% level in Brazil and China, but the productivity of rice and wheat are lower than that of these countries indicating poor water use efficiency. Further, water scarcity and quality of water are assuming great challenges now as changes in the large-scale hydrological cycles due to climate change are the indicators of a fast emerging water-deficit country. Close to 50 per cent crop agriculture is likely to remain rainfed, further, natural water systems, on becoming hydro logically water deficit, will lose their dilution capacity, leading to a higher concentration of chemicals and other pollutants. These factors would create numerous water management challenges, in both rivers and groundwater across the country. Groundwater being a major source of irrigation, the inbuilt water and energy nexus will have a big impact on energy requirement. Most northern and peninsular regions are already water-stressed and, are fast becoming water-scarce, both physically and economically. This will further aggravate the existing internal or interstate conflicts besides heightening competition among different users. According to a study by the International Food Policy Research Institute, 45 per cent of the total GDP (US$ 63 trillion) will be at risk due to water stress by 2050.

Biodiversity of plants and livestock, which is so crucial for sustaining long-term productivity, is under threat. The rate of extinction is alarming, as only four crops provide about 60 per cent of global food, causing declines in genetic diversity among cultivated species. The genetically uniform systems are extremely vulnerable to external shocks under extreme weather conditions and emerging diseases and pathogens. Since 1900s, about 75 per cent of crop diversity has been lost from the farmers' fields. Similar is the case with livestock where the number of indigenous breeds with better adaptability, disease-resistance and feed-use efficiency is declining. Conservation and improvement of such breeds are to assume foremost importance.

DIVERSIFICATION OPTION

The agriculture development in the past has been means of food and raw material, which has to be seen now as means of employment- led economic goals, alleviation of poverty and self–reliance through its linkages and a multiplier effect. Globalization of agriculture has opened new opportunities and also the challenge of stiffer competition. The challenge thus, demands for adjustment of the structure of the economy to resonate with internal stipulation. To address the challenges in agriculture, diversification has emerged as the best option, to address nutritional adequacy, employment opportunities, farm income enhancement and use of natural resources. Among various options for diversification, horticulture has proved, beyond doubt, its potentiality for gainful diversification.(Chadha et al., 2013; Singh, 2014).Any developing economy need to take care of availability of food, nutritional security, sustainable livelihoods and health care for ensuring inclusive growth. In this scenario, horticulture has emerged as one of the most important sub-sectors of agriculture in the country making the onset of **'Golden Revolution'**(Dinesh,2017).

The role of horticulture in enhancing productivity of land, generating employment, value addition, improving economic conditions of the farmers and entrepreneurs, increasing exports and above all providing nutritional balance to the people has been well acknowledged. The sector includes a wide variety of crops under different groups such as fruits, vegetables, root and tuber crops, mushroom, floriculture, medicinal and aromatic plants, nuts, plantation crops including coconut and oil palm. The horticulture sector has emerged as a promising area for diversification in agriculture on account of high-income generation per unit of area, water and other farm inputs and environmental friendly production systems. Government of India accorded high priority for the development of this sector, particularly since the VIII Plan and beyond (Singh, 2014).

The impact has been visible in terms of increase in production and productivity of horticultural crops. Over the last decade, the area under horticulture grew by about 2.7 percent per annum and annual production increased by 7 percent. India has now emerged as world leader in the production of a variety of fruits like mango and banana and is the second largest producer of fruits and vegetables. Besides, India has maintained its dominance in the production of coconut, cashew-nut and a number of spices. Development trend of horticulture during the decade has proved, beyond doubt, that, horticulture is the best option for diversification of agriculture to address the issues of employment profitability and environmental concerns .Considering the predicted need for 660 MT of horticultural produce by 2050 in view of growing population as against the production of 240 MT in 2010-11 and the 300 MT during 2016-17(which is 4.8% higher as compared to the previous year's i.e. 2015-16 estimates) pose great challenge for all those who claim stake in agriculture particularly horticultural sector(Singh,2015) in the background shrinking land area , water scarcity , erratic and unpredictable rainfall pattern due to climate change, labour scarcity etc. Yet, the growing demand and market for horticultural produce coupled with good agribusiness opportunity for inputs like seeds, poultry material, equipment, green house designs and construction, irrigation, equipment and above all marketing information and marketing for produce and high value addition hold much promise.. This changed scenario is expected to improve the economy and profitability to become competitive. The economic importance of horticultural produce has been increasing over the years due to increasing domestic and international demand. Area, production, productivity, availability and export have increased manifolds. This has provided ample opportunities for utilization of waste lands, employment generation and effective land use planning. Diversification, recognized as one of the options for improving land use planning, has dramatic impact. Although climate change pose a threat to agriculture in general, horticulture based cropping system have potential for sequestering carbon for mitigation of climate change .The perennial trees act as carbon sinks by sequestering atmospheric carbon (Singh,2015).In the background of our government's aim to achieve doubling farmers income by 2020 also assumes greater role for horticulture sector as it generates more income than agriculture sector.

In this context, it is felt that under the **Isha Agro Movement Programme**, various Agri-Horti-Forestrey models are proposed at farmers' field level in tune with different agro –ecological situations of various states, with the sole idea of demonstrating generation of sustainable higher income per unit area, conserving soil health and environment, ultimately focusing environment –friendly livelihood.

2. OBJECTIVES OF THE PROJECT

a. To provide location specific multi-tier fruit crop model to the farmers so as to demonstrate their suitability and benefit under farmers' field conditions,

b. To guide the farmers on growing of different crops (Agri, Horti, Fodder and Forestry) in one unit area,

c. To document the soil health parameters (physical, chemical and biological) at periodic intervals, *nay*at yearly basis to monitor the soil health progress,

d. To document all input and labour costs*vis a vis* income from produce so as to arrive at final economics of the model to make more farmers to follow this useful crop model.

3. Characteristics of the proposed one acre Agri-Horticulture – Forestry Model

The one acre agri-horticulture forestry model has been developed with the following characteristics: These characteristics can be seen as "The carbon farming solution to global warming, the five tenets of carbon farming viz. No tillage,Organic mulch,natural compost formation,livestock inputs, cover crops" are the basic approaches of the model proposed. Besides, use of biofertilisers, bioinoculants and biocontrol/ biopesticides will be encouraged in this model to derive maximum benefit from eco-friendly farming based on scientific evidences accruing in use of these bioagents.

SCIENTIFIC BACKGROUND OF THIS MODEL

Although many literatures are available to support that various intercrops can be successfully grown in mango orchards, guava and amla orchards in their pre-bearing ages (Kumar, 2011, Kumar, 2013, Mehta and Singh.2005), no clear proven literature supporting our present model in mango based cropping system is available. However, well documented evidence of multi-tier system of cropping in coconut based orchard available at ICAR-CENTRAL PLNATATION CROPS

RESEARCH INSTITUTE (CPCRI), Kasargod, Kerala is taken as the base model to work out this current mango based cropping system. According to Choudappa *et al* 2016, CPCRI has developed coconut based cropping system aiming at crop diversification and intensive cropping in the interspaces available which is highly rewarding and is also with sustainability where production process is optimized through efficient utilization of inputs in safeguarding the environment. the results further indicated that multistorey cropping in coconut with cocoa/or tree spices like clove, nutmeg , other crops like pepper, pineapple ,banana , cinnamon etc resulted in increased yield of coconut nuts by 117-171 percent , besides providing additional income from the other crops , thus making the system more efficient and sustainable. Besides, further research in this model also proved to be more economic if fodder crops and tree crops like *Erythrina indica*, teak, *Acacia mangium* , *Ailanthus excelsa* are also included.

Similarly , research conducted at semi arid and arid region of Rajasthan by ICAR-Central Institute for Arid Horticulture, Bikenar, Rajasthan has confirmed that to mitigate the risk of total crop failure, suitable crop combinations involving perennial fruit crops like Amla+Ber or Khejri (fodder tree)+ Cluster bean + fennel or coriander are found sustainable and remunerative under arid system (Saroj, 2017).He also highlighted that the yield of intercrops was found higher under multiple cropping than under sole cropping besides the perennial fruit crops whose canopies are regularly maintained through pruning helps to improve the soil fertility through leaf litter fall, thus improving the physical , chemical and biological properties of the soil.

With this scientific background, the present **one acre Agri-Horticulture -Forestry model is** prepared and proposed.

MULTI-TIER FRUIT TREE SPECIES

- The multi-crop model proposed involves combination of various fruit crops like mango, guava, pomegranate, amla, ber, jamun, manila tamarind, bael and jackfruit etc.
- The combinations have been worked out taking into account the compatibility of the crops, especially the canopy of the crops which harness sunlight at

different height, roots foraging at different zones in the soil , bio diversity aspects, and economic aspects so as to achieve an early return on investment.

- Poly-culture fruit species have been chosen not only for complementary, but also to buffer the farmer on account of unexpected losses in any one species. This is an important aspect of providing income stability to the farmers.
- Another important aspect of multi-tier fruit crop is that it reduces/minimizes labour requirement during peak harvest time thereby reducing farmer's stress.
- Horticulture multi-tier fruit crops have been assumed to be taken in a way that is specific to the concerned agro-climatic region so as to maximize the solar insolation, thus increasing the yield capacity of the proposed model.

Multipurpose tree plantation on the east-west border for fruit, fodder, timber needs(Refer fig below)

- The multipurpose tree plantation on the east-west border acts as a wind break providing stability to the micro-climate in the fruit crop area and also enhancing the overall plant diversity. It also provides along term income insurance for the farmer through sale of timber.
- The fodder crop plantation on the boundary will fulfill the fodder requirement for the **livestock .**
- **Herbal and green leaf manure tree species on north**-south border, will be used for bio-input preparation and also provides additional green leaves / bio mulch.

Intercropping of banana, papaya, vegetable, chillies is for generating income in initial years

- These intercrops generate income during the initial few years when the horticulture crops are in gestation thereby offsetting the loss of income for farmers in the initial few years.
- The specific crops used should be selected based on water availability.
- These crops also add lot of biomass to the soil.

Model assumes use of drip irrigation

- Given the shortage of water *per se*, the model assumes use of drip irrigation so as to ensure maximum water-use efficiency.
- Drip system ensures increased productivity in all horticultural crops, minimum by 30 percent in view of maintaining optimum soil moisture with least stress.
- Ensuring more crops per drop through micro irrigation and moisture retention through mulching is one of the key features of this model.

Ensuring soil biodiversity and reducing soil erosion

- Soil bio-diversity is improved due to multiple rhizosphere of different fruit crops, and the presence of a variety of microorganism associated with the rhizosphere.
- Soil erosion is totally avoided by the non tillage, multi tier, multi-crop, and mulching model that has been proposed, resulting in better recharge of ground water, concomitantwith pollutant free,quality of runoff water.
- No tillage with good ground cover ensures increased soil beneficial bioflora , culminating in sustainable soil fertility.

Use of native livestock for additional income, and for preparing bio-inputs

- The proposed model involves usage of native livestock for input required towards cultivation which serves as additional source of income to farmer families.
- In this model, the bio inputs prepared like **Jeevamirtham, Ganajeevamirtham**, herbal pest repellents, herbal growth promoters etc., are to be prepared by the farmer using the livestock and from the plants in the border area.

Promote insect diversity

- Insect diversity is promoted to ensure that a natural and balanced population of insects is present.
- Unlike in monoculture, with poly-culture as proposed in this model, rapid multiplication of pest population, or dissemination of disease causing

pathogens is avoided.

- As we propose horticulture high density tree cropping system , the necessity for tillage is avoided(No tillage farming) and is also discouraged resulting in forest like situation providing better water holding capacity and humus formation.

The whole Agri-Horti-Forestry model envisaged,aims to simulate a forest like condition which is the recommended approach for greening of flood plains which may have potential for sequestering carbon for mitigation of climate change. The fixed asset value of the land in terms of soil fertility is ultimately improved for a future sustainable agriculture.

4.SPECIFIC EXAMPLE OF A MULTI-TIER FRUIT CROP MODEL:

4.1.(MANGO + GUAVA +POMEGRANATE CULTIVATION)

The schematic diagram of this proposed model is presented below:

1. All around the perimeter of the one acre farm, **6 m** width is allotted exclusively to raise multipurpose tree plantation on the east-west border and **Herbal and green leaf manure tree species on north**-south border besides fodder crop on all sides as ground cover. (Area to be covered =1416 m2.)
2. In the balance area i.e 4000-1368=2584 m2 , the following fruit crops will be maintained as indicated below :

Tier	Fruit crop	Variety*	Spacing (in feet)	No.of plants / ac**
First-tier	Mango	Banganapalli/ Alphonso/ Keser/ Langra/ Rumani/ Bangalora (Gorakh Singh, 2012)	36 x 36	24

Second -tier	Guava	Lucknow-49/ Arka Kiran/ Allahabad Safeda (Gorakh Singh, 2012)	18 x 9 (one row of guava (running east to west) in between two rows of mango and three guava trees in a line(running east to west) between two mango trees)	145
Third – tier	Pome-granate	Bhagawa (Gorakh Singh, 2012)	One row of pomegranate at 9 feet spacing inbetween every mango and guava lines.	200
	Banana	Grand Naine	Along the drip line at 9 feet spacing, one banana plant will be maintained for the first two years.	340 banana plants

**varietal selection is as per preference in the state/location*

*** 5-10 % variation in population may prevail depending upon the lay out of the field.*

Note :

- *As for as possible, separate line is provided for mango, guava and pomegranate as each fruit kind's stress period before flower induction, flowering period and water requirement varies.*
- *This calls for laying separate valve operating system while laying out the drip system.*

In one acre, about 24 mango trees, 145 guava trees, and 200 pomegranate plants could be accommodated leading to 369 fruit trees as the main crops , however , there may be + or – of 5-10 % variation in population depending upon the lay out of the field used .Thespacing for each of the three species is worked out based on the canopy and root spread as indicated below:

S.No	Crop	Canopy spread	Root spread	Remarks
1	Mango	Restricted to Maximum of 9 feet radius only	80 % of active roots are restricted between 5-6 feet from the trunk and capable of sending effective roots upto 4 feet deep. (Pareek *et al* 1993;Kumar,2013)	Formative Training in the initial 1-3 years and annual pruning after harvest is required to restrict the spread of the canopy besides maintaining the height in manageable size to facilitate easy harvest (Kumar,2013).
2	Guava	Restricted to maximum of 5 feet radius only	80 % of active roots are restricted between 2-4 feet from the trunk and capable of sending effective roots upto one foot deep only. (Pareek *et al* 1993)	Formative Training in the initial 1-2 years and regular pruning twice in a year after harvest is required to restrict the spread of the canopy besides maintaining the height in manageable size to facilitate easy harvest. (Kumar,2013;Rajan *et al.*,2017)

3	Pomegranate	Restricted to maximum of 4 feet radius only	80 % of active roots are restricted between 1.5 to 2.0 feet from the trunk and capable of sending effective roots upto one 1.5 feet deep only.	Formative Training in the initial 1-2 years and regular pruning twice in a year after harvest is required to restrict the spread of the canopy besides maintaining the height in manageable size to facilitate easy harvest(Anon,2017)
4	Banana	Does only filtered shade .	80 % of active roots are restricted between 1.5-2.0 feet from the pseudo stem and depth upto 1.5 feet only(Lahava and Turner, 1983)	Adds lot of biomass to the soil which are richer sources of N and K nutrients(Lahava and Turner, 1983 ; Nalina *et al* 2000a and 2000b)

Along the border, in the east-west direction as alley crop, two rows of trees consisting of 14 jamun/jack fruit trees and 70 native and endemic multi-purpose timber trees are planted. Along the border in the north-south direction herbal and mulch plants are planted and maintained as shrubs for mulch and bio-input needs. See schematic diagram that follows on the next page.

4.2. (MANGO + AMLA+GUAVA CULTIVATION)

The schematic diagram of this proposed model is presented below:

- All around the perimeter of the one acre farm, 6 m width is allotted exclusively to raise multipurpose tree plantation on the east-west border and **Herbal and green leaf manure tree species on north**-south border besides fodder crop on all sides as ground cover. (Area to be covered =1416 m2.)
- In the balance area i.e 4000-1368=2584 m2 , the following fruit crops will be maintained as indicated below :

Tier	Fruit crop	Variety*	Spacing (in feet)	No.of plants / ac**
First-tier	Mango	Banganapalli/ Alphonso/ Keser/ Langra/ Rumani/ Bangalora	36 x 36	24
Second-tier	Amla	Kanchan, Krishna, Na-7, Chakiya (Gorakh Singh, 2012)	18 x 18 (one row of amla line spaced at 18 feet running South to North in between two rows of mango and one more amla plant in betweenany two mango trees running South to North)	60
Third –tier	Guava	Lucknow-49/ Lalit/Allahabad Safeda	One row of guava at 9 feet spacing in between one row of amla and Mango running South to North and guava is spaced at 9 feet in each line (9 x 9 feet)	170

	Banana	Grand Naine	Along the drip line at 9 feet spacing, one banana plant will be maintained for the first two years.	340 banana plants

*varietal selection is as per preference in the state/location

** 5-10 % variation in population may prevail depending upon the lay out of the field.

In one acre, about 24 mango trees, amla 60 trees and 170 guava trees could be accommodated leading to 254 fruit trees as the main crops , however , there may be + or – of 5-10% variation in population may prevail depending upon the lay out of the field used . The spacing for each of the three species is worked out based on the canopy and root spread.

S.No	Crop	Canopy spread	Root spread	Remarks
1	Mango	Restricted to Maximum of 9 feet radius only	80 % of active roots are restricted between 5-6 feet from the trunk and capable of sending effective roots upto 4 feet deep.	Formative Training in the initial 1-3 years and annual pruning after harvest is required to restrict the spread of the canopy besides maintaining the height in manageable size to facilitate easy harvest.
2	Amla	Restricted to Maximum of 6 feet radius only, smaller size leaves and deciduous nature of leaves cast lesser shade	Deep rooted and horizontal active roots restricted to 4 feet only (Ramesh,2005).	Annual pruning of indeterminate shoots to 50 % of its length to restrict the spread of the canopy (Jadav and Khimani,2005).

3	Guava	Restricted to maximum of 5 feet radius only	80 % of active roots are restricted between 2-4 feet from the trunk and capable of sending effective roots upto one foot deep only.	Formative Training in the initial 1-2 years and regular pruning twice in a year after harvest is required to restrict the spread of the canopy besides maintaining the height in manageable size to facilitate easy harvest.
4	Banana	Does only filtered shade .	80 % of active roots arerestricted between 1.5-2.0 feet from the pseudo stem and depth upto 1.5 feet only.	Adds lot of biomass to the soil which are richer sources of N and K nutrients.

5. INTERCROPPING IN ABOVE FRUIT MODEL

As the gestation period for fruit crops is more than 4 years, 2 years and one year respectively for Mango, Guava and Pomegranate, it is advised to go for inter-crops like banana, papaya and vegetables .

Major fruit crops suggested in the model

As the entire system of irrigation to be followed is drip, it is better we go for banana for initially two years along the drip line in between any two pomegranate or guava at a spacing of 9 feet. The additional expenditure and income obtained are given in (b-1). Vegetable is not recommended as too many drippers are to be made in each line which will affect the life of the drip system.However, during rainy months, leguminous vegetables can be grown as rainfed crops which are not included in calculating the income. Growing of banana is good as it leaves lot of biomass which contains > 3.0 % of potash which is good for all our fruit crops (Lahava and Turner, 1983; Nalina *et al.*, 2000a and 2000b).

6. PACKAGES OF PRACTICES TO BE FOLLOWED

In this model, scientific based package of practices suggested by the ICAR – research institutes and State Agricultural Universities are blended in such away the farmers will get good yield at the same time the soil fertility is also protected for sustaining the land for future generation. The use of drip system of irrigation is also made mandate in this model in view of its multi-fold benefits. The packages of practices to be followed for the fruit crops handled in these models are appended vide Annexure –I.

7. ECONOMICS OF THE ONE ACRE MODEL

If this proposed model were to be implemented, the governments should be willing to bear the short term cost of livelihood loss for farmers. Also scale and the pace of the scale up required for the project can only be taken up by state machinery. The major bottleneck of the project will be the willingness and ability of cash crop riverside farmers to convert to horticulture farmers. Most of the farmers who are small and marginal in India do not have the ability to absorb the risk of such transition. The government therefore should be ready to provide a livelihood subsidy or loan to the farmer for the initial years of gestation of the fruit trees.

In case of the inorganic fruit model the total quantum of investment required over three years for the entire set of two million odd farmers on the 20,000 kilometre river length would be Rs. 33,000 crores over the entire three year period of gestation (assuming Rs.75k, Rs. 74k, and Rs. 15k required in year 1,2,3 respectively for a given farmer). For the organic fruit model the total government outlay would be lower at Rs.26,000 crores (assuming Rs.75k, Rs.55k required in the first two years for a given farmer). This investment could be made as a subsidy or as a long-term loan to the farmer to be repaid. Either way this government investment seems highly desirable given the enormously strong payback in terms of saving our rivers, substantially reducing carbon footprint, ensuring significant forest cover gains, large scale promotion of personal health, or even in terms of looking at this as a financial investment for society with a strong internal rate of return.

7.1 COSTS/ RETURN ANALYSIS OF THE MULTI-FRUIT CROP MODEL (ANNEXURE IV):

The cost economics of the model is based on incurring a cost of Rs.1.5-2.0 lakhs initially in the first year. And in the second year varying from 1.8 -2.0 lakhs, however, the intercrop provides a net revenue of about Rs.6k in the second year itself. Subsequently in the third year the maintenance cost would be Rs.70000 to 80,000 in both the models.The most significant feature of this model is on an average the farmers are able to get **Rs.1.33 to Rs. 1.50 Lakhs per annum** as against Rs.17,000 per annum in pure crop model of growing mango(P-1 and P-2). Besides, in multi crop model, the break even starts at 2nd year itself in the case of Mango-guava and pomegranate model and from 6th year itself in Mango+Amla and Guava model as against only in the 8th **year** in pure crop fruit model.The details are shown in the table.(mpg-1, mpg-2, mag-1 and mag-2).

It is assumed that in line with current government practice all the establishment costs will be funded by the government. The ongoing maintenance costs will be funded by the farmer himself.

Break up of Costs	With Drip
Establishment cost (1st year) Sapling cost, planting materials for fodder trees, ploughing, mulch crop, pit making, seed preparation, drip installation, labour cost	Rs.1.5-2.0 lakhs
Maintenance costs per year : (2nd Year) Weed management through power tiller ,Jeevamirtham, Growth promoter, Supplemental mulching	Rs.18-2.0 lakhs (since banana is grown)
Maintenance costs per year: (After 3 years with increased labour costs) Pruning, Jeevamirtham, Plant protection spray, harvesting, additional labour, weed management	Rs.70000-80,000

7.2 FARMER EARNINGS VIA THE MULTI FRUIT-CROP MODEL

In the base earning model for the farmer we have assumed that the horticulture produce is of the normal inorganic kind, and not of the organic kind. Given that, the resultant earnings ofthe farmer would become Rs.1.8 lakhs per annum by year 5, and about Rs.5.0 lakhs per annum by year 10. *(See detailed calculations inmpg-2)*. This earning is more than the current farmer income of Rs.0.09 lakhs per annumwhen he grows pure mango crop in the first ten years period. In addition there will be earnings from the sale of timber in the long run after 15 years – that has not been accounted for in the earnings model. There will also be some regular earnings from fodder which also has not been accounted for.The earnings from possible intercropping in the first few years is also not included.

The indirect benefits such as enhancement of soil fertility, recharging of ground water, improvement in microclimate, lesser spread in pests and diseases out-break and lesser risk due to fluctuation of prices of produce etc are also to be weighed positively in this multi fruit –crop model.

7.3 COMPARISON OF MULTI-FRUIT CROP EARNING MODEL WITH SINGLE CROP MODEL

It is pertinent to compare the enhanced earnings that result from using a multi-crop model of mango + guava + pomegranate, or as mango + guava + amla , compared to say mango itself. With just one crop (mango), though the income start accruing from 4th year onwards, break even starts only in 9th year but in multi crop model , the break even starts early (5th year to 7th year itlelf depending on the model) .The advantage of mango + guava + amla model is its long economic period *vis a vis* mango + guava + pomegranate model wherein after 10th year or 15th year , pomegranate plantation may require replanting or rejuvenation due to build up of soil biotic factors causing pomegranate to decline.. Hence,both the models are practical, depending upon the situation and economic background of the farmers, suitable model can be adopted.

7.4. COMPARISON OF MULTI--FRUIT CROP EARNING MODEL WITH FIELD CROPS

According to the Centre for Agricultural and Rural Development Studies,Tamil Nadu Agricultural University, Coimbatore, in the riverside based field, the crops like paddy, sugarcane and banana are generally grown but the annual income realised by the growers per acre in these crops stand around, Rs.50,000(2 crops / year) , Rs.65,000 and Rs.85,000 respectively (Annexure –II) .However, in the fruit based multi-crop model, the average net income per year is Rs. Rs1.50-1.54 Lakhs per annum which is nearly double to that of field crops. This kind of model thus meets the government’s aim of doubling the Farmers income. The benefits of multi-crop model in sustaining the fertility of the soil are tremendous as against the field crop which is known to mine the mineral nutrients greatly.By following these models , it is likely that farmers in come may be sometimes actually higher than what it is predicted, as a conservative approach is made in calculating the yield and the income based on prevailing farm gate prices etc.(Annexure-III).

7.5. HANDLING THE ISSUE OF LONG GESTATION: FARMER NEEDS A LIVELIHOOD SUBSIDY/LOAN

The challenge in the economic model is that the earnings of the farmer for the first few years of conversion are below the threshold of their current earning of Rs.75k per annum. The fact is that not many farmers will have the savings to fund this upfront cash outlay. This would slow down the implementation of the program because only a small percentage of the farmers will be able to fund their livelihoods for the initial three year gestation before income rise above their current earning threshold.

To tackle this, we are recommending that the government compensate the nominal temporary loss of livelihood. We have assumed that the farmer must have an annual surplus at least similar to their current average earnings of Rs74988. With this assumption the additional government cost per farmer would be Rs.75k in the first year, Rs. 74k in the second year, and Rs.15k in the third year

One of the very strong cases for justification of compensation of nominal loss for farmer income is the eco-system services that rivers and the trees on the floodplains of the rivers will provide. In the case of Uttarakhand which is the origin for many rivers that flow into the northern plains has had many evolved conversations on a system where the national government pays an eco-system service tax towards the services provided by these rivers. If a clear economic number could be calculated with most recent Net Present Value of the service provided by the rivers, the states can levy such taxes on the users and use that to fund the compensation for farmers.

As the government even if one were to look at the internal rate of return on these costs for society as a whole, then the societal return on this investment is a handsome 41% per annum. The temporary livelihood subsidy for the first three years thus represents a very effective way of redistributing wealth in society in favour of the poor.

There is also the alternative of not providing a livelihood subsidy but providing a livelihood loan which the farmer returns after five years in three annual tranches. This would reduce the effective cost of the program to the government but would entail significant additional complexity in terms of creating the on-ground capability to recover funds after five years.

8. ISSUES RELATED TO ORGANIC CULTIVATION

There is a substantial additional benefit of getting the farmer to move from inorganic to organic cultivation of fruits. This is because the sale price realization of organic crops is about 50 % more than the inorganic versions, mostly in metro politic cities..The awareness of consumers to pay on discriminative prices for organic products vs. inorganic ones is totally lacking in many parts of India. This problem requires creation of awareness on the benefit of organic produces among the consumers. According to the Organic Farming Policy 2005 of Ministry of Agriculture, Department of Agriculture & Cooperation, it is very important to rationalize the importance of domestic market development. Efforts should be made to develop organic Bazaar as a local marketing programme which will provide assured organic products, fair prices for producers and consumers and opportunities for new relationship between producers and consumers. Simultaneously, the product of organic producer will be linked with Agri Export Zone. The existing certification system is alien to the Indian farmers. The procedure needs to be simplified. Approach should be made to develop 'Participator Guarantee System' for domestic certification purpose where there will be interactive participation of small farmers, enterprises, traders and consumers. This implies a greater support is required from Government to encourage these farmers who are converting to multi-tier fruit crop model under organic systemof cultivation.

Based on this, if one takes the base multi-crop pattern of mango + guava + pomegranate the cumulative income surpasses cumulative cost at second year itself and nearly 2 lakhs per year is obtainable as net income from 6th year which may even attain 5 lakhs by 10th year. On the other hand, under the normal conventional pure mango growing system, break even obtained only at 8th year and possible net profit thereafter is only 2 laks at 10th year. So it is evident that moving to organic fruit crops is hugely beneficial to the farmer in the long-term. It is also pertinent to note that in the case of organic multi-crops it is likely that the livelihood subsidy that the government would need to provide would come down in both quantum and duration. We would probably need a subsidy for only two years and not three. And the quantum would also come down substantially for the second year - needing about Rs. 75k in year one as in the inorganic fruit scenario, but much lower in the second year at Rs. 55k as compared to the inorganic fruit scenario.

9. THE ROLE OF SUPPLY OF QUALITY PLANTING MATERIALS IN THESE HORTICULTURE CROPS

Availability of genetically superior, true to type quality planting materials in large number or in required quantity is the basis for successful establishment of good orchard system. But in practice, the farmers are confronted with many problems in sourcing the quality planting materials of horticultural crops.Inadequate availability of quality planting material is one of the important deterring factors in development of sound horticulture industry. It is of special significance especially in perennial horticultural crops which has a long gestation period and effects are known only in later stages. In the existing infrastructure, there are just over 100 big nurseries. A number of State Government nurseries also exist in different states but in many places they are under utilized or used to produce only local and traditional varieties in the absence of mother plants of improved cultivars. Planting material is also being produced by the ICAR institutes and different SAUs which are hardly sufficient to meet the every year requirement. Private nurseries also play important role to meet the requirement of the growers and at present the number of small and medium scale nurseries is over 6300. All these agencies are presently producing only 30-40% demand of planting material using the existing infrastructures.

Thus, the farmers do not have access to good quality certified disease free planting material of true to type varieties as a result of which production, productivity and quality of the of produce suffers heavily. At present, most of the dependence is on the unregulated private sector nurseries in most of the states which lacks modern infrastructure such as green house, mist chamber, efficient nursery tools and gadgets, implements and machinery. There are several constraints in the existing system of plant propagation. There are several private nurseries operating in the country playing important role in multiplication of planting material of horticulture crops and many of them follow traditional methods and lack adequate infrastructure and sell plant material of unknown pedigree. Of many other constraints, un-availability of standardized root stocks and non- maintenance of healthy stocks of elite varieties are worth mentioning. It is of special significance especially in perennial horticultural crops which has a long gestation period and effects are known only in later stages.

The Working Group on Horticulture and Plantation Crops for the Eleventh Five Year Plan has projected the total requirement of planting materials of fruits, coconut, cashew, black paper, tree spices, areca-nut etc. as 2000 million by the year 2012 at a modest growth rate of 4% per annum. In the segment of fruit crops alone, the projected demand for the planting material would be 7,145,851 by the year 2007-08; which may increase to 8,359,632 by the year 2011-12. Supply of such a huge quantity of disease free, true to type quality planting material is a big challenge and needs to be addressed at the right time.

The Seeds Act and the Nursery Registration Act have been in operation since December 1966. However, as reported by the said Working Group, the Nursery Registration Act is presently in force in respect of horticulture nurseries only in the States of Punjab, Maharashtra, Himachal Pradesh, Uttar Pradesh, Uttrakhand, Jammu and Kashmir, Orissa and Tamil Nadu. Some system of registering/ monitoring exists for horticulture nurseries in the States of Andhra Pradesh, Assam, Bihar, Goa, Haryana, Karnataka, Kerala while there is no horticulture nursery act in the States of Arunachal Pradesh, Chattisgarh, Jharkhand, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Tripura and West Bengal. In the absence of any formal system of quality assurance for horticulture planting material, it is not feasible to put any kind of quality control related restrictions on horticulture nurseries which do not have adequate production-related infrastructure and pedigreed mother plants.


Quality Mango graft from a reputed nursery

Under this situation, the National Horticulture Mission has taken initiative to specify Nursery Standards by specifying Infrastructure required for setting up of Model Horticulture Nursery etc. With a view to ensure availability of Good quality planting material, National Horticulture Board(NHB) of Ministry of Agriculture (GOI) has started a system of Recognition of Horticulture Nurseries on voluntary basis(Sharma and Singh,2016) since 2009-10.Under this scheme, so far 1413 nurseries have been accredited till 2015-16 and these nurseries are expected to renew their accreditation once in two years.This accreditation system encourages healthy competition between recognized nurseries to retain the accreditation *vis a vis* production and supply of quality planting materials. This system would definitely help to ensure the availability of quality planting materials in horticulture crops. Still, farmers are to be suitably educated on the need to procure only the quality planting material from these recognized nurseries only besides the State Governments should also strictly enforce these standards by suitably modifying their State Seed Acts on supplying quality Planting materials.

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ANNEXURE 12

ANNEXURE -I
PACKAGES OF PRACTICES OF SELECTED FRUIT CROPS

1.MANGO

VARIETIES

The leading commercial varieties of the state.

SOIL AND CLIMATE

Ideal soil for mango is red loamy. Good drainage is preferable for better establishment. Ideal pH range is from 6.5 to 8.0.

SEASON OF PLANTING

Planting spreads from July to December.

PLANTING MATERIAL

Soft Wood Grafts cured and kept in the nursery for 3-4 months with 45 cm height are used for planting.

FIELD PREPARATION

Dig pits of 1 m x 1 m x 1 m. Fill in with topsoil mixed with 10 kg of FYM

SPACING

Adopt any one of the following spacing depending on requirements.

- Under conventional system of planting: 7-10 m either way
- High Density Planting : 5m x 5 m (400 plants /ha)

PLANTING

Grafts are planted in the centre of pit with ball of earth intact followed by watering and staking.

The graft union must be 15 cm above the ground level.

IRRIGATION

Regular watering is recommended till establishment. Under micro-irrigation the requirement is restricted to one-third of the water required for conventional method. Hence, adopt Drip irrigation system with 2 drippers per plant delivering 4 litres per dripper per hour. Avoid irrigation for 30 days for induction of stress before flowering season; resume as soon as flowering commences.

INTERCROPPING

Short duration crops like legumes, vegetables, groundnut etc. can be raised during pre- bearing age.

MANURES AND FERTILIZERS (KG PER TREE)

Manures and Bio-Fertilizers	1st Year	Annual increase	6th year onwards
FYM/ well decom-posed Compost	10.00	10.00	50
Any oil cake	1.0 kg	1.0 kg	5.0 kg
Azospirillum	50 g	50 g	250 g
Phosphobacteria	50 g	50 g	250 g
Potash Solubilising Bacteria	25 g	25 g	100g
VAM	50 g	50 g	250 g
Patent Kali /SOP 3-4 % Foliar spray	2 times in a year	3-4 times in a year	4 times in a year especially 3 sprays during Fruit setting to fruit Development phase. (Kumare-tal2006)

The manures may be applied in two equal splits, first during June and second dose during October. Manures are applied 45 to 90 cm away from the trunk upto the peripheral leaf drip and incorporated.

The leaf droppings may be sweeped and incorporated into the trenches meant for applying manures and sprinkled with Microbial culures containing Bacillus, Psuedomonas etc (Decomin) @ 1.0 kg per tone of the leaf material to hasten decomposition.

CANOPY MANAGEMENT

- Remove root stock sprouts and low lying branches nearer to ground to facilitate easy cultural operations.
- Remove overlapping, intercrossing, diseased, dried and weak branches in old trees to get good sunlight and aeration.
- Carry out judicious pruning of the internal branches during August – September, once in three years.
- Do not allow flowering up to three years by removing the inflorescences as and when they appear.
- Retain two healthy shoots by trimming away the weak shoots among the crowded terminal shoots during August-September annually.
- Prune back 20 cm of annual growth of the terminals immediately after harvest.
- Irrigate the field immediately after pruning to hasten buds to sprout.

PLANT PROTECTION

- **Pests- sucking pests like Hopper, Leaf galls and Aphids, Mealy bug.**
  - To control these, spray Neem oil or neem kernel extract , followed by spraying with Biocontrol agents like Verticillium lecanii - 0.5 - 1.0 %, which affects all stages of these pests.
- **Nut Weevil** and Stem borer : spray Metarhizium anisopliae - 0.5 - 1.0 % which affects all stages of these pests.
- **Anthracnose and powdery mildew** : Spray *Psuedomonas fluorescence* @ 0.5 -1.0 % 4-5 times starting from August –September itself at 30-45 days interval.
- **Fruit fly-** Use Pheromone traps @ 4-5 per acre during the Fruit development phase
- **Sooty mould-** Maida 5% (1 kg Maida or starch) boiled with 1 lit of water and diluted to 20 litres will control the incidence of sooty mould. Avoid spraying during cloudy weather

2.BANANA

VARIETIES

Grand Naine, Rasthali, , Nendran, , Karpooravalli, Neypoovan

SOIL AND CLIMATE

Well drained loamy soils are suitable for banana cultivation. Alkaline and saline soils should be avoided.

SEASON OF PLANTING

If irrigation is available, it can be planted throughout the year, but avoid extreme hot summer or cold winters.

SELECTION AND PRE-TREATMENT OF SUCKERS

Select sword suckers of 1.5 to 2.0 kg weight which are free from diseases and nematodes. Trim the roots and decayed portion of the corm, cut the pseudostem leaving 20 cm from the corm and grade the suckers to size. Suckers are to be treated with cowdung, urine and bacterial cultures like Azatobacter and Phosphate Solubilising Bacteria.

If tissue culture plants are available, then the plants should be 25-30 cm tall with a minimum of 4-5 green leaves, having conical stem with firm anchorage and 3 months of hardening stage.

LAND PREPARATION

Before planting, green manure crop is advocated. FYM @ 30 t/ac should be applied with green manure crop . FYM should be treated with Trichoderma viridie@ 1.0 kg per Ton of FYM.

PLANTING DENSITY

Generally a spacing of 2 m x 2 m is recommended for the above varieties.

IRRIGATION

Irrigate immediately after planting; give life irrigation after 4 days; subsequent irrigations are to be given once in a week for garden land bananas. Irrigate the fields copiously after every manure application. Use drip irrigation @ 5-10 litres/

plant/day from planting to 4th month, 10-15 litres/plant/day from 5th to shooting and 15-20 litres /plant/day from shooting to till 15 days prior to harvest.

APPLICATION OF MANURES

Banana is nutrient demanding crop. Hence, the following organic manure has to be applied at 3,5 and 7 th month after planting.

S.No	Organic Manure	Quantity per plant (kg)
1	Compost	2.5
2	Vermicompost	1.0
3	Poultry manure	2.5
4	Neem cake	1.0
5	Azospirillum	20 g
6	Phosphobacterium	20 g
7	Trichoderma viride	20 g

As it is a potash demanding crop, spray Penta-kali or SOP @ 2-3 % starting from 3^{rd} month after planting till fruit maturity (Ramesh Kumar etal 2006).

AFTER CULTIVATION

- Digging at monthly intervals and earthing up of soil will facilitate better establishment of plants.
- Desuckering should be done at monthly intervals
- The dry and diseased leaves are removed and burnt to control the spread of leaf spot diseases.
- Male flowers may be removed a week after opening of last hand
- Cover the bunch with banana leaves to avoid sunscald.

PLANT PROTECTION

Stem weevil (*Odoiporus longicollis*)- Remove dried leaves periodically and keep the plantation clean. Prune the suckers every month

Infected trees should be uprooted, chopped into pieces and burnt. Spray Metarhizium anisopliae - 0.5 - 1.0 % which affects all stages of these pests.

Banana Aphids and Thrips- control these, spray Neem oil or neem kernel extract , followed by spraying with Biocontrol agents like Verticillium lecanii - 0.5 - 1.0 %, which affects all stages of these pests.

FUSARIUM WILT MANAGEMENT

- Removal of infected trees and application of lime @1-2 Kg/pit.
- Capsule application of Psuedomonas .fluoroscens @ 60 mg/capsule/tree on 2nd, 4th and 6th month after planting. The capsule is applied in the corm by making a hole of 10 cm depth at 45°.

Leaf spot diseases –spray Psuedomonas fluorescens @ 0.5-1.0 % at monthly intervals.

3.GUAVA (*Psidium guajava* L.)

Myrtaceae

VARIETIES

AllahabadSafeda, Lucknow 49, Arka Kiran and Lalit are the suitable varieties for cultivation.

SOIL AND CLIMATE

Guava grows well both in wet and dry regions but it does better under irrigation in the dry tracts. It can be grown upto 1000 m altitude. Well drained soils are the best suited for guava cultivation. It can tolerate salinity and alkalinity. In saline soils add 3 Kg Gypsum/plant during planting and once in three years after planting to overcome the problem.

PLANTING MATERIAL

Grafted materials are to be used as planting material.

SEASON OF PLANTING

The planting is distributed from June - December.

SPACING

A spacing 5 - 6m in either way is generally followed. But for High density planting, the spacing varies from 3 x 6 m to as close as 3 x 2 m.

PLANTING

Plant the grafts with the ball of earth in the centre of pit of 45 cm x 45 cm x 45 cm size filled with FYM 10 Kg , neem cake 1 Kg and top soil.

IRRIGATION

Irrigate copiously immediately after planting, again on third day and afterwards once in 10 days or as and when necessary. Drip irrigation is recommended to get good crop .

MANURES AND BIO-FERTILIZERS

Inputs	1st Year/tree	Annual increase/tree	6th Year onwards/tree
FYM/ well decomposed Compost	5 kg	5 kg	25 kg
Any oil cake	1.0 kg	1.0 kg	5.0 kg
Azospirillum	25 g	25 g	125 g
Phosphobacteria	25 g	25 g	125 g
Potash Solubilising Bacteria	25 g	25g	100 g
VAM	25 g	25 g	125 g
Patent Kali /SOP 3-4 % Foliar spray	2 times in a year	2-3-times in a year	3-4 times in a year

AFTER CULTIVATION

Pruning of past season's terminal growth to a length of 10-15 cm is to be done during September-October and February – March to encourage more laterals. The erect growing branches are to be bent by tying on to pegs driven on the ground

PLANT PROTECTION

PESTS

Tea mosquito bug, Aphids, Mealy bug;

Neem oil spray and release of *Cryptolaemus montrouzieri* beetles (Coccinellid beetles) @ 10 beetles /tree is also recommended, followed by spraying with Biocontrol agents like Verticillium lecanii - 0.5 - 1.0 %, which affects all stages of these pests.

4. AMLA *(Phyllanthus emblica)*

Euphorbiaceae

VARIETIES

The most popular cultivable varieties of amla are Banarasi, NA 7, Krishna, Kanchan, Chakaiya, BSR 1.

SOIL AND CLIMATE

Amla is a subtropical plant and prefers dry climate. It is a hardy plant and can be grown in variable soil conditions. The crop can tolerate salinity and alkalinity.

PLANTING MATERIAL

Soft wood Grafts are the best material used for planting.

PLANTING

Planting is done during July-August with a spacing of 6 x 6 m in pits of 1x1m or 1.25 x 1.25m.

IRRIGATION

Irrigate the plants initially for establishment. No irrigation is required during rainy and winter season. Drip irrigation is appropriate which can save water upto 40-45%.It responds well for drip irrigation than conventional irrigation.

MANURES AND BIO-FERTILIZERS (PER PLANT/YEAR)

Manuring should be done immediately after pruning.

Inputs	1st Year/tree	Annual increase/ tree	6th Year onwards/tree
FYM/ well decomposed Compost	10.00 Kg	10.00 Kg	50.00 Kg
Any oil cake	1.0 kg	1.0 kg	5.0 kg
Azospirillum	50 g	50 g	250 g
Phosphobacteria	50 g	50 g	250 g
Potash Solubilising Bacteria	25 g	25g	100 g
VAM	50 g	50 g	250 g
Patent Kali /SOP 3-4 % Foliar spray	2 times in a year	2-3-times in a year	3-4-sprays, out of which 3 sprays during Fruit setting to fruit Development phase.

TRAINING AND PRUNING

The main branches should be allowed to appear at a height of 0.75-1 m above the ground level. Plants should be trained to modified central leader system. Two to four branches with wide crotch angle, appearing in the opposite directions should be encouraged in early years.

During March – April, prune and thin the crowded branches to provide maximum fruit bearing area in the tree.besides, the indeterminate branches may be headed back at 2/3 level from its origin.

PLANT PROTECTION

PEST

Gall caterpillar and Bark eating cater pillar - spray Metarhizium anisopliae - 0.5 - 1.0 % which affects all stages of these pests.

5.POMEGRANATE

VARIETIES :

Bhagwa and Mrudula

PLANTING MATERIAL

Conventional methods of propagation have their own limitations to produce clean and disease free planting material on mass scale. Hence, Tissue culture plants are good material.

CLIMATE

Pomegranate plants flourish under bright sun light and dry climate. Pomegranate plant can survive under extreme low (0°C) and very high (50° C) temperature, however, 15-40° C is considered to be an ideal for vigorous growth of the plant. Pomegranate crop is recommended in a region that receives moderate rainfall of 500-800 mm per year.

SOIL

Deep loamy or alluvial, well drain soil is highly recommended for pomegranate cultivation. Soil depth minimum 1.5 meter, pH 6.0-8.0, reach in organic carbon is considered to be an ideal soil for pomegranate cultivation. However, pomegranate can be grown on soils which are considered to be unsuitable for most of other fruit trees. Plant can tolerate soils which are limy and slightly alkaline too. Ill drain soil having water logging properties are not at all recommended for pomegranate cultivation.

PLANTING SEASON

Pomegranate plant grows well during dry conditions rather than humid. Therefore pomegranate plantation is highly recommended after completion of rainy season.

LAND PREPARATION AND METHOD OF PLANTATION

Land should be ploughed 2-4 times, rotavator and leveled and allowed for solarization for 2-4 weeks. 8-10 tractor trolleys of Farm Yard Manure (FYM) must be added and spread over the field uniformly. Now field become ready for carrying out further process of planting. Depending on the soil quality planting may be performed either on pits or raise bed. Pit planting is recommended for highly drained, sandy, soft rocky soil while raise bed planting is recommended for deep loamy, alluvial soil.

PIT SIZE

Pit size is depends on drainage quality of the soil. 3'x3'x3' pit is recommended for sandy, soft rocky very high drain soils while 2'x2'x2' pit is recommended for moderate drain soil whereas 1'x1'x1' pit is recommended for well drain soils.

BED SIZE

The ideal size of the bed is 3' wide and 2' high. 1'x1'x1' pit must be dig out at the planting place over a bed. Composition of potting media is very important for initial establishment and further growth of the plant. The components and quantity of potting media per pit are:

2 part soil + 1 part FYM (maximum 20 kg per plant) + 1 Kg Neem Cake + 250 gms rockphosphate Components must be mixed thoroughly before putting it in the pit..

CROP GEOMETRY

Low dense plantation is recommended in high rain fall, humid climate, ill drain soil and low light intensity areas; where as moderate dense plantation is recommended in low rail fall, dry climate, well drain soil, and high light intensity areas. Considering all above factors, below crop geometry has been recommended for Tissue Culture pomegranate cultivation for both the varieties:

Type of crop geometry	Spacing in Feet	No. of plants/acre
Low dense	15 x 10, 14 x 10	290,311
Moderate dense	12 x 10, 13 x 9	363 , 372

WATER MANAGEMENT

Online drip system is recommended for low density plantation, howeverØ either inline or online drip system is recommended for high density plantation. Discharge: 4 L/HrsØ No of laterals: Double lateralØ No. of drippers/plant: 6-8Ø Distance between two drippers: 60 cms.

FERTILILZER MANAGEMENT

Tissue Culture pomegranate plant takes 18 months from the date of plantation to complete its vegetative phase and becomes capable for reproductive growth. Total fertilizer requirement of mature pomegranate plant is 625 gms N, 250 gms P and 250 gms K per plant per year. Our Organic manures should meet this amount for good flowering and development.

MANURES AND BIO FERTILIZERS

Inputs	1st Year/tree	Annual increase/tree	4th Year onwards/tree
FYM/ well decomposed Compost	5 kg	5 kg	25 kg
Any oil cake	3.0 kg	1.0 kg	5.0 kg
Azospirillum	50 g	25 g	125 g
Phosphobacteria	50 g	25 g	125 g
Potash Solubilising Bacteria	25 g	25 g	100 g
VAM	50 g	25 g	125 g
Patent Kali /SOP 3-4 % Foliar spray	2 times in a year	3-4 times in a year	4-5 sprays , out of which 3 sprays during Fruit setting to fruit Development phase.

FLOWER & FRUIT MANAGEMENT (BAHAR TREATMENT)

Flowering and fruit treatment is decided on below factors: 1. Favorable period for exposing tree to the stress. 2. Availability of water 3. Disease and pest management 4. Harvesting period

Pomegranate tree flowers round the year; therefore selection of flowering period becomes easy in for this crop. However, there are three main seasons popular for flower and fruit treatment, these are, Mrig Bahar (June-July), Hasta Bahar (September-October) and Amebye Bahar (Dec-Jan).

There are two methods used to expose tree against the stress, first by water reduced stress while second is the chemical induced stress. First method is recommended under organic farming.In first method irrigation is completely or partially stopped for 4-6 weeks depending on the soil type and environmental conditions. 50-70% leaf defoliation is expected and considered to be an ideal stage of stress However, disease and pest management becomes very critical in this treatment because of favorable conditions for the growth of micro-organism, insect and pest.

MRIG BAHAR (June/July treatment): In this treatment, flowering is allowed at the beginning of monsoon. This treatment is well preferred by farmers from arid to semi-arid region where there are limited water resources availableredominant because of high humidity.

HASTA BAHAHR (SEPTEMBER/OCTOBER TREATMENT):

This treatment is followed just after completion of rainy season i.e. during September to October. It has been observed that flower management during Hasta Bahar is very difficult because of unsuitable conditions for giving water stress to the plant

AMBEY BAHAHAR (DECEMBER/FEBRUARY TREATMENT):
Plants are exposed to water stress during December to February depending on variety. This treatment is practiced by the growers who grow their orchards under heavy clay soil. Special attention is required to control sun burn and cracking to the fruit in this treatment.

SPECIAL OPERATIONS:

1. Prunning young trees:

Newly planted young trees require pruning at right stage and regular intervals to develop desired size and shape of canopy. First pruning must be taken place after 30-60 days after planting while rest of the pruning must be carried out after every 2-3 months interval. There must be 5-7 pruning carried out from the date of planting to the maturity of the plant i.e. plant ready for switching over to reproductive phase. Ideal stem size for pruning is refill thickness (2-3 mm) while ideal length of prune stem is around 12''-15'' long.

Along with the pruning, training the tree is also important. There are three types of canopy patterns which can be developed for better productivity and ease for cultural operations. These patterns are decided on the basis of crop geometry.

- Round: When plant to plant and row to row distance is same and wide
- Oval: When plant to plant distance is lesser than row to row distance or even at high density population
- Wall: When plant to plant distance is too less

2. Removal of water shoot
Pomegranate tree tends to produce water shoots during its whole life cycle. Water shoots are produced more extensively during first eighteen months i.e. during vegetative phase. If does not remove at appropriate time it stops growth of normal shoots. Identification and removal of water shoot is very important. Water shoots grow straight and long without producing branches, stem is green at early stage. It should be removed by pulling the shoot from the base.

3. Propping
Pomegranate wood is brittle that cannot sustain heavy weight load of the fruit that bears to the plant. It requires propping 2-3 months prior to maturity of the fruits. Cost of propping increases over the trees that have long branches. Propping can be of two types, first temporary and second, permanent. In temporary propping, threads are used to hold the loaded branches while in permanent propping, either bamboos or steel rods/pipes/angels are used to establish permanent support to the tree.

4. Disease and pest management
There are number of insect, pest, bacterial, fungal diseases occur on pomegranate. Some of the devastating diseases, insect and pest are addressed below with their control measures.

- **Bacterial Blight Disease:** This is the most devastating disease on pomegranate caused by bacterial species Xanthomonas oxinipodies pv. Puniceae. It is a non-systemic disease that infects leaf, flower, fruit and stem.. Severe infestation leads to leaves shedding. Symptoms on stem: The stem start forming brown to black spots around the nodes. In advanced stages girdling and cracking of node occurs which finally lead to breakdown of the branches. Symptoms on fruit: Brown to black spots appears on the pericarp with 'L 'or 'Y' shaped cracks on fruits.

  Control measures: No suitable control measures are available till date, however, to reduce the disease, clean planting material and orchard sanitation are heavily recommended. The infected branches should be pasted with Bordeaux paste. Spray of Bordeaux mixture 0.5 %.

  Recently, IIHR-Bioconsortium is known to give a good control of the bacterial Blight disease.

- **Fungal Wilts/ Rots:** This disease is caused by fungal organism Fusarium oxysporum, Rhizoctonia solani, Ceratocystis fimbriata. Common symptoms of this disease are yellowing of leaves in single branch, sudden wilting of leaves and drying plant, vertical stem cracking and brown discoloration of the internal root tissue and pith of stem. Control measures: Maintain proper drainage of water, Use of biocontrol agent like Trichoderma culture also found effective.

- **Insect and pest:** Thrips, Aphids and Mealybugs-

SOURCE OF REFERENCES

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8.Anon,2017 Souvennir on “Farmers’- Friendly Technologies”. Regional Horticultural Fair,held on 15-19th January, 2017at ICAR-. Indian Institute of Horticultural Research, Bengaluru.

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ANNEXURE 12

ANNEXURE - II

COST OF CULTIVATION OF PADDY AND SUGARCANE IN TAMIL NADU

(Rs. / hectare)

Sl.No	Particulars	Crop	
		Paddy	Sugarcane
I	Operational cost	62515	177232
	Human labour	26832	94111
	Animal labour	350	2275
	Machine Power	11850	20230
	Seed	8680	25034
	Fertilizers and Manures	11310	26030
	Plant protection charges	1900	2935
	Irrigation charges	168	624
	Interest on working capital	1425	5993
II	Fixed Cost	9135	21348
	Sub Total (I + II)	71650	198580
	Managerial Cost @10%	7165	19858
III	Total cost	78815	218438
	Yield (Qtl)	52	998
IV	Cost of Production (Rs./qtl)	1516	219
	Total cost of production	78832	218562
	Revenue	104000	284430
	Net profit	25168	65868

Source : Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore.

ANNEXURE -III

TABLE 1. POSSIBLE YIELD OF DIFFERENT FRUIT CROPS HANDLED IN THIS PROJECT
Yield /tree (in Kg)

Age	Mango	Guava	Amla	Pomegranate	Banana
1	0	0	0	0	25***
2	0	0	0	2	27
3	0	5	5	5	
4	10	10	10	10	
5	20	20	20	20	
6	30	30	30	30	
7	50	30*	40	30	
8	60	30	50	30	
9	80	30	70	30	
10	100	30	80**	30	

*can yield more if maintained under normal spacing but under multiple cropping, canopy management (pruning) is followed to contain the fruit bearing area which helps to reduce harvesting charges.

**Single tree can yield even more than 150 kg but under multiple cropping,canopy management (pruning) is followed to contain the fruit bearing area which helps to reduce harvesting charges.

*** Grand Naine variety can yield this bunch but other varieties like Ney Poovan (Kadali) can yield around 8-10 kg only

REFERENCE :

- TNAU Agri Portal: Horticulture in www.tnau.ac.in
- Websites of ICAR-Central Institute for Research on Sub tropical Horticulture, Lucknow, ICAR- . Indian Institute of Horticultural Research, Bengaluru and ICAR-National Research Centre for Banana, Trichirapalli sourced through www.icar.org.in

TABLE 2. FARM GATE PRICES OF DIFFERENT FRUIT CROPS HANDLED IN THIS PROJECT (Rs./Kg)*

Year	Mango	Guava	Amla	Pomegranate	Banana
1					6.0
2				20	6.0
3		15	20	20	
4	25	15	20	20	
5	25	15	20	20	
6	25	20	25	25	
7	25	20	25	30	
8	30	20	25	30	
9	30	20	25	30	
10	30	25	25	35	

*farm gate price is assumed to be 30-40 % of the prices quoted in the whole sale market as cited in Horticulture Board, Monthly Price and Arrival report in various markets of Indian cities

TABLE 3. SPACING BETWEEN PLANTS OF DIFFERENT FRUIT CROPS HANDLED IN THIS PROJECT

Fruit Crop	Normal*	In this Project**
Mango	10 m x 10 m or 33 feet x 33 feet	36 x 36 feet
Guava	6 m x 6 m	9 x 6 feet,18 x 9 feet
Amla	18 feet x 18 feet	18 feet x 18 feet
Pomegranate	13 feet x 9 feet	18 x 9 feet
Banana	6 x 6 feet	9 feet along the drip line of fruit crops (9 feet x 9 feet)

*Crop production Techniques of Horticulture Crops,2014 Directorate of Horticulture and Plantation Crops and Tamil Nadu Agricultural University, Coimbatore

** Based on the experience of the consultant and also the crops canopy spread and root activity.

ANNEXURE 12

ZBNF Mango (Pure crop)

p-1	ZBNF Mango (Pure crop at 10 x10m spacing) 50 trees	1st Year	2 nd year	3rd year	4th year	5th year	6th year	7th year	8th yrar	9th year	10th year
S.No	Partriculars	Cost (Rs)									
A	**Establishment cost (1st year)**										
1	Raising fodder(agathi, suba bul) and mulch trees (glericedia)for a length of 250 m along the border 100 trees (3mx3m)	2000	0	0	0	0	0	0	0	0	0
2	Ploughing& rotovating - 2 hours (2hrs x 600 Rs)	1200	1200	1500	1500	1800	1800	1980	2178	2396	2635
3	Soil application of Ganajeevamirtham@400 kg/acre (1 B type x 250)	250	300	300	500	500	500	550	605	666	732
4	Sowing mulch crop (50kg seeds x 40 Rs)	2000	2000	2500	2500	3000	3000	3300	3630	3993	4392
5	Incorporation of mulch (labour + fuel + Brush cutter) (600+300+300)	1200	1200	1500	1500	1800	1800	1980	2178	2396	2635
6	Pit making (3 cubic feet size)@10x10m spacing - 50 pits - JCB	2500	0	0	0	0	0	0	0	0	0
7	Drip system instalation installation and maintenance	45000	1000	1000	1000	1000	20000	2000	2000	2000	2000
8	Sapling cost (50 x Rs.80)	4000	0	0	0	0	0	0	0	0	0
9	seedling dipping with Beejamirtham	200	0	0	0	0	0	0	0	0	0
10	weed management and supplemental mulching	2000	2000	2500	2500	3000	3000	3300	3630	3993	4392
11	Jeevamirtham through drip labour cost + maintenance - 12 times	2400	2400	2800	2800	3200	3200	3520	3872	4259	4685
12	plant protection sprays (2 sprays - @ Rs.300/ spray) but uincreased to 4 sprays during 3rd and above	600	600	1200	1200	1200	1200	1320	1452	1597	1757
13	Training and pruning cost 2 A type @ Rs.300/day	600	1200	2000	2500	3000	3000	3300	3630	3993	4392
	Addition of biofertilisers and biocontrol agents,SOP and patent - Kali(Throgh Drip)	3000	3500	4000	4500	5000	5000	5500	6050	6655	7321
14	Spraying of growth poromoters (2 sprays - @ Rs.300/ spray),increased to 4 sprays from 3rd year onwards	600	600	1200	1200	1200	1200	1320	1452	1597	1757
15	Harvesting and packing charges	0	0	0	1250	2500	3750	4125	4538	4991	5490
16	Sub Total	67550	16000	20500	22950	27200	47450	24385	26824	29506	32456
17	Over head expenses (@ 10%)	6755	1600	2050	2295	2720	4745	2438.5	2682.35	2950.585	3245.644
	Total	74305	17600	22550	25245	29920	52195	26824	29506	32457	35703

From 6th Year onwards , the total cost isarrived @ 10 % increse in cost over the previous year

Yield From One Acre of Mango Plot

Age (year)	yield (kg/tree)	Yield /acre	*Returns (Rs)	Cumulative Return
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	10	500	10000	10000
5	20	1000	20000	30000
6	30	1500	37500	67500
7	50	2500	62500	130000
8	60	3000	75000	205000
9	80	4000	100000	305000
10	100	5000	125000	430000

*Rs.20 per kg at farmgate price for first five years and Rs.25 per kg from 6-10 years

ZBNF MANGO (PURE CROP)

COST -RETURN ANALYSIS

Year	Establishing cost with Drip	Interest	cumul interest	Intrst on cumltv intst	Total cost	Cumulative cost	Cumulative returns	Net Profit or loss
1	74305	5201	6262	0	79506	83120	0	-83120
2	17600	1232	7494	438	19270	102390	0	-102390
3	22550	1579	9073	525	24653	127043	0	-127043
4	25245	1767	10840	635	27647	154691	10000	-144691
5	29920	2094	12934	759	32773	187464	30000	-157464
6	52195	3654	16588	905	56754	244218	67500	-176718
7	26824	1878	18465	1161	29863	274081	130000	-144081
8	29506	2065	20531	1293	32864	306945	205000	-101945
9	32407	2268	22799	1437	36113	343057	305000	-38057
10	35703	2499	25299	1596	39798	382855	430000	47145
	only in 10th year break even takes place							

Year	Establishing cost with subsidy for Drip	Interest	cumul interest	Intrst on cumltv intst	Total cost	Cumulative cost	Cumulative returns	Net Profit or loss
1	29345	2054	6262	0	31399	34970	0	-34970
2	17600	1232	7494	438	19270	54240	0	-54240
3	22550	1579	9073	525	24653	78893	0	-78893
4	25245	1767	10840	635	27647	106541	10000	-96541
5	29920	2094	12934	759	32773	139314	30000	-109314
6	52195	3654	16588	905	56754	196068	67500	-128568
7	26824	1878	18465	1161	29863	225931	130000	-95931
8	29506	2065	20531	1293	32864	258795	205000	-53795
9	32407	2268	22799	1437	36113	294907	305000	10093
10	35703	2499	25299	1596	39798	334705	430000	95295
	only in 9 th year break even takes place							

MANGO

		Mango + Guava + Pomegranate Model										Yield From One Acre of Mango Plot				
mpg-1	Mango Spacing 36 x 36 feet (24 trees)	1st Year	2 nd year	3rd year	4th year	5th year	6th year	7th year	8th yrar	9th year	10th year	Age (year)	yield (kg/ tree)	Yield /acre	Return* (Rs)	Cumu lative Return
S.No	Partriculars	Cost (Rs)										1	0	0	0	0
A	Establishment cost (1st year)											2	0	0	0	0
1	Raising fodder(agathi, suba bul) and mulch trees (glericedia)for a length of 250 m along the border 100 trees (3mx3m)	2000	0	0	0	0	0	0	0	0	0	3	0	0	0	0
2	Ploughing& rotovating - 2 hours (2hrs x 600 Rs)	1200	0	0	0	0	0	0	0	0	0	4	5	120	2400	2400
3	Soil application of Ganajeevamirtham @400 kg/acre (1 B type x 250)	150	150	150	250	250	250	275	303	333	366	5	8	192	3840	6240
4	Sowing mulch crop (50kg seeds x 40 Rs)	2000	2000	2500	2500	3000	3000	3300	3630	3993	4392	6	10	240	6000	12240
5	Incorporation of mulch (labour + fuel + Brush cutter) (600+300+300)	1200	1200	1500	1500	1800	1800	1980	2178	2396	2635	7	12.5	300	7500	19740
6	Pit making (3 cubic feet size) @10x10m spacing - 50 pits - JCB	2500	0	0	0	0	0	0	0	0	0	8	15	360	9000	28740
7	Drip system instalation installation and maintenance	60000	1000	1000	1000	1000	20000	22000	24200	26620	29282	9	17.5	420	10500	39240
8	Sapling cost (50 x Rs.80)	2000	0	0	0	0	0	0	0	0	0	10	20	480	12000	51240
9	seedling dipping with Beejamirtham	100	0	0	0	0	0	0	0	0	0					
10	weed management and supplemental mulching	2000	2000	2500	2500	3000	3000	3300	3630	3993	4392	*Rs.20 per kg at farmgate price for first five years and Rs.25 per kg from 6-10 years				
11	Jeevamirtham through drip (labour cost + maintenance - 12 times)	1200	2400	2800	2800	3200	3200	3520	3872	4259	4685					
12	plant protection sprays (2 sprays - @ Rs.300/ spray) but uincreased to 4 sprays during 3rd and above	600	600	1200	1200	1200	1200	1320	1452	1597	1757					
13	Training and pruning cost (2 A type @ Rs.300/day)	300	1200	2000	2500	3000	3000	3300	3630	3993	4392					
14	Addition of biofertilisers and biocontrol agents,SOP and patent -Kali (Throgh Drip)	1500	1500	2000	2200	2200	2500	2750	3025	3328	3660					
15	Spraying of growth poromoters (2 sprays - @ Rs.300/ spray),increased to 4 sprays from 3rd year onwards	600	600	1200	1200	1200	1200	1320	1452	1597	1757					
16	Harvesting and packing charges	0	0	0	1250	2500	3750	4125	4538	4991	5490					
17	Sub Total	77350	12650	16850	18900	22350	42900	47190	51909	57100	62810					
18	Over head expenses (@ 10%)	7735	1265	1685	1890	2235	4290	4719	5191	5710	6281					
	Total	85085	13915	18535	20790	24585	47190	51909	57100	62810	69091					

GUAVA

												Guava yield from multicrop model				
	Guava Spacing 18 x 9 , 145 trees/ac	1st Year	2 nd year	3rd year	4th year	5th year	6th year	7th year	8th yrar	9th year	10th year	Age (year)	yield (kg/ tree)	Yield /acre	Return* (Rs)	Cumu lative Return
S.No	Partriculars	Cost (Rs)										1	0	0	0	0
A	Establishment cost (1st year)							0	0	0	0	2	0	0	0	0
1	Raising fodder(agathi, suba bul) and mulch trees (glericedia)for a length of 250 m along the border 100 trees (3mx3m)	0	0	0	0	0	0	0	0	0	0	3	5	725	10875	14500
2	Ploughing& rotovating - 2 hours (2hrs x 600 Rs)	0	0	0	0	0	0	0	0	0	0	4	7.5	1087.5	16312.5	30813
3	Soil application of Ganajeevamirtham@400 kg/acre (1 B type x 250)	0	0	0	0	0	0	0	0	0	0	5	10	1450	29000	59813
4	Sowing mulch crop (50kg seeds x 40 Rs)	0	0	0	0	0	0	0	0	0	0	6	12	1740	34800	94613
5	Incorporation of mulch (labour + fuel + Brush cutter)	0	0	0	0	0	0	0	0	0	0	7	15	2175	54375	148988
6	Pit making (2cubic feet size)	2900	0	0	0	0	0	0	0	0	0	8	18	2610	65250	214238
7	Drip system instalation installation and maintenance	0	0	0	0	0	0	0	0	0	0	9	20	2900	72500	286738
8	Sapling cost	6000	0	0	0	0	0	0	0	0	0	10	20	2900	72500	359238
9	seedling dipping with Beejamirtham	100	0	0	0	0	0	0	0	0	0					
10	weed management and supplemental mulching	0	0	0	0	0	0	0	0	0	0	*Rs.15 per kg at farmgate price for first 3-4 years and Rs.20 -25 per kg from 6-10 years				
11	Jeevamirtham through drip labour cost + maintenance - 12 times	1200	2400	2800	2800	3200	3200	3520	3872	4259	4685					
12	plant protection sprays (2 sprays - @ Rs.300/ spray) but uincreased to 4 sprays during 3rd and above	600	600	1200	1200	1200	1200	1320	1452	1597	1757					
13	Training and pruning cost 2 A type @ Rs.300/day	300	1500	2000	2500	3000	3500	3850	4235	4659	5124					
14	Addition of biofertilisers and biocontrol agents,SOP and patent - Kali(Drip)	1500	2000	2500	3000	3500	4000	4400	4840	5324	5856					
15	Spraying of growth poromoters (2 sprays - @ Rs.300/ spray),increased to 4 sprays from 3rd year onwards	600	600	1200	1200	1200	1200	1320	1452	1597	1757					
16	Harvesting and packing charges	0	0	3000	4000	5000	6000	6600	7260	7986	8785					
17	Sub Total	13200	7100	12700	14700	17100	19100	21010	23111	25422	27964					
18	Over head expenses (@ 10%)	1320	710	1270	1470	1710	1910	2101	2311	2542	2796					
	Total	14520	7810	13970	16170	18810	21010	23111	25422	27964	30761					

POMEGRANATE

	Pomegranate Spacing 18 x 9 feet 240 plants /ac	1st Year	2 nd year	3rd year	4th year	5th year	6th year	7th year	8th yrar	9th year	10th year	Age (year)	yield (kg/tree)	Yield /acre	*Returns (Rs)	Cumulative Return
S.No	Partriculars	Cost (Rs)										1	0	0	0	0
A	Establishment cost (1st year)											2	2	400	6000	8000
1	Raising fodder(agathi, suba bul) and mulch trees (glericedia)for a length of 250 m along the border 100 trees (3mx3m)	0	0	0	0	0	0	0	0	0	0	3	5	1000	15000	23000
2	Ploughing& rotovating - 2 hours (2hrs x 600 Rs)	0	0	0	0	0	0	0	0	0	0	4	8	1600	32000	55000
3	Soil application of Ganajeevamirtham@400 kg/acre (1 B type x 250)	0	0	0	0	0	0	0	0	0	0	5	10	2000	40000	95000
4	Sowing mulch crop (50kg seeds x 40 Rs)	0	0	0	0	0	0	0	0	0	0	6	10	2000	50000	145000
5	Incorporation of mulch (labour + fuel + Brush cutter)	0	0	0	0	0	0	0	0	0	0	7	12.5	2500	62500	207500
6	Pit making (2cubic feet size)and planting	4800	0	0	0	0	0	0	0	0	0	8	15	3000	75000	282500
7	Drip system instalation installation and maintenance	0	0	0	0	0	0	0	0	0	0	9	15	3000	75000	357500
8	Sapling cost Rs.40 x 240	9600	0	0	0	0	0	0	0	0	0	10	15	3000	75000	432500
9	seedling dipping with Beejamirtham	100	0	0	0	0	0	0	0	0	0					
10	weed management and supplemental mulching	0	0	0	0	0	0	0	0	0	0	*Rs.15 per kg at farmgate price for first three years				
11	Jeevamirtham through drip labour cost + maintenance - 12 times	1200	2400	2800	2800	3200	3200	3520	3872	4259	4685	and Rs.20,25 per kg from 6-10 years				
12	plant protection sprays including cost of insect proof net (2 sprays - @ Rs.300/ spray) but uincreased to 4 sprays during 3rd and above	600	20600	1200	1200	1200	1200	1320	1452	1597	1757					
13	Planting , staking etc, training and pruning -pruning 4-6 times in a year	2200	2500	3000	3500	4000	4000	4400	4840	5324	5856					
	Addition of biofertilisers and biocontrol agents,SOP and patent - Kali(Drip)	2000	2500	3000	3500	4000	4500	4950	5445	5990	6588					
14	Spraying of growth poromoters (2 sprays - @ Rs.300/ spray),increased to 4 sprays from 3rd year onwards	600	600	1200	1200	1200	1200	1320	1452	1597	1757					
15	Harvesting and packing charges	0	0	3000	4000	5000	6000	6600	7260	7986	8785					
16	Sub Total	18900	28300	13700	15700	18100	20100	22110	24321	26753	29428					
17	Over head expenses (@ 15%)	2835	4245	2055	2355	2715	3015	3317	3648	4013	4414					
	Total	21735	32545	15755	18055	20815	23115	25427	27969	30766	33843					

MANGO + GUAVA + POMEGRANATE MODEL

mgp-2 **Mango + Guava + Pomegranate Model**

Cost -Return analysis

Cumulative Return						
Year	Mango	Guava	Pome granate	Banana	Total	Cumulative return
1	0	0	0	108528	108528	108528
2	0	0	8000	224808	232808	341336
3	0	14500	23000		37500	378836
4	2400	30813	55000		88213	467049
5	6240	59813	95000		161053	628101
6	12240	94613	145000		251853	879954
7	19740	148988	207500		376228	1256181
8	28740	214238	282500		525478	1781659
9	39240	286738	357500		683478	2465136
10	51240	359238	432500		842978	3308114

Cumulative cost										
Year	Establishing cost with subsidy for Drip-Mango	Guava	Pomegranate	Bananan	Total cost	Interest	Cumulative interest	Grand total cost	Cumulative cost	Net Profit or loss
							0			
1	85085	14520	21735	75349	196689	13768	13768	224225	224225	-115697
2	13915	7810	32545	51357	105627	7394	21162	134183	358408	-17072.01
3	18535	13970	15755		48260	3378	24540	76179	434587	-55750.53
4	20790	16170	18055		55015	3851	28391	87257	521844	-54795.45
5	24585	18810	20815		64210	4495	32886	101591	623435	4666.28
6	47190	21010	23115		91315	6392	39278	136985	760420	119533.6
7	51909	23111	25427		100447	7031	46309	153787	914207	341974
8	57100	25422	27969		110491	7734	54044	172269	1086476	695182.2
9	62810	27964	30766		121540	8508	62552	192600	1279076	1186060
10	69091	30761	33843		133694	9359	71910	214963	1494039	1814074

Breakeven starts in the fifth year it self

On average, a Farmer gets Rs.1,80000 as net profit per year.

ECONOMICS OF BANANA CULTIVATION VAR. GRAND NAINE

b-1	Economics of Banana cultivation var. Grand Naine			Banana	Income		
S.No	Particulars	Main crop	First Ratoon		Main crop	First Ratoon	Cumulative
1	Land preparation	2000	0	Average yield /plant	25 kg	27 kg	
2	Farm yard Manure @ Rs.5000 per tractor, 4 loads	20000	10000	Yield per acre(assuming 90 % plants yielding marketable bunch (in Kg)	28000	30000	
3	Tissue culture plants 1250 @13.50	16875	0	Average Farm gate Price	Rs.6.0 /kg	Rs.6.0 /kg	
4	Pit making and planting	6250	0	Income per acre	168000	180000	348000
5	earthing up	3000	3000	Income from 2584 m2 area	108528	116280	224808
6	Cost of oil cake and vermicompost, biofertilisers, SOP and Patent Kali	20000	20000	Net Income /2584 m2 area	33179	64923	
7	Plant protection using botanicals, biocontrol agents	10000	10000	Average income per year	49051		
8	Desuckering	1500	1500				
9	Weed management	6000	4000				
10	Irrigation	6000	6000				
11	Propping support @ Rs.30,000 usable for 2 years	15000	15000				
12	harvesting charges	10000	10000				
	Total	116625	79500				
			Banana				
		First year	Second year		First year	Second year	
	Total cost per acre	116625	79500	Net return per 2584 m2 area	33179	64923	
	Total cost per 2584m2	75349	51357				
	Cumulative cost per 2584 m2	75349	126706				
	For 210 banana plants	20400	13900		29400	31500	
			34300			60900	

Reference :

1.Booklet on “ Production Technolgy For Banana under drip irrigation”,.by Jain Irrigation Systems Ltd, Jalgaon, 2010

2. ICAR NRC Banana-Annual Report, 2014-15.

MANGO

		Mango + Amla + Guava Model										Yield From One Acre of Mango Plot				
mag-1	Mango Spacing 36 x 36 feet (24 trees)	1st Year	2 nd year	3rd year	4th year	5th year	6th year	7th year	8th yrar	9th year	10th year	Age (year)	yield (kg/tree)	Yield /acre	*Returns (Rs)	Cumulative Return
S.No	Partriculars	Cost (Rs)										1	0	0	0	0
A	Establishment cost (1st year)											2	0	0	0	0
1	Raising fodder(agathi, suba bul) and mulch trees (glericedia)for a length of 250 m along the border 100 trees (3mx3m)	2000	0	0	0	0	0	0	0	0	0	3	0	0	0	0
2	Ploughing& rotovating - 2 hours (2hrs x 600 Rs)	1200	0	0	0	0	0	0	0	0	0	4	5	120	2400	2400
3	Soil application of Ganajeevamirtham@400 kg/acre (1 B type x 250)	150	150	150	250	250	250	275	303	333	366	5	8	192	3840	6240
4	Sowing mulch crop (50kg seeds x 40 Rs)	2000	2000	2500	2500	3000	3000	3300	3630	3993	4392	6	10	240	6000	12240
5	Incorporation of mulch (labour + fuel + Brush cutter) (600+300+300)	1200	1200	1500	1500	1800	1800	1980	2178	2396	2635	7	12.5	300	7500	19740
6	Pit making (3 cubic feet size)@10x10m spacing - 50 pits - JCB	2500	0	0	0	0	0	0	0	0	0	8	15	360	9000	28740
7	Drip system instalation installation and maintenance	60000	1000	1000	1000	1000	20000	22000	24200	26620	29282	9	17.5	420	10500	39240
8	Sapling cost (50 x Rs.80)	2000	0	0	0	0	0	0	0	0	0	10	20	480	12000	51240
9	seedling dipping with Beejamirtham	100	0	0	0	0	0	0	0	0	0	*Rs.20 per kg at farmgate price for first five years and Rs.25 per kg from 6-10 years				
10	weed management and supplemental mulching	2000	2000	2500	2500	3000	3000	3300	3630	3993	4392					
11	Jeevamirtham through drip labour cost + maintenance - 12 times	1200	2400	2800	2800	3200	3200	3520	3872	4259	4685					
12	plant protection sprays (2 sprays - @ Rs.300/ spray) but uincreased to 4 sprays during 3rd and above	600	600	1200	1200	1200	1200	1320	1452	1597	1757					
13	Training and pruning cost 2 A type @ Rs.300/day	300	1200	2000	2500	3000	3000	3300	3630	3993	4392					
	Addition of biofertilisers and biocontrol agents,SOP and patent - Kali(Throgh Drip)	1500	1500	2000	2200	2200	2500	2750	3025	3328	3660					
14	Spraying of growth poromoters (2 sprays - @ Rs.300/ spray) increased to 4 sprays from 3rd year onwards	600	600	1200	1200	1200	1200	1320	1452	1597	1757					
15	Harvesting and packing charges	0	0	0	1250	2500	3750	4125	4538	4991	5490					
16	Sub Total	77350	12650	16850	18900	22350	42900	47190	51909	57100	62810					
17	Over head expenses (@ 10%)	7735	1265	1685	1890	2235	4290	4719	5190.9	5709.99	6280.989					
	Total	85085	13915	18535	20790	24585	47190	51909	57100	62810	69091					
		From 6th Year onwards , the total cost isarrived @ 10 % increse in cost over the previous year														

GUAVA

												Guava yield from multicrop model				
	Guava Spacing 9 x 6feet (trees) 500 tree	1st Year	2 nd year	3rd year	4th year	5th year	6th year	7th year	8th yrar	9th year	10th year	Age (year)	yield (kg/tree)	Yield /acre	*Returns (Rs)	Cumulative Return
S.No	Partriculars	Cost (Rs)														
A	Establishment cost (1st year)											1	0	0	0	0
1	Raising fodder(agathi, suba bul) and mulch trees (glericedia)for a length of 250 m along the border 100 trees (3mx3m)	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
2	Ploughing& rotovating - 2 hours (2hrs x 600 Rs)	0	0	0	0	0	0	0	0	0	0	3	5	850	12750	14500
3	Soil application of Ganajeevamirtham@400 kg/acre (1 B type x 250)	0	0	0	0	0	0	0	0	0	0	4	7.5	1275	19125	33625
4	Sowing mulch crop (50kg seeds x 40 Rs)	0	0	0	0	0	0	0	0	0	0	5	10	1700	34000	67625
5	Incorporation of mulch (labour + fuel + Brush cutter)	0	0	0	0	0	0	0	0	0	0	6	12	2040	40800	108425
6	Pit making (2cubic feet size)	3400	0	0	0	0	0	0	0	0	0	7	15	2550	63750	172175
7	Drip system instalation installation and maintenance	0	0	0	0	0	0	0	0	0	0	8	18	3060	76500	248675
8	Sapling cost	6800	0	0	0	0	0	0	0	0	0	9	20	3400	85000	333675
9	seedling dipping with Beejamirtham	100	0	0	0	0	0	0	0	0	0	10	20	3400	85000	418675
10	weed management and supplemental mulching	0	0	0	0	0	0	0	0	0	0	*Rs.15 per kg at farmgate price for first four years and Rs.20				
11	Jeevamirtham through drip labour cost + maintenance - 12 times	1200	2400	2800	2800	3200	3200	3520	3872	4259.2	4685.12	per kg from 5-6 and Rs.25 from 7-10 years				
12	plant protection sprays (2 sprays - @ Rs.300/ spray) but uincreased to 4 sprays during 3rd and above	600	600	1200	1200	1200	1200	1320	1452	1597.2	1756.92					
13	Training and pruning cost 2 A type @ Rs.300/day	300	1500	2000	2500	3000	3500	3850	4235	4658.5	5124.35					
14	Addition of biofertilisers and biocontrol agents,SOP and patent - Kali(Throgh Drip)	1500	2000	2500	3000	3500	4000	4400	4840	5324	5856.4					
15	Spraying of growth poromoters (2 sprays - @ Rs.300/ spray),increased to 4 sprays from 3rd year onwards	600	600	1200	1200	1200	1200	1320	1452	1597.2	1756.92					
16	Harvesting and packing charges	0	0	2500	3500	4000	5000	5500	6050	6655	7320.5					
17	Sub Total	14500	7100	12200	14200	16100	18100	19910	21901	24091.1	26500.21					
18	Over head expenses (@ 10%)	1450	710	1220	1420	1610	1810	1991	2190.1	2409.11	2650.021					
	Total	15950	7810	13420	15620	17710	19910	21901	24091.1	26500.21	29150.23					
		From 6th Year onwards , the total cost is arrived @ 10 % increse in cost over the previous year														

AMLA

												Amla				
	AMLA Spacing 18 x 18 feet 240 plants /ac	1st Year	2 nd year	3rd year	4th year	5th year	6th year	7th year	8th yrar	9th year	10th year	Age (year)	yield (kg/tree)	Yield /acre	*Returns (Rs)	Cumulative Return
S.No	Partriculars	Cost (Rs)										1	0	0	0	0
A	Establishment cost (1st year)											2	0	0	0	0
1	Raising fodder(agathi, suba bul) and mulch trees (glericedia)for a length of 250 m along the border 100 trees (3mx3m)	0	0	0	0	0	0	0	0	0	0	3	5	300	4500	4500
2	Ploughing& rotovating - 2 hours (2hrs x 600 Rs)	0	0	0	0	0	0	0	0	0	0	4	10	600	9000	13500
3	Soil application of Ganajeevamirtham@400 kg/acre (1 B type x 250)	0	0	0	0	0	0	0	0	0	0	5	20	1200	18000	31500
4	Sowing mulch crop (50kg seeds x 40 Rs)	0	0	0	0	0	0	0	0	0	0	6	30	1800	36000	67500
5	Incorporation of mulch (labour + fuel + Brush cutter)	0	0	0	0	0	0	0	0	0	0	7	40	2400	48000	115500
6	Pit making (2cubic feet size)and planting	1200	0	0	0	0	0	0	0	0	0	8	50	3000	60000	175500
7	Drip system instalation installation and maintenance	0	0	0	0	0	0	0	0	0	0	9	60	3600	90000	265500
8	Sapling cost	2400	0	0	0	0	0	0	0	0	0	10	80	4800	120000	385500
9	seedling dipping with Beejamirtham	200	0	0	0	0	0	0	0	0	0	*Rs.15 per kg at farmgate price for first five years, Rs. 20 from 6-8 years and Rs.25 per kg from 9-10 years				
10	weed management and supplemental mulching	0	0	0	0	0	0	0	0	0	0					
11	Jeevamirtham through drip labour cost + maintenance - 12 times	1200	2400	2800	2800	3200	3200	3520	3872	4259.2	4685.12					
12	plant protection sprays (2 sprays - @ Rs.300/ spray) but uincreased to 4 sprays during 3rd and above	600	1200	1200	1200	1200	1200	1320	1452	1597.2	1756.92					
13	Training and pruning	2200	2500	3000	3500	4000	5000	5500	6050	6655	7320.5					
14	Addition of biofertilisers and biocontrol agents,SOP and patent - Kali(Throgh Drip)	2000	2500	3000	3500	4000	4500	4950	5445	5989.5	6588.45					
15	Spraying of growth poromoters (2 sprays - @ Rs.300/ spray),increased to 4 sprays from 3rd year onwards	600	600	1200	1200	1200	1200	1320	1452	1597.2	1756.92					
16	Harvesting and packing charges	0	0	1500	2000	3000	3500	3850	4235	4658.5	5124.35					
17	Sub Total	10400	8900	12200	13700	16100	17600	19360	21296	23425.6	25768.16					
18	Over head expenses (@ 10%)	1040	890	1220	1370	1610	1760	1936	2129.6	2342.56	2576.816					
	Total	14835	9790	13420	15070	17710	19360	21296	23425.6	25768.16	28344.98					
		From 6th Year onwards , the total cost isarrived @ 10 % increse in cost over the previous year														

MANGO + AMLA + GUAVA MODEL

	Cumulative Return					
Year	Mango	Guava	Amla	Banana	Total	Cumu lative return
1	0	0	0	108528	108528	108528
2	0	0	0	224808	224808	224808
3	0	14500	4500	0	19000	243808
4	2400	33625	13500	0	49525	293333
5	6240	67625	31500	0	105365	398698
6	12240	108425	67500	0	188165	586863
7	19740	172175	115500	0	307415	894278
8	28740	248675	175500	0	452915	1347193
9	39240	333675	265500	0	638415	1985608
10	51240	418675	385500	0	855415	2841023

	Cost -Return analysis											
Year	Establish ing cost with subsidy for Drip-Mango	Guava	Amla	Banana	Total cost	Interest	Cumu lative interest		total cost	Cumu lative cost		Net Profit or loss
1	25085	15950	9020	75349	125404	8778	8778		142961	142961		-34433
2	13915	7810	9790	51357	82872	5801	14579		103252	246213		-21405
3	18535	13420	13420		45375	3176	17756		66307	312520		-68712
4	20790	15620	15070		51480	3604	21359		76443	388963		-95630
5	24585	17710	17710		60005	4200	25560		89765	478727		-80029
6	47190	19910	19360		86460	6052	31612		124124	602851		-15988
7	51909	21901	21296		95106	6657	38269		140033	742884		151394
8	57100	24100	23425		104625	7324	45593		157542	900426		446768
9	62800	26500	25768		115068	8055	53648		176770	1077196		908412
10	69100	29150	28344		126594	8862	62509		197965	1275161		1565862.3

MANGO + AMLA + GUAVA MODEL

	Cost -Return analysis											
Year	Establish ing cost with subsidy for Drip-Mango	Guava	Amla	Banana	Total cost	Interest	Cumu lative interest		total cost	Cumu lative cost		Net Profit or loss
1	25085	15950	9020	75349	125404	8778	8778		142961	142961		-34433
2	13915	7810	9790	51357	82872	5801	14579		103252	246213		-21405
3	18535	13420	13420		45375	3176	17756		66307	312520		-68712
4	20790	15620	15070		51480	3604	21359		76443	388963		-95630
5	24585	17710	17710		60005	4200	25560		89765	478727		-80029
6	47190	19910	19360		86460	6052	31612		124124	602851		-15988
7	51909	21901	21296		95106	6657	38269		140033	742884		151394
8	57100	24100	23425		104625	7324	45593		157542	900426		446768
9	62800	26500	25768		115068	8055	53648		176770	1077196		908412
10	69100	29150	28344		126594	8862	62509		197965	1275161		1565862.3

ANNEXURE 13

VETIVER – ONE SPECIES, MULTITUDE OF POSSIBILITIES

Cdr. S. Lakshmanan Iyer (Retd.)

ABSTRACT

Vetiver System (VS) developed by Vetiver Network International, is based on the application of genotypes closely related to only the South Indian variety of vetiver grass (Chrysopogon zizanioides). The extraordinary characteristics of veitiver offers many livelihood related options to farmers, while concurrently offering a multitude of practical, inexpensive, low maintenance and very effective bioengineering techniques for steep slope stabilization, wastewater disposal, phyto-remediation of contaminated land and water, and other environmental protection purposes ranging from soil erosion control, groundwater recharge and water conservation, embankment protection during floods, etc.

The unique characteristics of vetiver include the following:

Rooting system having a mean tested tensile strength of about 75 Mega Pascal (MPa), which is equivalent to 1/6 of similar mild steel reinforcement. It also offers a shear strength increment of 39% at a depth of 0.5m (1.5 feet).

Some varieties (like VS1) have a rooting depth of 3-4 m, which can be achieved in the first year itself.

Can stand relatively deep water flows, and can survive flooding for short durations of a few days.

Tenaciously binds the soil and is difficult to dislodge.

Highly resistant to pests, diseases, making its leaves useful for house thatching, handicrafts and mulching applications.

A dense hedge is formed when planted close together acting as a very effective sediment filter and water spreader.

Tolerance to extreme climatic variation such as prolonged drought, flood, submergence, rainfall and frost.

Extreme temperature resilience – from -14 °C to +55 °C.

Ability to re-grow very quickly after being affected by drought, frosts, salinity and adverse conditions.

Tolerance to wide range of soil pH from 3.3 to 12.5 without soil amendment.

High level of tolerance to herbicides and pesticides.

Highly efficient in absorbing dissolved nutrients such as Nitrogen, Phosphorus and heavy metals in polluted water.

Highly tolerant to growing medium high in acidity, alkalinity, salinity, sodicity and magnesium.

Highly tolerant to Aluminium, Manganese and heavy metals such as Arsenic, Cadmium, Chromium, Nickel, Lead, Mercury, Selenium and Zinc in the soils.

Palatability - Cattle, goats, sheep, pigs

Use of Vetiver System can potentially enhance yield of crops.

Vetiver is being used in by farmers in agricultural fields across the world for a variety of reasons ranging from soil and moisture conservation to pest control to use of leaves as raw material for handicrafts.

The only limiting factor for vetiver is lack of sunlight.

Its wide climatic adaptability renders it suitable for use across all agro-climatic zones of India. It should be included as part of the first stage of various initiatives proposed for rejuvenating rivers – be it through afforestation along river banks, or farm land or other government lands.

1. INTRODUCTION

Vetiver plant species belonging to the genus *Chrysopogon* are native not only to India but also South-East Asia and South & Western Africa. However, the Vetiver System (VS) developed by Netiver Network International, is based on the application of genotypes closely related to only the South Indian variety of vetiver grass (Chrysopogon zizanioides).

Due to the extraordinary characteristics of vetiver grass, it has found important applications as a very simple, practical, inexpensive, low maintenance and very effective bioengineering technique for steep slope stabilization, wastewater disposal, phyto-remediation of contaminated land and water, and other environmental protection purposes.

The South Indian species is also chosen due to propagation only by vegetative means only; seeds are either not produced, or are not viable. When planted in single rows vetiver plants will form a hedge which is very effective in slowing and spreading run off water, reducing soil erosion, conserving soil moisture and trapping sediment and farm chemicals on site.

Vetiver grass, due to its extraordinary and unique morphological and physiological characteristics described in subsequent sections, is considered the best choice for all of the above applications. In addition, the extremely deep and dense root system of vetiver binds the soil and at the same time makes it very difficult for it to be dislodged even under high velocity water flows. This very deep and fast growing root system also makes vetiver very drought tolerant and highly suitable for steep slope stabilization.

2. VETIVER AS A BIO-ENGINEERING TOOL – A BRIEF HISTORY

In the early part of last century the sugar industry had recognized the value of Vetiver grass for conservation purpose and it was used in the West Indies and South Africa for this purpose. Although the sugar industry has used Vetiver grass as a vegetative soil conservation measure in isolated parts of the world for the past 50 years, it has gone unnoticed by researchers, even in the same countries. It has been overlooked by lecturers and professors teaching soil conservation. Strangely, it has never been a subject of any research. Yet for over 200 years, it has been used by farmers in India as a permanent hedge. It has been free of problems and dense enough to effectively filter silt out of runoff.

Vetiver grass has been used for soil and water conservation in agricultural lands for many years but its related impact on land stabilization, soil erosion and sediment control only started in the late 1980s following its promotion by the World Bank.

In China its use has extended from agriculture to engineering and mechanical devices being replaced. It has been used successfully to stabilize flood embankments, river and canal embankments in many countries.

Considering the grave situation of soil and water loss particularly from agricultural fields and rivers, a few environmentalists established India Vetiver Network (INVN) as a Trust in2007. Since 2016, the Office of INVN has been located at the Tamilnadu Agricultural University (TNAU), Coimbatore. As of date, Dr. Rajamani, a faculty of TNAU functions as the Secretary and Mr. P. Haridas, a botanist who retired after a long illustrious career at Tata Tea, is the President. Their contact details are indicated in the adjoining box.

INDIA VETIVER NETWORK (INVN)

Secretary: Dr. Rajamani
(eMail: med@tnau.ac.in)

President: Mr. P Haridas
(eMail: pottekadharidas@gmail.com)

Vetiver planting in commercial scale for preventing soil erosion and conserving water was first started by Tata Tea Limited (now Tata Global Beverages Ltd.) in their Tea Plantations in India in the late 1980s. By seeing the thundering success of Vetiver System Technology, it became a company policy to establish Vetiver hedges instead of constructing stone revetments in tea fields for preventing soil erosion and conserving moisture.

Tata Tea Limited in collaboration with The Vetiver Network International (TVNI) sponsored a National Workshop on Vetiver System Technology in February, 2008 at Kochi, Kerala.

A major river bank stabilization project undertaken by Vietnam Government is the stabilization of Mekong river banks. It was proved to be a powerful solution for eroding river banks. Attempts were also made to stabilize Bramhaputra river banks and the results were presented at International Conference on Vetiver held at Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow in 2011.

India Vetiver Network was actively involved in the River Bank Stabilization work undertaken by many Panchayats of Malappuram District, Kerala during the period 2009-2011. These results were also presented at the above conference.

3. UNIQUE CHARACTERISTICS OF VETIVER GRASS

(Paul Truong; Tran Tan Van; Elise Pinners, 2008)

a. Morphological characteristics:

- Dense and finely structured root system
- These roots have a mean tested tensile strength of about 75 Mega Pascal (MPa), which is equivalent to 1/6 of similar mild steel reinforcement. It also offers a shear strength increment of 39% at a depth of 0.5m (1.5 feet).
- Roots grow very fast
- Some varieties (like VS1) have a rooting depth of 3-4 m, which can be achieved in the first year itself
- Stiff and erect stems that can stand relatively deep water flows
- Tenaciously binds the soil and is difficult to dislodge
- Highly resistance to pests, diseases
- A dense hedge is formed when planted close together acting as a very effective sediment filter and water spreader.
- New shoots develop from the underground crown making vetiver resistant to fire, frosts, traffic and heavy grazing pressure.
- New roots grow from nodes when buried by trapped sediment. Vetiver will continue to grow up with the deposited silt eventually forming terraces, if

trapped sediment is not removed.

b. Physiological characteristics

- Tolerance to extreme climatic variation such as prolonged drought, flood, submergence.
- Extreme temperature resilience – from -14°C to +55°C.
- Ability to re-grow very quickly after being affected by drought, frosts, salinity and adverse conditions after the weather improves or soil ameliorants added.
- Tolerance to wide range of soil pH from 3.3 to 12.5 without soil amendment.
- High level of tolerance to herbicides and pesticides.
- Highly efficient in absorbing dissolved nutrients such as Nitrogen, Phosphorus and heavy metals in polluted water.
- Highly tolerant to growing medium high in acidity, alkalinity, salinity, sodicity and magnesium.
- Highly tolerant to Aluminium, Manganese and heavy metals such as Arsenic, Cadmium, Chromium, Nickel, Lead, Mercury, Selenium and Zinc in the soils.

c. Ecological characteristics

- It is intolerant to shade. Shading will reduce its growth and in extreme cases, may even eliminate vetiver in the long term.
- In an open environment, weed control may be needed during establishment phase.
- On erodible or unstable ground, vetiver first reduces erosion, stabilizes the erodible ground (particularly steep slopes), then because of nutrient and moisture conservation, improves its micro-environment so other volunteered or sown plants can establish later. Because of these characteristics vetiver can be considered as a nurse plant on disturbed lands.

d. Adaptability Range

- pH: 3.3 to 12.5

- Rainfall: 250 – 5000 mm
- Frost (Ground Temp): -22^{o}C
- Heat Wave: 55^{o}C
- Palatability: Cattle, goats, sheep, pigs
- Nutritional Value:
- Crude protein 3.3%
- Crude fat 0.4%
- Crude fibre 7.1%
- Vetiver grass can be destroyed easily either by spraying with glyphosate (Roundup) or by cutting off the plant below the crown.

e. An Effective Bio-Engineering Tool:

The following of Vetiver's unique attributes have been researched, tested, and developed throughout the tropical world, thus ensuring that vetiver is really a very effective bioengineering tool:

- Although technically a grass, vetiver plants used in land stabilisation applications behave more like fast-growing trees or shrubs. Vetiver roots are, per unit area, stronger and deeper than tree roots.
- Vetiver's extremely deep and massive finely structured root system can extend down to two to three meters (six to nine feet) in the first year. On fill slope, many experiments show that this grass can reach 3.6m (12 feet) in 12 months. (Note that vetiver certainly does not penetrate deeply into the groundwater table. Therefore at sites with a high groundwater level, its root system may not extend as long as in drier soil).
- Vetiver's extensive, and thick root system binds the soil which makes it very difficult to dislodge, and extremely tolerant to drought.
- Vetiver roots are stronger than those of many hardwood species. Vetiver roots have very high tensile strength that has been proven positive for root

reinforcement in steep slopes.

- Vetiver roots can penetrate a compacted soil profile such as hardpan and blocky clay pan common in tropical soils, providing a good anchor for fill and topsoil.
- When planted closely together, vetiver plants form dense hedges that reduce flow velocity, spread and divert runoff water, and create a very effective filter that controls erosion. The hedges slow down the flow and spreads it out, allowing more time for water to soak into the ground.
- Acting as a very effective filter, vetiver hedges help reduce the turbidity of surface run-off.
- Since new roots develop from nodes when buried by trapped sediment, vetiver continues to rise with the new ground level. Terraces form at the face of the hedges, however this sediment should never be removed. The fertile sediment typically contains seeds of local plants, which facilitates their re-establishment.
- Vetiver tolerates extreme climatic and environmental variation, including prolonged drought, flooding and submergence, and temperature extremes.
- This grass regrows very quickly following drought, frost, salt and other adverse soil conditions when the adverse effects are removed.
- Vetiver displays a high level of tolerance to soil acidity, salinity, sodicity and acid sulphate conditions

4. VETIVER FOR AGRICULTURE IMPROVEMENT

(Truong, Van, & Pinners, The Vetiver System for Agriculture, 2008)

a. 3.1 Introduction:

Vetiver is being used by farmers in agricultural fields across the world for a variety of reasons ranging from soil and moisture conservation to pest control to use of leaves as raw material for handicrafts.

b. Vetiver Grass Technology (VGT):

The Vetiver Grass Technology (VGT), in its most common form, is simply the establishment of a narrow (less than 1 meter wide) live stiff grass barrier, in

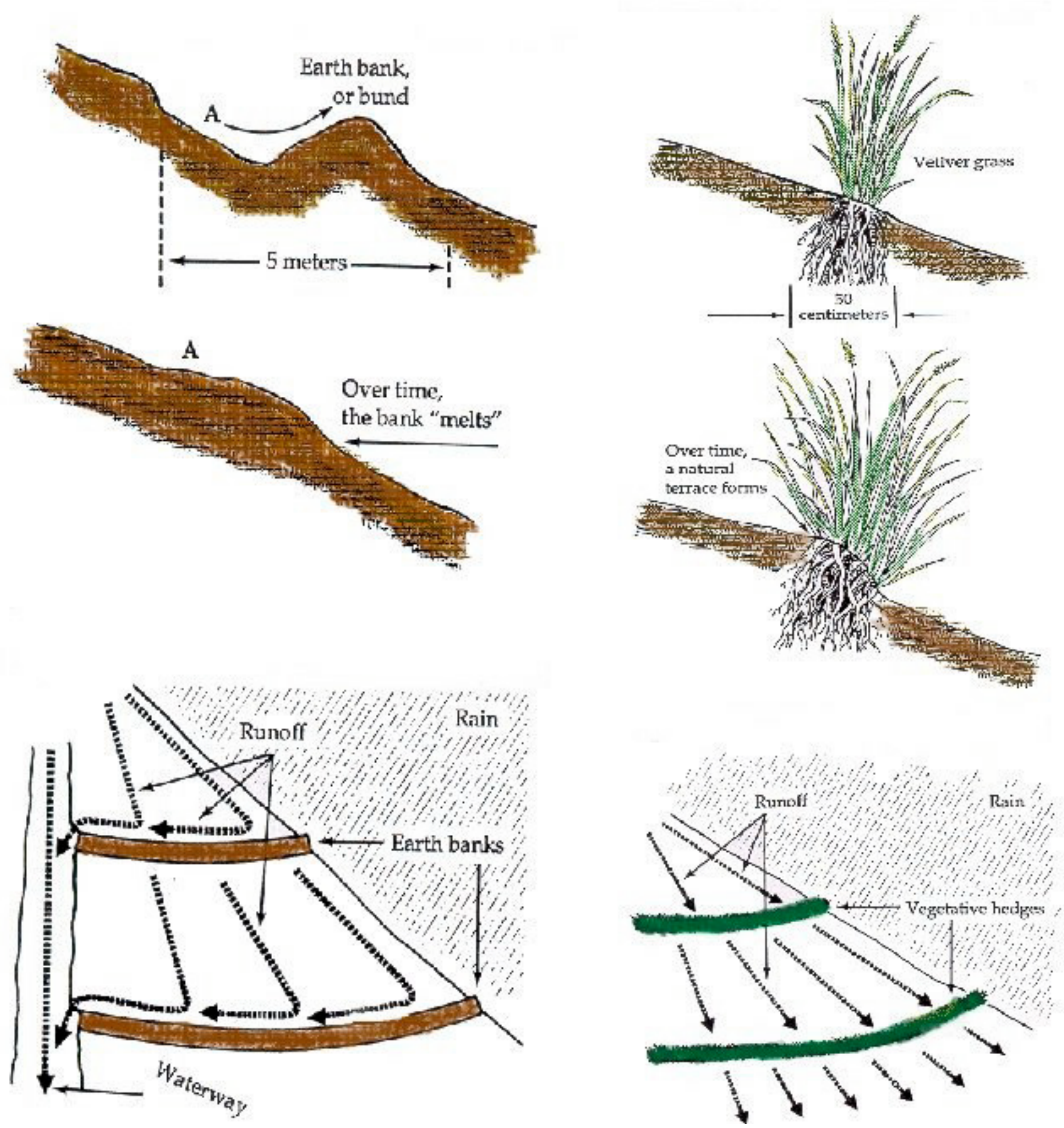

Figure 1: Above left: contour bank; below left: banks divert the water; above right: Vetiver hedges create banks or terraces over time; below right: Vetiver hedges slow the run-off to increase infiltration, and the water remains in the field (Greenfield 1989).

the form of a hedge, across the slope of the land. When applied correctly, the technology is effective on slopes from less than 1 to over 100%.

A well-established grass hedge will slow down rainfall run-off, spreading it out evenly, and will trap run-off sediments to create natural terraces. Vertical intervals can be more accurately decided by observation. This is something the planter can do; if rills start to develop below or above the hedge, another barrier can be planted to intercept them.

The system is very user friendly. All this is possible without the use of complex hydrological data and design, and without the aid of high cost consultants and surveyors.

c. Soil & Moisture Conservation:

Vegetative barriers such as vetiver hedges planted across the slope or on the contour control the runoff, spreading it out and slowing it down as it slowly filters through the hedge. Since the erosive power of both water and wind erosion is proportional to the flow velocity (the speed of the downhill water and the force of the wind), the main principle of soil conservation is to reduce the speed of water and air. Correctly installed, vetiver hedges effectively control both water and wind erosion.

In addition to reducing surface erosion on sloping land, vetiver's massive root system also contributes to slope stability. The deep, fibrous roots reduce the risk of landslide or collapse. Vetiver's stiff stems form a dense hedge that reduces water velocity, allows more time for water to infiltrate the soil, and, where necessary, diverts surplus runoff water. This is the principle of "flow-through" erosion control for farms on the flood plains as well as on steep slopes in high rainfall areas.

d. Vetiver Application in Flood Plains:

The Vetiver System can be an important tool to control flood erosion in all the flood plains. Vetiver hedges on flood plains can:

- Reduce flow velocity and the run-off's erosive power.
- Trap fertile alluvial soil on site, which maintains the fertility of the plain.

- Increase water infiltration in low rainfall regions.

e. Case Studies of Vetiver Application on Sloping Land:

(i) Sorghum Crop in India:

- Crop land with 1.7% slope, vetiver contour hedges reduced run-off (as percentage of rainfall) from 23.3% (control) to 15.5% and soil loss from 14.4 t/ha to 3.9 t/ha, and increased sorghum yield from 2.52 t/ha to 2.88 t/ha over a four-year period.
- The yield increase was attributed mainly to in situ soil and moisture conservation over the entire toposequence protected by the vetiver hedge system. (Truong 1993)

(ii) ICRISAT:

- Under small plot conditions at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), vetiver hedges were more effective in controlling run-off and soil loss than either lemon grass or stone bunds.
- Run-off from the vetiver plots was only 44% of that of the control plots on 2.8% slope and 16% on 0.6% slope.
- Average reductions of 69% in run-off and 76% in soil loss were recorded from vetiver plots, compared to control plots (Rao, Rao, Raju, & Prasadini, 1996)

(iii) Nigeria:

- Vetiver strips were established on 6% slopes at the end of 20m (60ft) run-off plots for three growing seasons to assess their effects on soil and water loss, soil moisture retention and crop yields.
- Results showed that vetiver stabilized soil and chemical conditions within the entire 20m (60ft) distance behind the strip.
- Under vetiver management, cowpea yields were increased between 11 and 26%, and maize increased about 50%. In comparable 20m runoff plots without vetiver (control), soil loss and runoff water were 70% and 130% higher, respectively.

- Vetiver strips increased soil moisture storage between 1.9% and 50.1%, depending on depth.
- The nutritive content in eroded soils on the control plots was consistently poorer than on vetiver plots, which also enhanced Nitrogen use efficiency by about 40%.
- This research demonstrates the usefulness of vetiver hedges as a soil and water conservation measure under Nigerian conditions.

(iv) Natal, South Africa:

- Vetiver hedges have increasingly replaced contour banks and waterways on steep sugarcane lands, where farmers have concluded that the vetiver system is the most effective and low-cost form of soil and water conservation in the long term.

(v) Vetiver – Effect on Soil loss & Water Run-off: Effect of vetiver hedges on soil

EFFECT OF VETIVER SYSTEM ON SOIL LOSS & RUN-OFF
(TRUONG, VAN, & PINNERS, THE VETIVER SYSTEM FOR AGRICULTURE, 2008)

Table 1: Effects of VS on soil loss and runoff on agricultural lands.

(Truong and Loch, 2004)

Countries	Soil loss (t/ha)			Runoff (% of rainfall)		
	Control	Conven-tional	VS	Control	Conven-tional	VS
Thailand	3.9	7.3	2.5	1.2	1.4	0.8
Venezuela	95	88.7	20.2	64.1	50	21.9
Venezuela (15% slope)	16.8	12	1.1	88	76	72
Venezuela (26% slope)	35.5	16.1	4.9	-	-	
Vietnam	27.1	5.7	0.8	-	-	
Bangladesh	-	42	6-11	-	-	
India	-	25	2	-	-	

Effect of Vetiver Hedge on Water & Soil Conservation

(Xu, Lu, & Truong)

Field Sites	Annual Rainfall (mm)	Treat-ment	Surface Runoff			Eroded Soil		
			Total (mm)	Decrease (mm)	Decrease (%)	Total (kg/m^2)	Decrease (kg/m^2)	Decrease (%)
Yonghe Town, Xingning City, Guangdong Province	1931.8	Control	1015.8			14.53		
		Vetiver Hedge	409.1	606.7	59.7	1.06	13.47	92.7
Sixia Small Catchment, Chongren County, Jiangxi Province	1766.0	Control	223			3.36		
		Vetiver Hedge[b]	151	72	32.7	1.22	2.14	63.7
		Level Terrace	170	53	23.8	1.67	1.69	50.3

[a] Figures were averaged from measurements in 1993 and 1994. Vetiver was planted in 1992. Observation area for each treatment was 100 m^2

[b] Vetiver hedges were established on 6^0 slopes

loss and rainwater run-off had been studied in various places. The two tables here show data from two different studies.

5. OTHER ON-FARM APPLICATION OF VETIVER:

(Truong, Van, & Pinners, The Vetiver System for Agriculture, 2008)

a. Crop protection – stem borer control:

- Stem borers attack maize, sorghum, rice and millets in Africa and Asia. The moths lay their eggs on the leaves of the crop.
- Professor Johnnie van den Berg, entomologist (School of Environmental Sciences and Development, Potchefstroom University, South Africa) found that the moths prefer to lay eggs on the leaves of vetiver planted around the crop instead of on the maize or rice crop itself. Given the option, about 90% of the eggs are deposited on vetiver instead of on the crop.
- Because vetiver leaves are hairy, the larvae that hatch on them cannot move around easily. The larvae fall off the plant (photo 11) and die on the ground, resulting in very high mortality, about 90%.
- Vetiver also harbours many helpful insects that are predators of pests that attack crops.

- Vetiver alone is not enough to control pests and must be part of an overall Integrated Pest Management package that manages crop health.

b. Vetiver as Animal Feed:

- Vetiver leaves are readily eaten by cattle, goats and sheep. Table 2 shows the nutritive content of vetiver.
- Young vetiver grass is quite nutritious. Their nutrient content, like many tropical grasses, varies according to season, growth stage and soil fertility.
- However, the nutritional value of mature vetiver grass is low, and it lacks crude protein.
- Vetiver leaves are generally useful by-products of soil and water conservation measures. When vetiver is used for other purposes, fodder may prove an added value.

Analytes	**Units**	**Vetiver grass**		
		Young	*Mature*	*Old*
Energy (ruminant)	kCal/kg	522	706	969
Digestibility	%	51	50	-
Protein	%	13.1	7.93	6.66
Fat	%	3.05	1.30	1.40
Calcium	%	0.33	0.24	0.31
Magnesium	%	0.19	0.13	0.16
Sodium	%	0.12	0.16	0.14
Potassium	%	1.51	1.36	1.48
Phosphorus	%	0.12	0.06	0.10
Iron	mg/kg	186	99	81.40
Copper	mg/kg	16.5	4.0	10.90
Manganese	mg/kg	637	532	348
Zinc	mg/kg	26.5	17.5	27.80

- Vetiver leaves are nutritious when cut (pruned) at intervals between one and three months, depending on climatic conditions. Vetiver leaves are readily eaten by cattle, goats and sheep. This Table shows the nutritive value of vetiver grass.
- Vetiver can grow under very high levels of nitrogen (as much as 10,000 kg of N per ha). Thus when vetiver is an integral part of a constructed wetland for waste treatment (animal and human), it will yield over 100 tons of dry matter per ha and is high in nutrients.

- Vetiver will also grow well on saline soils. If the area has a high ground water table, as is the case of parts of Haryana and Punjab States, there is a potential of dry matter yields of 70 tons per ha of forage.

c. Vetiver as Mulch to Control Weeds and Conserve Soil Water:

- Given the higher silica content, vetiver shoots take a longer time to break down. This makes vetiver ideal for use as mulch and roof thatching (as thatch it does not harbour insects).
- When spread evenly on the ground, whole or desiccated, vetiver leaves form a thick matt that suppresses weeds. Vetiver mulch has been used to successfully control weeds in coffee and cocoa plantations in the Central Highlands of Vietnam and tea plantations in India.
- The thick cover of vetiver mulch increases water infiltration and reduces evaporation.
- It also protects the soil surface from the impact of raindrops, a major cause of soil erosion.
- Research in India, Nigeria and Thailand and other countries demonstrate improvement in crop yields.
- Vetiver hedgerows reduce rainfall run-off significantly. Much of this reduction finds its way to the groundwater as recharge. This is a very important aspect as there is plenty of evidence that this improved recharge results in increased and prolonged stream flow, subsurface recharge of farm ponds, and improved spring flows - all important to small farmers and the community as a whole.

d. Vetiver Seedlings Production:

- Due to the growing demand for vetiver in VS applications for non-agricultural sectors, the production of vetiver seedlings (slips) as a marketable product is an expanding actuality.
- Vetiver slips are easy to produce in very large quantities. The most common forms of production are bare-rooted or containerised.
- Under good conditions (adequate water and nutrients) it is quite possible to

produce at least 500,000 slips (with three tiller each) per ha per year. At a conservative rate of ₹ 1 per slip, this translates as ₹ 5 lakh / ha.

- It is therefore to the benefit of farmers, if farmer groups or their representatives lobby other sectors to use the Vetiver System for slope protection, pollution control, and disaster mitigation.
- In countries, such as India, Indonesia, and Haiti, where vetiver is grown for the aromatic oil, the sale of the plant is a marketable material.

e. Productivity enhancement on sandy and saline sodic soil under semi-arid conditions:

- From 2003 to 2005, Professor Le Van Du and his students from Ho Chi Minh City Agro-Forestry University, Vietnam, planted vetiver on these saline sodic soils to determine whether VS could improve the productivity of farms in desert-like conditions .
- The scientists noted a great improvement in soil fertility after only three months, specifically that soluble salt and pH had been greatly reduced.
- Although soil pH had hardly changed after three years of grape cultivation, following the vetiver installation soil, pH declined up to 2 units from the surface layer to a depth of 1m (3'), and dissolved salt content. The reduction in sodium content by more than half dramatically improved the productivity of local crops such as corn and grapes.

f. Protection of farm infrastructure

- The Vetiver System is widely used to protect farm infrastructure by stabilizing farm dams, aquaculture dikes, and rural roads, among other applications.

6. VETIVER FOR WASTEWATER TREATMENT

(Truong, Van, & Pinners, The Vetiver System for Improving Water Quality, 2009)

a. Physiological attributes that makes vetiver useful for wastewater / effluent treatment:

- Highly tolerant to soil high in acidity, alkalinity, salinity, sodicity and magnesium.

- Highly tolerant to Al, Mn, and heavy metals such as As, Cd, Cr, Ni, Pb, Hg, Se and Zn in the soil and water
- Highly efficient in absorbing dissolved N and P in polluted water
- Highly tolerant to high levels of N and P nutrients in the soil
- Highly tolerant to herbicides and pesticides.
- Breaks down organic compounds associated with herbicides and pesticides.
- Regenerates rapidly following drought, frost, fire, saline and other adverse conditions, once those adverse conditions are mitigated.

b. Extensive R&D and applications in Australia, China, Thailand and other countries have established that vetiver is highly effective in treating polluted wastewater from domestic and industrial discharges. The possibilities include the following:

- Disposal of septic effluence
- Disposal of landfill leachate
- Disposal of industrial wastewater
- Improving wastewater quality
- Trapping debris, sediment and agro-chemicals in agricultural lands
- Absorbing and tolerating pollutants and heavy metal
- Floating wetlands

7. OTHER USES OF VETIVER

a. Handicraft
Rural communities in Thailand, Indonesia, Philippines, Latin America, and Africa are using vetiver leaves to produce various handicrafts.

b. Roof thatch

Vetiver leaves last long at least twice as long according to farmers in Thailand, Africa and the South Pacific (compared to the traditional grass they have used for thatch).

Another report about vetiver thatching is that the leaves repel termites.

c. Mud brick production

Vetiver straw is widely used in Senegal, Africa, to make mud bricks that resist cracking.

Housing construction in Thailand uses bricks and columns made from clay composite to which vetiver leaves have been added. These building materials have rather low thermal conductivity, which makes the resulting construction comfortable and energy efficient, as well as a labour-based appropriate technology.

8. SLOPE STABILISATION & DISASTER MITIGATION (Greenfield, 2008)

a. 6.1 Introduction:

Besides soil erosion, the Vetiver System (VS) can reduce or even eliminate many types of natural disasters, including landslides, mud slides, road batter instability, and erosion (river banks, canals, coastlines, dykes, and earth-dam batters).

b. Use of Vegetation for Slope Stabilisation:

Vegetation has been used as a natural bioengineering tool to reclaim land, control erosion and stabilize slopes for centuries. Its popularity has increased markedly in the last decades as more information about vegetation is now available to engineers and due to the cost-effectiveness and environment-friendliness of this “soft” engineering approach.

A slope will become unstable due to:

- Surface erosion or "sheet erosion": Sheet erosion when not controlled often leads to rill and gully erosion that, over time, will destabilize the slope
- (b) Internal structural weaknesses: Structural weakness will ultimately cause mass movement or landslip.

Since sheet erosion can also cause slope failure, slope surface protection should be considered as important as other structural reinforcements, but unfortunately its importance is often overlooked. Protecting the slope surface is an effective, economical, and essential preventive measure. In many cases, applying some preventive measures will ensure continued slope stability, and always cost much less than corrective measures.

The vegetative cover provided by grass seeding, hydro-seeding or hydro-mulching normally is quite effective against sheet erosion and small rill erosion, and deep-rooted plants such as trees and shrubs can provide some structural reinforcement for the ground.

However, on newly-constructed slopes, the surface layer is often not well consolidated, so even well-vegetated slopes cannot prevent rill and gully erosion. Deep-rooted trees grow slowly and are often difficult to establish in such hostile territory. In these cases, engineers often rue the inefficiency of the vegetative cover and install structural reinforcement soon after construction. In short, traditional slope surface protection provided by local grasses and trees cannot, in many cases, ensure the needed stability.

c. Vetiver's Superiority and Suitability for Slope Stabilisation:

The tensile strength of vetiver roots increases with the reduction in root diameter, implying that stronger, fine roots provide greater resistance than thicker roots. The tensile strength of vetiver roots varies between 40-180 MPa in the range of root diameter between 0.2 - 2.2 mm (0.008 - 0.08"). The mean design tensile strength is about 75 MPa at 0.7-0.8 mm (.03") root diameter, which is the most common size of vetiver roots, and equivalent to approximately one sixth of mild steel. Therefore, vetiver roots are as strong as or even stronger than those of many hardwood species that have been proven positive for slope reinforcement.

Vetiver grows quickly, becomes established under hostile conditions, and its very deep and extensive root system provides structural strength in a relatively short period of time. Thus, vetiver can be a suitable alternative to traditional vegetation, provided that the following application techniques are learned and followed carefully.

- Vetiver is very effective when planted closely in rows on the contour of slopes. Contour lines of vetiver can stabilize natural slopes, cut slopes and fill embankments. Its deep, rigorous root system helps stabilize the slopes structurally while its shoots disperse surface run-off, reduce erosion, and trap sediments to facilitate the growth of native species.
- Vetiver can grow vertically on slopes steeper than 150% (~56°). Its fast growth and remarkable reinforcement make it a better candidate for slope stabilisation than other plants.
- Another less obvious characteristic that sets it apart from other tree roots is its power of penetration. Its strength and vigour enable it to penetrate difficult soil, hardpan, and rocky layers with weak spots. It can even punch through asphalt concrete pavement. Vetiver roots can be characterised as "living soil nails" or dowels of 2-3 m (6-9 feet) depth, commonly used in "hard approach" slope stabilisation work.

Combined with its ability to become quickly established in difficult soil conditions, these characteristics make vetiver more suitable for slope stabilisation than other plants.

d. Vetiver for Water Disaster Mitigation:

To reduce the impact of water related disasters such as flood, river bank and coastal erosion, dam and dike instability, vetiver is planted in rows either parallel to or across the water flow or wave direction.

Its additional unique characteristics are very useful:

- Given its extraordinary root depth and strength, mature vetiver is extremely resistant to washouts from high velocity flow. Vetiver planted in north Queensland (Australia) has withstood flow velocity higher than 3.5m/sec (10'/sec) in river under flood conditions and, in southern Queensland, up to 5m/sec (15'/sec) in a flooded drainage channel.

- Under shallow or low velocity flow, the erect and stiff stems of vetiver act as a barrier that reduces flow velocity (i.e. increase hydraulic resistance) and traps eroded sediment. In fact, it can maintain its erect stance in a flow as deep as 0.6-0.8m (24-31").
- Vetiver leaves will bow under deep and high velocity flow, providing extra protection to surface soil while reducing flow velocity.
- When planted on water-retaining structures such as dams or dikes, vetiver hedgerows help reduce the flow velocity, decrease wave run-up (lap-erosion), over-topping, and ultimately the volume of water that flows into the area protected by these structures. These hedgerows also help reduce so-called retrogressive erosion that often occurs when the water flow or wave retreats after it rises over water-retaining structures.
- As a wetland plant, vetiver withstands prolonged submergence. Chinese research shows that vetiver can survive longer than two months under clear water.

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ANNEXURE 14

- Project Green Hands

PGH HISTORY AND PROCESS DOCUMENTATION

In the early 2000s, an agency of the U.N conducted a survey in the state of Tamil Nadu and predicted that 60% of the state would turn into a desert by 2025. Sadhguru decided to check up on this prediction and travelled around Tamil Nadu. He saw that the state was headed towards desertification *much more* rapidly than the U.N prediction. The green cover of Tamil Nadu was only 17% and 11.4 crores needed to be planted to increase the green cover to the required green cover of 33%

Realizing the profound ecological problems occurring in the state of Tamil Nadu, Sadhguru applied his unique approach to the problem.He saw that the population of Tamil Nadu was 6 crores. If each one planted two trees and tended to them, within 10 years, they would have 11.4 Crores and our vision would come true. Even the poorest of the poor are in a position to nurture two saplings, and the rich and the resourceful have the ability to do much more.

With this background, Project GreenHands (PGH) was launched in 2005 as an inspiring grassroots ecological initiative. The first project was the rehabilitation of the Tsunami affected coastal area where PGH planted 25,000 trees with the community participation.

In 2006, as a first step, to raise awareness and to establish a public profile, PGH undertook the seemingly insurmountable task of planting seven lakh saplings across the state of Tamil Nadu in just one day. A mass tree planting marathon was held on October 17, 2006where over 200,000 volunteers planted 852,587 saplings in a day resulting in the setting of a Guinness World Record. But unlike other records and record holders, this is one record that PGH will be glad to see broken.

With the buzz created from the tree-planting marathon, PGH received a wave of public, corporate and government support. PGH has over the years, built on this foundation of support to reach out to communities and people across the country. Starting from the geographical land area of Tamil Nadu, PGH is reestablishing the power of individual action for large-scale change. Government institutions, NGOs, corporate partners, and individuals have pitched in to grow saplings and plant trees, and to support the effort. Through its activities, PGH aims to inspire people around the world to appreciate the true value of trees and the vital role that they play within human environments.

During the year 2010, Project GreenHands was awarded India's highest environmental award, the **Indira Gandhi PariyavaranPuraskar.** On 30 Sep 2010, PGH was declared winner of "**Beyond Sports Award 2010**" in the Sports for Environment category in the award function at USA. Recently PGH won the **"Environmental Award – 2010"** from Department of Environment, Government of Tamil Nadu.

PGH has so successfully enabled the planting of over 30 million saplings in Tamil Nadu with the support and participation of over 2 million people.

Today PGH has 4 verticals

1. TREES FOR ALL

Planting trees are important but it is more import to plant trees in people's minds. When an individual is touched deeply, he need not be reminded to water the tree or told to care for it.

Through the "Trees for All" initiative, saplings are handed out as part of education programs aimed at teaching people about the multiple benefits that trees offer. PGH has 35 nurseries established across the state through which on an average 4 million saplings are produced every year. 84 different tree species (combination of fruit, fodder, timber, flowering and avenue trees) endemic to Tamil Nadu are raised in these nurseries. School children, college students, corporate employees, Isha volunteers, nature enthusiasts take part in production activities like filling pockets with soil, transplanting seedlings, watering etc.,

These saplings are offered to anyone who pledges to take care of the tree for a minimum of two years. Awareness programs are organized in educational institutions, offices and public functions, where saplings are distributed. These saplings become the dynamic, living hearts of the PGH movement.

USP: Country's largest network of organically grown tree saplings – Annual target 4 million saplings

2. TREES FOR LIFE

PGH in its own way has been working with farmers in the last decade to create awareness on farm forestry and encourage them to plant trees.

With rise in price of farm inputs, delayed rainfall, shortage of labour and increased cost of living, the repercussions for an average farmer is far more disastrous than what meets our eye. Most farmers have abandoned traditional, sustainable agriculture and now depend on costly loan from banks or money lenders for continuing agriculture.

Through the "Trees for Life" agro forestry campaign, farmers are encouraged to plant a combination of fruit, fodder and timber trees in the farmland. Designed to bring tree-based agriculture back to the heart of Indian farming, through this model, farmers are guided to choose and plant the right kind of tree sapling to take care of all issues like crop failure, soil erosion and water inadequacy thereby creating a self-sustaining movement. Farmers are mobilized through awareness campaigns, advertisement in farmer magazines etc.,

Trees bring biodiversity, soil fertility, a cooler climate, cleaner air and increased rainfall. Their yields reduce agricultural expenditure while creating the possibility of future income through small-scale forestry enterprises.

USP: A to Z of agro-forestry plantation is provided free of cost

3. GREEN SCHOOL MOVEMENT

Seeking to bring about a sense of awareness and reverence for nature and to involve children in ecological restoration efforts, PGH has partnered with and conducted various tree planting drives and mass awareness campaigns across schools and colleges.

Green School Movement is a joint collaboration of Isha and Tamil Nadu education department where school children who are members of National Green Corps (NGC) - a program conceptualized and initiated by the Ministry of Environment are trained in sapling production and plantation.

Green School Movement is designed to create "Eco-consciousness" among school children through a change in their attitude, by involving them in sapling production and plantation. Each school who is part of the movement will take up a target of producing and distributing 2,000 saplings each. PGH will provide the seeds, cover and technical training to each school. From sowing the seed, filling pockets, watering, nurturing and until planting all the activities are done by school children. Children get to experientially see the whole cycle of nature ie. from a seed till it sprouts, becomes a tree, and produces seeds of its own. Through this model, children become aware and begin to relate to trees as Life. The sense of ownership and level of commitment with students is high because they have been involved in all aspects of nursery production over a period of 6 months.

USP: When children see the first two leaves sprouting from the seeds that they have sown, they immediately relate to trees as a life form.

Particulars	2011-12	2012-13	2013-14	2014 -15	2015-16	2016-17	Total
Number of schools	486	593	437	526	170	137	**2,349**
Seedlings produced	6,40,107	8,90,577	7,45,589	9,03,487	3,47,900	2,26,302	**37,53,962**
Planted in schools	36,364	36,097	23,227	44,696	22,766	**6334**	**1,69,484**
Distributed to students	4,42,413	6,02,854	5,17,031	7,06,993	2,62,450	191940	**27,23,681**
Distributed to public	1,61,330	2,37,701	2,05,331	1,51,798	62,684	28028	**8,46,872**
Students directly involved in sapling production	19,440	30,955	17,480	23,670	6,800	5480	**1,03,825**
Students involved in sapling distribution	2,10,560	2,82,979	2,36,954	1,13,376	76,708	31177	**9,51,754**

4. ISHA AGRO MOVEMENT

Agriculture as it happens in Tamil Nadu and elsewhere in the world involves relationship, transaction, interaction and learning between one farmer and another. But for almost the last three decades majority of the farming population in TN has been practicing chemical farming. Traditional system of agriculture has compromised and whatever set of package or practices given to the farmer involves chemical farming. In situations where farmers are facing issues such as climate change or pest attack, the solutions available are also chemical based. The harsh reality is that today there is no authority present that can offer directions or implementable solutions regarding chemical free farming.

Isha Agro Movement (IAM), an offshoot of Project GreenHands was launched in the year 2007 to propose a suitable alternative model for sustainable agriculture wherein the key focus was on good economic returns.

The project aims to accelerate the transition of farmers from chemical based system to sustainable system.

With an experience of almost a decade, today IAM has spread its roots across Tamil Nadu. We have established a platform for farmers who practise sustainable farming with a stable and sustained income. To build a community of natural farmers, state level training programs are organized where experts train farmers in the concept of natural farming. Handholding and guidance is seen as an important aspect and maximum support is extended to farmers for transitioning from chemical farming to natural farming.

Nearly 750 farmers are under the guidance and follow-up of Isha Agro movement

USP: Institutionalizing farmers for mutual learning (farmer to farmer) and sharing of knowledge

ANNEXURE 15

FRUIT CULTIVATION AND MARKETING IN INDIA: ISSUES & CHALLENGES

Rajesh Ramakrishnan[1]

ABSTRACT

Growth trends in horticulture: *Production of fruits and vegetables overtook India's foodgrain production by 31 million tonnes in 2014-15. Foodgrain production dropped in drought years (2002, 2004, 2009, 2014), while horticulture production was unaffected or continued to grow. India is the world's highest producer of banana and mango. The leading fruit-producing states are Andhra Pradesh, Maharashtra, Gujarat, Tamilnadu, Karnataka and Uttar Pradesh. The productivity of fruit crops has not increased over the years. Fruits and vegetables are mostly grown by marginal and small farmers (with less than 2 hectare of land).*

Inputs for fruit cultivation: *Availability of quality planting material for horticulture is one of the major hurdles to the growth of this sector. There are no uniform norms across States for nurseries, tissue culture labs and research. Many of our horticulture farmers are highly dependent on imported farm chemicals. A large number of farm chemicals are used for crops for which they are not registered. There is heavy dependence on imported technology for manufacturing microirrigation systems, fertigation systems, farm machinery and tools, lab equipment, design of structures for protected cultivation, cold chain infrastructure, machinery and equipment for packhouses, refrigerated transport system etc.*

Post-harvest handling, packaging, transport and storage: *Post-harvest losses range from 6.7 percent in papaya to 15.88 percent in guava. Government strategy has mainly revolved around promoting capital investment in post-harvest management (PHM) infrastructure. However, infrastructure development has been generally limited to high value commodities meant for exports or limited highend domestic markets. There is generally lack of standardization of norms and quality parameters of fruits, including*

[1] Development professional- natural resources management and livelihoods, Isha volunteer

maturity indices. Indiscriminate use of pesticides is a problem. The availability of IIP (Indian Institute of Packaging) approved designs of corrugated fibre board (CFB) boxes for fresh horticulture produce has been limited to only a few crops. Rake availability with railways for transporting fruits is very limited due to their demand for transport of food grains and other bulk commodities. Wagons are not designed to transport fruit, overheating in summer leads to damage to fruit. In the absence of BIS standards and BEE test protocols, standards have not been set for cold chain infrastructure and their performance testing.

Marketing: *The main constraint to expand production of fruits is the system of marketing and inadequate processing facilities. The onus for freeing market for horticultural produce rests with the States while support of Central government is crucial for promoting producers' organizations and fruits and vegetable processing. Under the provisions of the APMC Act in States, only State Governments are permitted to set up markets and it was made mandatory to carry out buying and selling of agriculture produce only within these markets. However, APMCs license "Adhatiyas" to carry out auction functions. Adhatiyas tend to manipulate sales of farm produce to specific traders. This leads to lack of transparency in auction of agriculture produce, and absence of real-time, truthful market information regarding price and arrivals of produce. The Central Government had put in place a Model Agriculture Produce Marketing (Development & Regulation) Act (2003) and had been incentivizing States to adopt it. The response of States to the Model Act has been lukewarm. Adoption of the Model Act has not resulted in enhanced investment by the private sector in value chain management for fresh horticulture produce. Nor is there better price discovery through direct procurement of agriculture produce under contract farming system. Lack of organised players in the terminal markets prevents large volumes of fresh produce being sourced by formal players, leaving the field open for thousands of small buyers in APMC mandis across the country. The efficiency of rural primary markets is poor due to high degree of congestion at market yards, low number of traders and non availability of supporting facilities and services and private investment. All transactions in markets should be recorded on realtime basis, in a transparent manner which ensures price discovery, and generates real time market information. Fruits and vegetables are outside the purview of the Model APLM Act introduced in April 2017 to replace the APMC Act 2003. Under the new Model Act, even the cold chain, cold storages, dry storages and silos where commodities are stored by farmers can be notified as markets. This enables the farmer to access a mandi or a market place as close as possible to his/her farm gate* *and then discover a price for his/her commodity.*

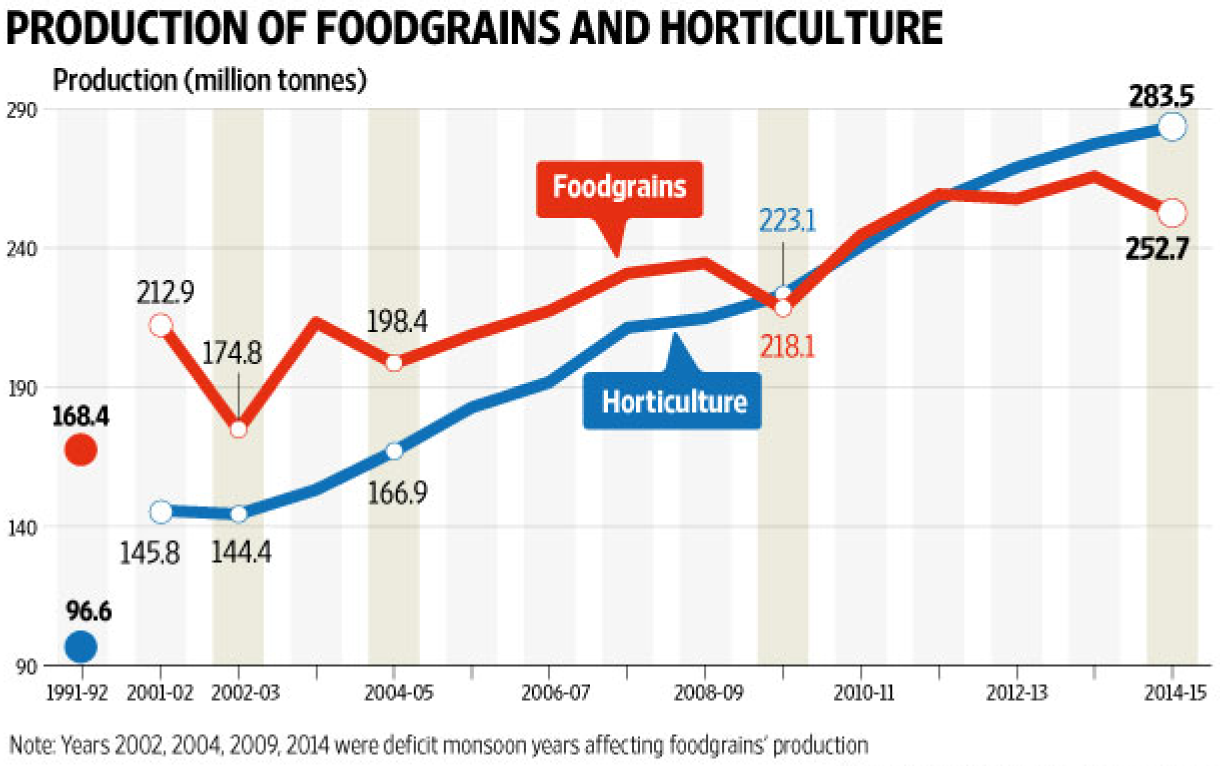
Risk mitigation: *Crop insurance has had limited success in the past due to inadequate Government subsidy to meet the cost of insurance, delayed and inadequate compensation, poor awareness of and low usage by farmers. Crop insurance for food crops requires scientists to develop scientific protocols for loss assessment on the basis of weather data. In earlier schemes, the premium for commercial and horticulture crops could be as high as 25 percent depending on the risk factor involved. Under Prime Minister's Fasal Bima Yojana, the premium to be paid by farmers will be 5 per cent. The balance premium will be paid by the government to provide full insured amount to the farmers against crop loss on account of natural calamities.*

Per capita consumption of fruits: *The Recommended Dietary Allowance (RDA) for moderately active male individuals arrived at by the Indian Council of Medical Research (ICMR) includes 100 grams of fruit per capita daily. The intake of fruits of even the urban top 5 percent (per capita expenditure per month) is modest. Their per capita consumption is 15 bananas a month, or one in two days. They have less than half a kilogram of mangoes a month and 200gm of watermelon. There is a large disparity in expenditure on fruits between the richest urban and poorest rural households. Even in the `middle' expenditure class, urban households spend more than twice as much on fruit compared to rural households. In a survey in five Indian cities, the average intake of fruit and vegetables was 3.5 servings or 280 grams per day. It comprised of 1.5 servings of fruit and two servings of vegetables. This is much lower than the recommendation of five servings a day by the World Health Organisation. For the age group 18-25 years, it is 2.97 servings per day.*

1. HORTICULTURE SECTOR- GROWTH TRENDS

Production of fruits and vegetables overtook India's foodgrain production by 31 million tonnes in 2014-15 (284 million tonnes against 253 million tonnes). This was the third straight year when horticulture output outstripped that of foodgrains. As Figure 1 shows, foodgrain production dropped in drought years (2002, 2004, 2009, 2014), while horticulture production was either unaffected or stayed on its upward growth trajectory (Bera, 2016).

FIGURE 1



Between 1991-92 and 2009-10, there has been general increase in production of fruits, vegetables, spices and plantation crops; however production of vegetables has recorded very high level of fluctuations.

There has been general increase in area under fruits, vegetables, plantation crops and spices during the initial period followed by a phase of stagnation for fruits and vegetables during 1997-2002. The area expansion trend for fruits and vegetables was restored during 2005-2007 and during 2007-2012 the rate of growth has increased (Planning Commission, 2012; also see Appendix 1).

The leading fruit-producing states between 2009-10 & 2014-15 are Andhra Pradesh, Maharashtra, Gujarat, Tamilnadu, Karnataka and Uttar Pradesh. The states leading in production of various fruits in this period are:

Table 1: Top producers of fruits between 2009-10 and 2014-15	
Fruit	**Top producers (Average production between 2009-10 and 2014-15)**
Apple	Jammu & Kashmir, Himachal Pradesh
Banana	Tamilnadu, Maharashtra, Gujarat
Citrus	Telangana, Andhra Pradesh
Grapes	Maharashtra
Guava	Madhya Pradesh, Uttar Pradesh
Litchi	Bihar
Mango	Uttar Pradesh, Andhra Pradesh
Papaya	Andhra Pradesh, Gujarat
Pineapple	West Bengal, Assam
Pomegranate	Maharashtra
Sapota	Karnataka, Gujarat, Tamilnadu
Others	Kerala, Maharashtra
Source: Based on data from Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, New Delhi	

Trend lines for productivity indicate that the productivity of fruits has not increased. Productivity of crops like banana, citrus fruits, papaya, pineapple, guava and sapota have recorded sustained increase but the productivity of mangoes and litchi are almost stagnant or sagging whereas, grapes, apples and pineapples have recorded fluctuating productivity due to adverse weather conditions and disease infestation. This may be attributed to lack of linkage between Government-supported area expansion programmes and availability of quality planting materials, low productivity of old and senile plantations and lack of Government scheme components dealing with increasing productivity of existing orchards (Planning Commission, *op. cit.*).

Most horticulture crops are grown with assured irrigation and, therefore, are more immune to monsoon deficits. This varies from 71% of area irrigated for tomatoes to 86% for potatoes. Eight vegetables that make up 74% of the total vegetable production in the country have 73% access to irrigation (Bera, *op. cit.*).

Fruits and vegetables are mostly grown by marginal and small farmers (with less than 2 hectare of land). This means that resource-poor farmers are likely to benefit most from the growth in the horticulture sector. More so, because the value of the horticulture output grew more than double compared with all other crops put together in the four years between 2008-09 and 2012-13 (Bera, *op. cit.*, also see Box 1).

BOX 1: Supply and demand prospects for fruits

Despite favorable demand and supply side factors, area under fruits and vegetables in the country has remained below 10 per cent. Even with one tenth share in area, fruits and vegetables contribute more than one fourth of earnings from crop sector in the country. Fruits and vegetables give 4-10 times the return from other crop groups namely cereals, pulses and oilseeds. A study on sources of growth indicate that diversification towards horticultural crops is the most powerful factor in raising growth rate of GDP in agriculture. A 1 percent shift in area from non horticultural crops to horticultural crops adds 0.46 percentage points to growth rate of agriculture sector. Due to changes in taste, preferences and food habits, the consumption pattern in India has been shifting towards fruits and vegetables. Such changes are also happening globally. Studies on food demand indicate that 1 per cent increase in per capita overall consumption expenditure results in 1.9% and 1.02% increase in demand for fruits and vegetables respectively. Thus, per capita intake of fruits and vegetables in the country will keep rising in coming years. Moreover, there is large deficiency of these items in Indian diet. India's import of fruits is rising by 20 per cent per year. All these indicators suggest that demand side prospects for fruits and vegetables are very bright. (Chand, undated)

2. SEED AND PLANTING MATERIAL, FARM CHEMICALS, FARM MECHANIZATION AND TECHNOLOGY

2.1 Seed & planting material

There is wide gap in productivity of any crop from State to State even when there is no varietal difference. Extension messages for horticulture crops should incorporate production and plant protection technology to bridge the gap between potential and actual productivity.

In spite of planning for area expansion, a system of production planning for seed & planting material for horticulture crops has not been put in place.

As public sector research in respect of seeds of fruits, vegetables and flowers has not been able to cope with the needs of the sector, large varieties of open private sector hybrids and imported hybrid seeds of horticulture crops, even though not offered for certification, has captured a major share of the Indian market.

The provisions of Seed Act 1966 and Seed (Amendment) Act 1972 do not address the quality needs of vegetatively propagated crops. The Union Government has, therefore, introduced a Seeds Bill, 2004 in Rajya Sabha in which for the first time clauses have been made for the registration of seed varieties and also the registration of horticulture nurseries in India. However, the Seed Bill is yet to be passed and come in to force as an Act. In this background, the farmers generally select the seeds for horticulture crops based on brand name and past performance but they continue to have difficulties in accessing quality planting materials for vegetatively propagated horticulture plants.

As the first step towards quality planting materials, DAC should designate agencies like NHB to accredit and rate horticulture nurseries. Protocols for accreditation of horticulture nurseries, approved by DAC in consultation with ICAR should be adopted.

Steps need to be taken for developing General and Specific Guidelines for Distinctness, Uniformity and Stability (DUS) testing of horticulture crops including grapes. These crops should then be notified as eligible for registration under Protection of Plant Varieties and Farmers' Rights (PPV & FR) Act, 2001.

While doing so, temperate fruit crops, grapes, strawberry, potato, vegetable crops and flower varieties need to be given priority in view of higher dependence on imported planting material and truthfully labeled seeds mostly sourced through private sector R & D and imports.

(Planning Commission, *op. cit.*)

2.2 Farm chemicals

Insecticides and pesticides manufactured by domestic companies constitute a major part of farm chemicals used in our farm sector in general. Our own R & D in respect of water soluble fertilizers, liquid fertilizers, plant growth regulating hormones and insecticide & pesticide molecules are far behind international levels. Many of our horticulture farmers are highly dependent on imported farm chemicals. However, our legal framework for protection of intellectual property rights is said to be not adequate enough to encourage foreign manufacturers of farm chemicals to introduce their new produce into the Indian market.

The procedure followed by Directorate of Plant Protection, Quarantine & Storage for registration of farm chemicals / formulations under provisions of the Insecticides Act, 1968 is said to be a time-consuming, cumbersome and costly affair; as such a large number of farm chemicals are used for crops for which they are not registered. It was revealed that pesticides not registered for a range of crops have been in use under technical advice of experts. A large number of bio-pesticide labs set up under various schemes of horticulture development have not been able to get registration as they are unable to fulfil data requirement (Planning Commission, *op. cit.*).

2.3 Farm mechanisation

Under the ICAR, Central Institute of Agriculture Engineering, Bhopal is the nodal institute in India to carry out R & D in farm mechanisation and Central Institute of Post Harvest Engineering Technology (CIPHET) is the nodal institution for carrying out R & D in the field of post harvest management of agriculture / horticulture crops. In addition, agriculture engineering divisions in Indian Institute of Technology Kharagpur and in State Agriculture Universities also carry out R & D on farm mechanisation, micro-irrigation, protected farming etc.

Needs of hi-tech commercial horticulture sector cannot be fulfilled by providing them with very basic tools and equipments like potato peeler, potato-slicers, banana comb-cutters, potato planters and diggers. This explains our heavy dependence on imported technology for manufacturing micro-irrigation systems, fertigation systems, farm machinery and tools, lab equipment, design of structures for protected cultivation, cold chain infrastructures, machinery and equipment for pack-houses, refrigerated transport system etc.

Technology for export quality production of several crops is mostly given to producers by overseas buyers; for example- grapes, banana, gherkins, walnut, cut & frozen fruits and vegetables and cut-flowers. In a number of cases, the overseas buyers are also imparting training for production, PHM and supplying packing materials too. Some of our public institutions are working in close liaison with our farmers, overseas buyers, etc. to adapt such technologies to Indian conditions and adopt them in our farming system. However, our own R & D in this regard is lagging behind.

Inputs regarding infrastructure design for protected cultivation are largely coming from the private sector. Schemes of horticulture development prescribe various types of poly houses and shed-nets without having technical specifications for each of them. Even the cost norms for such structures have been fixed without any cost analysis, which combined with direct interface between suppliers and implementing agencies has resulted in higher cost norms.

Scientists dealing with post harvest engineering technology are not able to combine the knowledge of life-sciences, which is essential for designing PHM infrastructure for fresh horticulture produce. As a result, technical design specifications for mushroom production units, fruit ripening units, reefer vans, cold storages, etc. had not been firmed up and cost norms are often fixed by heavy dependence on inputs from suppliers / manufacturers.

(Planning Commission, *op. cit.*)

3. SUPPLY CHAIN MANAGEMENT - POST HARVEST HANDLING, PACKAGING, TRANSPORT AND STORAGE

As fresh horticulture produce is highly perishable in nature, management of the entire supply chain has special significance in enhancing shelf-life of horticulture produce and in retaining nutritive values. Supply chain management or post harvest management (PHM) of fresh horticulture produce includes on-farm handling, sorting & grading, packaging, transport and storage solutions maintaining a cold chain in an economically viable manner from farm to fork.

CIPHET has carried out a statistically recommended method of data sampling and analysis in order to estimate post harvest losses of fresh horticulture produce. Losses were calculated in farm operations (harvesting, collection, sorting/grading, packing, transport) and storage (farm, godown/cold storage, wholesaler, retailer, processing unit). **The losses range from 6.7 percent in papaya to 15.88 percent in guava** (Table 2). Considerable losses in storage show the need for multi-crop cold storage units (Jha *et al.*, 2015).

Table 2: Harvest and post-harvest losses in fruits at national level

Fruit	Total loss (%)
Apple	10.39
Banana	7.76
Citrus	9.69
Grapes	8.63
Guava	15.88
Mango	9.86
Papaya	6.7
Sapota	9.73
Source: Jha *et al.* (2015)	

Only a small part of the Plan fund provided for horticultural development goes towards post-harvest related areas, while the larger chunk is allocated to area expansion. Further, the present strategy of tackling post-harvest losses in fresh horticulture produce revolves mainly around extending financial incentives and tax relaxations for promoting capital investment in pack-houses and cold chain infrastructure. There is limited acceptance of this by stake-holders.

In a very large number of cases, aggregation of horticulture produce, its transport to nearby markets, trading system for fresh produce and economic viability of PHM solutions have not been considered in an integrated project mode while implementing schemes relating to PHM. There has been too much reliance on the classic / theoretical model.

The 11th Plan strategy mainly revolved around promoting capital investment in PHM infrastructure: pack houses and integrated cold chain, fruit ripening chambers, and specialised storage structures had been initially introduced with financial assistance from Government. However, the off-take of pack houses and reefer transport system has been generally limited to high value commodities meant for exports or limited high-end domestic markets. In spite of efforts made to promote multi–chamber, multi-commodity cold storages, majority of cold storages have been set up for storage of potatoes which are also used for storage of a few other commodities like red chillies, tamarind, apples etc. Integrated pack houses have been set up mainly for products like table grapes and chives produced for exports to developed countries.

With the exception of certain fruits like papaya, sweet lime, kinnow, acid lime and fruits for export markets, there is generally lack of prescription regarding production of quality fruits in terms of size, shape, weight, uniform colour, texture, TSS: acid ratio, fruit pressure etc. When the percentage of quality fruits in a harvested lot is low, the producer farmers are reluctant to carry out size grading. There is no prescription for maturity indices of fruits too; as a result fruits are harvested at pre-mature stage or over-ripe stage which may not meet requirements of marketing. Indiscriminate use of pesticides is a problem in the case of several high value fruits as well.

Recommended practices for sorting & grading, packaging, etc. are adopted in fruits & vegetables produced for exports to developed countries, for example- table-grapes and banana, cut-flowers, chives, gherkins, process-worthy quality of wine variety of grapes etc. For export competitiveness, as far as possible, our producers and entrepreneurs prefer quality planting materials, farm inputs, packaging materials and production and PHM technology prescribed by experts and overseas buyers. In a number of cases of production for export on contractual basis i.e. with buy-back arrangements, the overseas buyers supply inputs and carry out technology transfer function themselves.

For domestic markets, fruits and vegetables are generally loose packed or packed using traditional bulk packing solutions like bamboo-baskets / gunny bags / plastic bags / large size carton boxes etc. It has been observed that the availability of IIP (Indian Institute of Packaging) approved designs of corrugated fibre board (CFB) boxes for fresh horticulture produce has been limited to only a few crops for which applied R & D has been sponsored by agencies like APEDA or by end-users. Therefore, a large number of models of CFB boxes in circulation have not been tested for their suitability for packing targeted horticulture produce and in taking care of handling, stacking and transport related risk-factors.

For bulk transport of banana, mangoes, onion, potato etc Indian railways provides rail rakes of goods trains; however, rake availability with railways is very limited due to their demand for transport of food grains and other bulk commodities. A large number of rakes are engaged in transport of food grains under PDS systems which do not have assured return journey cargo. On such routes, railways rakes are made available for transport of horticulture produce at concessional rates. But the ordinary wagons of goods train are not sufficiently ventilated and get heated during summer resulting in damage to the produce being transported. CONCOR, Central Ware House Corporation have not visualized beyond introducing refrigerated containers which may not be technically suitable in absence of infrastructure of pre-cooling and also may not be economically viable for most of the horticulture produce. In the case of exportable horticulture produce the protocol for PHM, packaging and transport is given by overseas buyers.

Critical storage conditions prescribed by international food logistic organisations which are commonly used by engineers for designing cold chain storage structures have not been validated for Indian agro-climatic conditions and cultivars.

The risk of weight loss and quality loss of horticulture produce stored in cold storage units is borne by the user of the facility; therefore, enhancement of subsidy for capital investment has not resulted into adoption of proper technical design and use of performance-tested components by cold storage owners.

A 2009 NHB study revealed that the majority of cold storage units set up for storing fresh fruits & vegetables in warehousing business model have not been designed by qualified engineers. Rather they have been constructed on the basis of ad hoc advice of suppliers of plant & machinery under consultancy services provided by chartered accountants who prepared bankable projects for securing credit for the projects. There are only a few manufacturers of critical components of cold chain infrastructure who have performance rating certificates issued by internationally accredited labs.

No technical standards have been put in place for specialised transport system including reefer transport system for maintaining cold chain. In 2011, UNECE (UN Economic Commission for Europe) standards had been adopted by NHB followed by their adoption by Horticulture Division of DAC. No test laboratory is yet available in India for testing performance rating of specialised transport vehicles including reefer transport vehicles and refrigerated containers.

BIS has not been able to keep pace with technical advancement in respect of materials used for thermal insulation in cold chain infrastructure. It has also not set up BIS standards for critical components used in cold chain infrastructure. Bureau of Energy Efficiency too, has not put in place any test protocol for performance rating for cold chain infrastructure from an energy efficiency point of view. In the absence of these, it is not possible to carry out performance rating test for cold storage units.

Engineers fresh out of college have no knowledge of critical storage conditions of fresh horticulture produce, they find it difficult to make heat load calculation and configure the plant & machineries in an energy-efficient manner. Operators of cold chain infrastructure too are not equipped with knowledge of special nature of fresh horticulture produce in terms of their sensitivity to storage conditions and safety. Therefore, there is a crying need for human resource development to meet the requirement of skilled man-power in the cold chain sector.

(Planning Commission, *op. cit.*)

4. HORTICULTURE MARKETING

The purpose of regulation of agricultural markets was to protect farmers from the exploitation of intermediaries and traders and also to ensure better prices and timely payment for produce. Only State Governments were permitted under the provisions of the APMC Act to set up markets and it was made mandatory to carry out buying & selling of agriculture produce only within these markets. The management of APMCs does not carry out auction-functions directly. Instead, licenses are given to brokers/commission agents known as "Adhatiyas" for carrying out auction of produce brought to the market. "Adhatiyas" are responsible to pay the seller and recover the purchase price from the buyers. As most of the trade of perishables is on credit, the "Adhatiyas" tend to manipulate sales of farm produce to traders known to them and who have better track record in making payments. This leads to lack of transparency in auction of agriculture produce, absence of real-time, truthful market information regarding price and arrivals of produce etc. The licensed brokers in the regulated markets have developed monopoly and political clout, and do not allow easy entry of new persons.

Farmers have to bring their produce to the market yard where they do not get any value-added services and buyers cannot buy the produce at the farm or at their processing plant or warehouse. The produce is required to be transported from the farm to the market yard and then only it can be purchased. These rules, combined with the perishability of the produce make it difficult for farmers to bargain for a better price. Traceability of produce, which is important for export markets, also becomes impossible.

Regulated markets were expected to plough back their revenue earnings into development of crop specific infrastructure. But there are very few agriculture produce markets specially designed for dealing with fresh horticulture produce that are highly perishable in nature and require proper handling, efficient sales, proper storage and further transport (Box 2).

BOX 2: Marketing constraints in horticulture

Highly elastic demand for fruits and vegetables, preference of consumers for fresh farm produce and new e-commerce offer vast scope for increase in production of fruits and vegetables and farmers' income in the country. The major constraint however is marketing. This is reflected in slowdown in diversification towards horticulture crops, very high growth in horticultural imports, large price spread between producers and end users, high level of post harvest losses, frequent and often violent price fluctuations, low level of processing, and very low post harvest value addition. The main constraint to expand production of fruits and vegetables is the system of marketing and inadequate processing facility.

Demand side factors and technology are highly favourable for horticulture revolution at small farms. What is needed is policy support for market liberalization, producers' organizations and processing. These require action both by the states and the Central government. The onus for freeing market for horticultural produce rests with the states while support of Central government is crucial for promoting producers' organizations and fruits and vegetable processing. (Chand, *op.cit.*)

4.1 Model APMC Act

Two main legislative instruments with the central and state governments, viz, the Agricultural Produce Marketing (Regulation) Act and Essential Commodities Act, 1955 respectively are used to monitor the activities of market functionaries; however, provisions of the two Acts do not deal with the identified gap in agriculture / horticulture marketing system. As agriculture marketing is a State subject in the Constitution, the Central Government had put in place a Model Agriculture Produce Marketing (Development & Regulation) Act and has been incentivizing States to adopt it. Adoption of the Model Act is a pre-condition for States being eligible for Central Schemes for infrastructure development in agriculture produce markets.

The Model Act permits legal persons, growers and local authorities to apply for the establishment of new markets for agricultural produce in any area. Consequently, in a market area, more than one market can be established by private persons, farmers and consumers. There will be no compulsion on the growers to sell their produce through existing markets administered by the Agricultural Produce Market Committee (APMC). APMCs have been made specifically responsible for: ensuring complete transparency in pricing system and transactions taking place in market area; providing market-led extension services to farmers; ensuring payment for agricultural produce sold by farmers on the same day; promoting agricultural processing including activities for value addition in agricultural produce; and publicizing data on arrivals and rates of agricultural produce brought into the market area for sale.

A new Chapter on ‘Contract Farming’ has been added to provide for compulsory registration of all contract farming sponsors, recording of contract farming agreements, resolution of disputes arising out of such agreements, exemption from levy of market fee on produce covered by contract farming agreements and to provide for indemnity to producers’ title/ possession over their land from any claim arising out of the agreement. Provision has also been made for direct sale of farm produce to contract farming from farmers’ fields without the necessity of routing it through notified markets. Provision has been made for imposition of single point levy of market fee on the sale of notified agricultural commodities in any market area and discretion has been provided to the State Government to fix graded levy of market fee on different types of sales.

Licensing of market functionaries has been ended and a time bound procedure for registration has been laid down; registration for market functionaries has been provided to operate in one or more than one market areas. Commission agency is prohibited and there will be no deduction towards commission from the sale proceeds payable to agriculturist sellers. The Model Act allows for establishment of consumers’/ farmers’ market to facilitate direct sale of agricultural produce to consumers, and for resolving of disputes, arising between private market/ consumer market and Market Committee. Market Committees have been permitted to use their funds to create facilities like grading, standardization and quality certification; to create infrastructure on their own or through public private partnership for post harvest handling of agricultural produce.

(Planning Commission, *op.cit.*)

4.2 Status of APMC Reforms

Sixteen states have almost completed APMC reforms on the lines of the Model Act. Three have not reformed their Acts at all, six have no APMC Act at all. The status of States' acceptance and implementation of the Model APMC Act as of April 2015 is shown in Appendix 2, Table A2.1.

Taking fruits and vegetables out of APMC

Fruits and vegetables are highly perishable and require differential treatment in their marketing. The standard mode of disposal of marketable surplus is sale in nearby market yards (mandi) which is subject to APMC rules and regulations. This requires produce to pass through a long market channel which involves payment of approved and unapproved taxes, market charges, and margins to a large number of intermediaries. Recently some States have brought perishable fruits and vegetables out of the purview of the APMC Act. Some States have not removed fruits and vegetables from APMC Act but have reduced or waived market fee. Others have taken fruits and vegetables out of APMC Act but levy market fee or cess or service charge (Chand & Singh, 2016. Also see Appendix 2, Table A2.2).

4.3 Unregulated markets

At present, horticulture produce along with other farm output is traded through a network of about 27738 wholesale and rural primary markets out of which only 7157 are regulated markets. Other rural primary markets include haats, shandies, painths and fairs which are estimated to be more than 20,000 across country which are owned and managed by private individuals, Panchayats and municipalities who are interested in collection of ground rent/fee/cess. About 90 percent of the total marketable surplus in the remote areas is sold through these markets. It is assessed that the efficiency of rural markets is poor due to high degree of congestion at market yards, less number of traders and non-availability of supporting facilities and services and private sector investment.

Like primary rural markets, the majority of standalone wholesale markets handle a mix of commodities including horticulture produce. Infrastructure facilities available in these markets at present are far from satisfactory and do not cater to special needs of perishables.

(Planning Commission, *op. cit.*)

4.3 Modern markets

There have been attempts to establish modern markets, which have not met with success. A wholesale market established by National Dairy Development Board (NDDB) in Bengaluru has low capacity utilization. Lack of participation by traders and exporters has marred modern flower auction houses set up at Bengaluru, Mumbai, Kolkata and Greater Noida. An electronic market, SAFAL National Exchange set up by NDDB also closed due to lack of business (Box 3).

Box 3: Experiments in modern markets

A modern wholesale market with sorting, grading and electronic auction facilities was set up by National Dairy Development Board in Bengaluru with FAO assistance. The market management looks after infrastructure management, facilitates business model which ensures price discovery, provides protection to sellers regarding realization of sales proceeds and facilitates to buyers the quality of produce. However, capacity utilisation of this market is sub optimal due to non-participation of traders, processors, exporters etc and its business is generally limited to local retailers.

Modern flower auction houses have been set up at Bengaluru, Mumbai, Kolkata and Greater Noida. These auction centres not only provide sorting & grading facilities, cold storages, and electronic auction system but also banking facilities, offices to producers and traders and value addition facilities. Management of these markets are responsible for function of market management, they facilitate a business model which ensures price discovery, protection to sellers to realise sales proceeds and provides quality assurance to the buyers. However, the auction house at Bengaluru is highly underutilized and those at Mumbai, Kolkata and Greater Noida have not started functioning for several years due to non-participation of traders and exporters.

SAFAL National Exchange of India Limited (SNX) was an initiative of National Dairy Development Board in collaboration with Multi Commodity Exchange of India (MCX) and Financial Technologies (India) Limited (FTIL). SNX was an electronic spot market which was set up to offer transparency and guarantee payment and delivery with quality for the benefit of sellers and buyers across the country. The exchange started operations in December 2007 and offered sale-purchase contracts in mango, onion, potato, tomato, grapes and banana. It closed down on March 31, 2009 for want of adequate business.

Source: Planning Commission, *op. cit.*

4.4 OTHER IMPORTANT ISSUES OF MARKETING AND PRICES OF HORTICULTURE PRODUCE

Organised retail chains like NDDB's SAFAL chain and outlets of private retail chains have not brought a difference in the wide variance between wholesale and retail prices of horticultural produce in urban areas. Direct selling of fruits and vegetables by farmers to consumers at reasonable prices has been introduced through Uzhavar Sandhais in Tamil Nadu, Apni Mandis in Punjab and Rythu Bazars in Andhra Pradesh. Town planning and traffic regulation concerns are often expressed against direct farmers' markets in urban areas. Town planning and traffic regulation perspectives should take into account the importance of direct selling of perishables to give a fair deal to both farmers and urban consumers by narrowing the gap between existing wholesale and retail prices.

Increased production through area expansion has occurred near existing production clusters of fruits. Marketing needs of these clusters can be met by introducing multi-modal transport system linking production clusters with major markets in consumption clusters.

Box 4: E-commerce in fruits and vegetables

The practice of marketing, required by market regulation, has prevented application of e-commerce in fruits and vegetables and kept producers and consumers apart. Recently in many cities online sale of fruits and vegetables has been started by some innovative vendors but it has no back-end support. Market regulations constrain online purchases from the farmers/producers which can be of immense benefit to producers as well as consumers.

Source: Chand, *op. cit.*

At present, market information for horticulture produce is collected by Directorate of Agriculture Marketing, DAC through the AGMARKNET Project. Market price and arrival is collected by mandi staff and uplinked on the AGMARKNET portal. The NHB also releases monthly and annual market bulletins. In the present scenario it is not possible to get real-time, truthful data regarding commodity arrival and price for agriculture / horticulture produce. Introduction of SOP can facilitate generation of real-time, truthful market information and market intelligence for horticulture produce.

Existing national grade standards should be harmonized with international grade standards; and should be made mandatory for fresh horticulture produce sold from organized retail chain outlets in packaged form. Once the consumer's awareness about quality standards increases and buyers' preference goes in favour of graded and quality produce, the other trade channels will reform themselves automatically for better standards.

(Planning Commission, *op. cit.*)

4.5 MODEL AGRICULTURE PRODUCE AND LIVESTOCK MARKETING, (PROMOTION AND FACILITATION) ACT 2017

The Model APLM Act was introduced in April 2017 to replace the APMC Act 2003. The key difference from the earlier Act is that it addresses all the components of the agricultural sector including the high value crops livestock, dairy, fishery etc. It also covers spices, herbal medicines and medicinal plants.

However, fruits and vegetables are outside the purview of the Act. The rationale for this is that the marketing system was earlier dominated by Government-led APMCs. The Act facilitates new markets in the private sector. The farmer has a choice and is not bound by any single market. At present, on average there is only one mandi per 465 square kilometers, thus entailing high transport costs for the farmer. Under the new Act, even the cold chain, cold storages, dry storages and silos where commodities are stored by farmers can be notified as markets. This enables the farmer to access a mandi or a market place as close as possible to his/her farm gate and then discover a price for his/her commodity. (S)he can go to any market at any place and sell to any buyer, so as to realize a better price. The objective is also to give the farmer the highest possible share of the market price through disintermediation. Intermediaries are removed unless they are adding some particular value to the produce which is transferred to the consumer.

The Act provides for regulation of markets within the government sector and private sector. The roles and responsibilities of two authorities are distinguished at the state level. One is the Managing Director of the Marketing Board who will serve as the CEO of all the APLMs which are government led. The Managing Director's role is to look after government markets and create an efficient system. The second is a regulator in the nature of a Director, Agriculture Marketing who will be the regulating authority. (S)he will give licenses, renew the licenses and regulate and ensure that all marketing channels, Government or private, adhere to the provisions of the new Act. The Director in a state can allow the licensee of another state to participate in the transaction within his/her own state. Multiple channels would have a level playing field and there would be regulation in terms of what fees are to be levied, how much is to be levied, and how to conduct the trade so that there is price discovery through an open, transparent and objective system of auction.

The Model Act facilitates the formation of a national market under the electronic National Agriculture Market or e-NAM which was inaugurated in April 2017. Today, as the country has been fragmented into different geographical areas, the number of traders has got limited and competition has got compromised. The objective of the Government is to create a state wide single market and thereafter a nationwide single market. APMCs will no longer have the power to give licenses to traders. An entire state will be declared as one single market and not fragmented into markets of different APMCs. The Director, Agriculture Marketing will have the power to give single trader licenses that will enable the holder to operate in all markets in a State, not in a single APMC as earlier. Single trader license, single point of levy and single regulatory system at the state level are seen as the steps towards creating a unified national market. Integration of all markets within a State will be done through a technology platform. The APLM Act allows for multiple electronic platforms, not just Government of India's e-NAM platform. States as well as private players can develop electronic platforms and offer them to the market, these multiple e-markets will be integrated into one State market. This will facilitate competition and ensure there is no monopoly of any single market or electronic platform. It will enable the move towards a more competitive environment where price discovery happens to the advantage of the farmers.

There are provisions in the Model Act that act against States setting rules that will restrict competition. For example, there is a cap on the market fee, one and half percent for fruits and vegetables and two per cent for food grains. There will be a single point of levy of market fee. Once the market fee is levied at the first point of transaction then at the second and subsequent transaction points, there will be no market fee.

5. RISK MITIGATION IN HORTICULTURE SECTOR

In the past, crop insurance has failed to provide relief to farmers. The reasons for failure include: a) reluctance on the part of governments to allocate adequate funds for providing subsidy required to support cost of insurance—exacerbated by the problems that arise when the central and the state governments have to agree on a subsidy-sharing formula; b) delays in payment of compensation—arising from bureaucratic hurdles in assessment of damage and disbursal of compensation; and c) inadequacy of the compensation amount in the case of crop failure (Agarwalla and Barua, 2017).

An analysis of nation-wide crop insurance data gathered by the National Institute of Securities Markets or NISM (through a survey conducted in 2014) concluded the following: a) average awareness about crop insurance country was only 38.8%, and

b) average usage of crop insurance was merely 6.7%. Awareness and usage varied widely across states. The low awareness, despite four decades of dissemination, indicates inadequate efforts by government to promote crop insurance. The low usage indicates that farmers either do not find crop insurance useful or are denied access to the insurance (*ibid.*).

In January 2016, the government announced a revamped crop insurance scheme, the Prime Minister's Fasal Bima Yojana (PMFBY), with the objective of removing the defects of extant insurance schemes. According to the government, farmers will get a higher claim for the full sum insured unlike the existing schemes. The new scheme will cover yield loss of standing crops, prevent sowing/ planting risk, post harvest losses and localised risks, including inundation. The new scheme is open to all farmers irrespective of whether they are borrowers or not. There will be one insurance company for the entire state, farm-level assessment of loss for localised risks and post-harvest loss. And private insurance companies, along with the Agriculture Insurance Company of India Ltd, will implement the scheme. In earlier schemes, the premium for commercial and horticulture crops was calculated on actuarial basis, meaning premiums could be as high as 25 percent depending on the risk factor involved. Under PMBFY, the premium to be paid by farmers will be 5 per cent. The premium rates to be paid by farmers are very low and balance premium will be paid by the government to provide full insured amount to the farmers against crop loss on account of natural calamities (LSS, 2016).

The Working Group on Horticulture for the 12th Plan had said that orchards of perennial crops like mangoes, dates, apples etc need to be covered by insurance schemes in line with Coconut Palm Insurance Scheme CPIS), or Weather Insurance Schemes for Tea and Coffee. For introduction of weather-based crop insurance scheme for crops like mangoes, dates, apples etc, it is necessary that ICAR scientists develop scientific protocols for loss assessment on the basis of weather data like temperature, humidity, wind speed, rain fall etc. Hi-tech, capital intensive infrastructure like poly-houses, net houses etc need to be covered by a suitable insurance scheme for which cost of premium may be shared between beneficiary, State and Central Govt on the ratio of MAIS or WBCIS. It needs to be examined whether PMBFY covers these aspects.

6. PER CAPITA CONSUMPTION OF FRUITS

The Recommended Dietary Allowance (RDA) for moderately active male individuals arrived at by the Indian Council of Medical Research (ICMR) includes 100 grams of fruit per capita daily. Fruits and vegetables are the major contributors of vitamin, mineral and fibre content to a balanced Indian diet recommended by ICMR (Rao, 2013). The Planning Commission had projected per capita *availability* of fruits at 120 grams by the end of 2015-16 (Planning Commission, *op. cit.*).

Fruit consumption data is captured by the household consumer expenditure surveys of the National Sample Survey Organisation (NSSO). A rural person consumed 4.18 bananas per month and an urban person consumed 6.69 bananas per month on average. A rural person consumed 58 grams of apple per month and an urban person 191 grams per month. Only 36.5 percent of rural households and 53.2 percent of urban households recalled consuming bananas in the previous 7 days. Only 8 percent of rural households and 22.7 percent of urban households recalled consuming apples in the previous 7 days. Per capita urban consumption of all commonly consumed fruits and nuts exceeded rural consumption whether measured in terms of value or quantity. Rural-urban disparities in consumption were relatively low in case of coconuts, mangoes, groundnuts and bananas, and high for apples, grapes and oranges (NSSO, 2014; see Table 3 and Box 4).

Table 3: Consumption of important fruits and nuts (all India)

Fruit/nut	Per capita consumption (in 30 days)				Percentage of consuming households (in 7 days)	
	Quantity		Value (in Rs.)			
	Rural	Urban	Rural	Urban	Rural	Urban
banana (no.)	4.18	6.69	8.12	15.31	36.5	53.2
orange, mausambi (no.)	0.40	1.02	1.51	4.48	5.3	12.4
apple (gm)	58	191	4.74	18.10	8.0	22.7
mango (gm)	160	202	4.79	8.33	10.4	13.4
grapes (gm)	38	84	1.97	4.84	7.3	13.0
papaya (gm)	53	81	0.91	1.76	4.0	6.1
Source: NSSO, 2014						

BOX 4: Consumption of fruits and vegetables among middle- and high-income groups in urban India

Consumption of fruits and vegetables is abysmally low among middle-and high-income groups in urban India, according to a survey conducted by the Indian Council for Research on International Economic Relations (ICRIER) in five Indian cities. The survey shows that the younger generation is consuming even less nutritious food than older people, primarily due to lifestyle choices.

The survey covered 1,001 individuals aged 18 years and above in the National Capital Region, Mumbai, Chennai, Hyderabad and Kolkata. The average intake of fruit and vegetables was 3.5 servings or 280 grams per day. It comprised of 1.5 servings of fruit and two servings of vegetables. This is much lower than the recommendation of five servings a day by the World Health Organisation.

For the age group 18-25 years, it is 2.97 servings per day. The average intake among students is abysmally low at 2.94 servings a day.

More than 500 respondents said that they are unable to eat proper food for lifestyle reasons like long working hours and consumption of junk food. Lack of availability of fruits and vegetables round the year and their high costs were cited as other important reasons.

Source: Singh (2016)

The NSSO survey on Household Consumption of Various Goods and Services in India, 2011-12 collected household expenditure data on fruits (Table 4).

Table 4: Monthly per capita expenditure on fruits by expenditure class (rural & urban)				
Fresh fruits	Monthly per capita consumption expenditure (Rs.)			
	Fractile 12 urban (top 5%)	Fractile 1 rural (bottom 5%)	Fractile 6 urban (40th-50th percentile)	Fractile 6 rural (40th-50th percentile)
	244.3	3.99	46.67	21.61
Source: Chakravarty, 2017				

Fractile 1 is the lowest 5% of the population in terms of consumption, fractile 12 is the top 5% of the population in terms of consumption, fractile 6 is the 40^{th}-50^{th} percentile, households that lie in the middle of the expenditure distribution. There is evidently a huge disparity in expenditure on fruits between the richest urban and poorest rural households. Even in the `middle' expenditure class, urban households spend more than twice as much on fruit compared to rural households.

But even the intake of fruits of the urban top 5 percent is modest. Their per capita consumption is 15 bananas a month, or one in two days. They have less than half a kilogram of mangoes a month and 200gm of watermelon. They have one coconut, 700gm of apples and 200gm of grapes in a month. The relatively well off 60^{th}-70^{th} percentile has seven bananas and1.1 oranges a month. The 40^{th}-50^{th} urban percentile has 5.8 bananas, three-fourths of an orange and 0.012 of a pineapple per month (Chakravarty, *op. cit.*)

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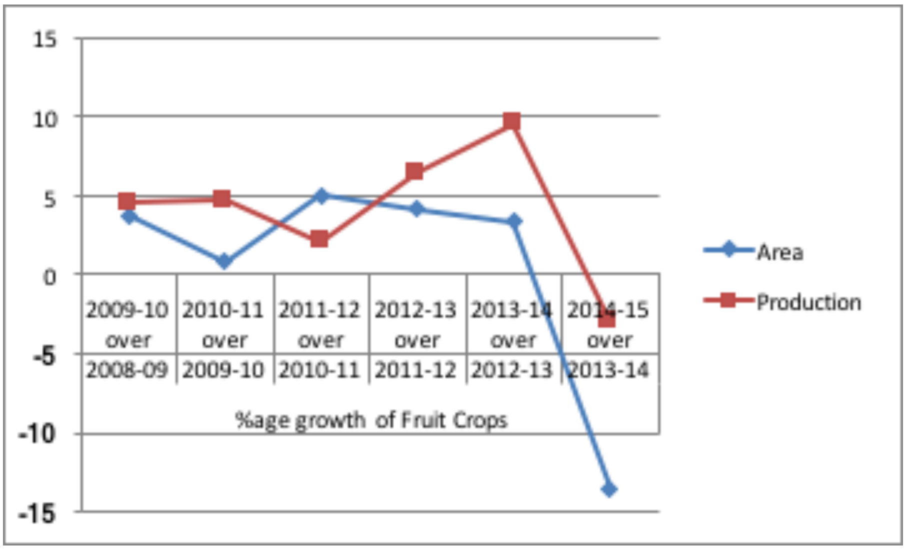
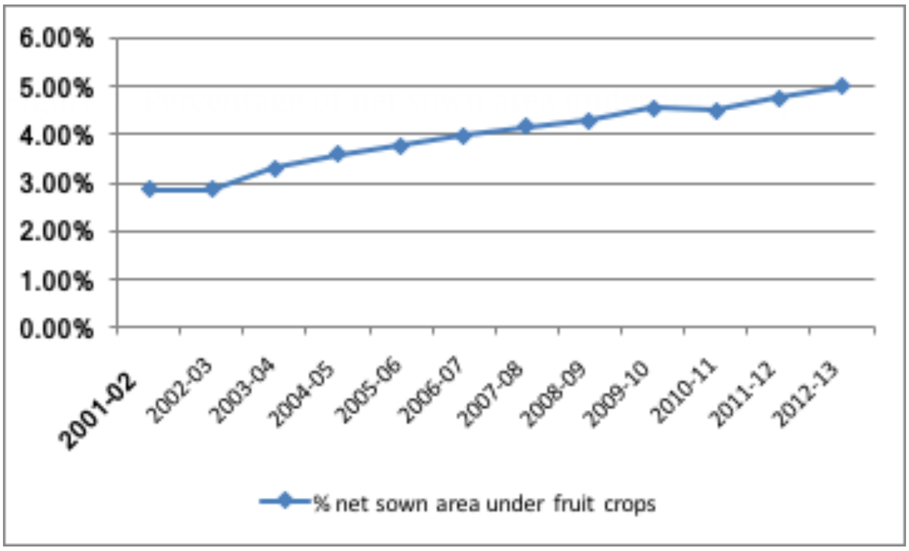
APPENDIX 1: AREA AND PRODUCTION OF FRUITS IN INDIA

Figure 1: Percentage increase in area and production of fruits (2008-09 to 2014-15)



Source: Based on data in Indian Horticulture Database 2014, National Horticulture Board, New Delhi

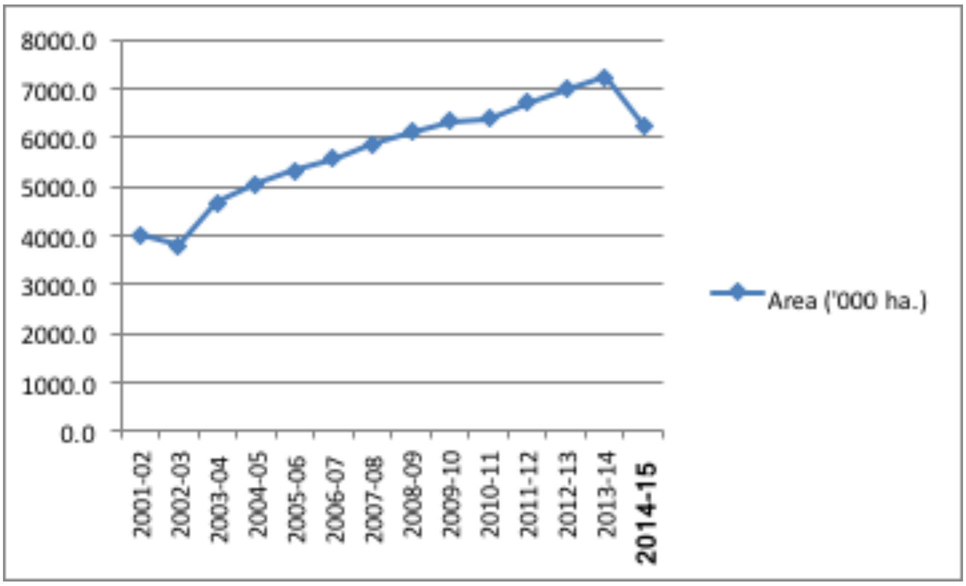
Figure 2: Percentage of net sown area under fruit crops



Source: Based on data in State of Indian Agriculture 2015-16; Ministry of Agriculture and Farmers' Welfare, New Delhi

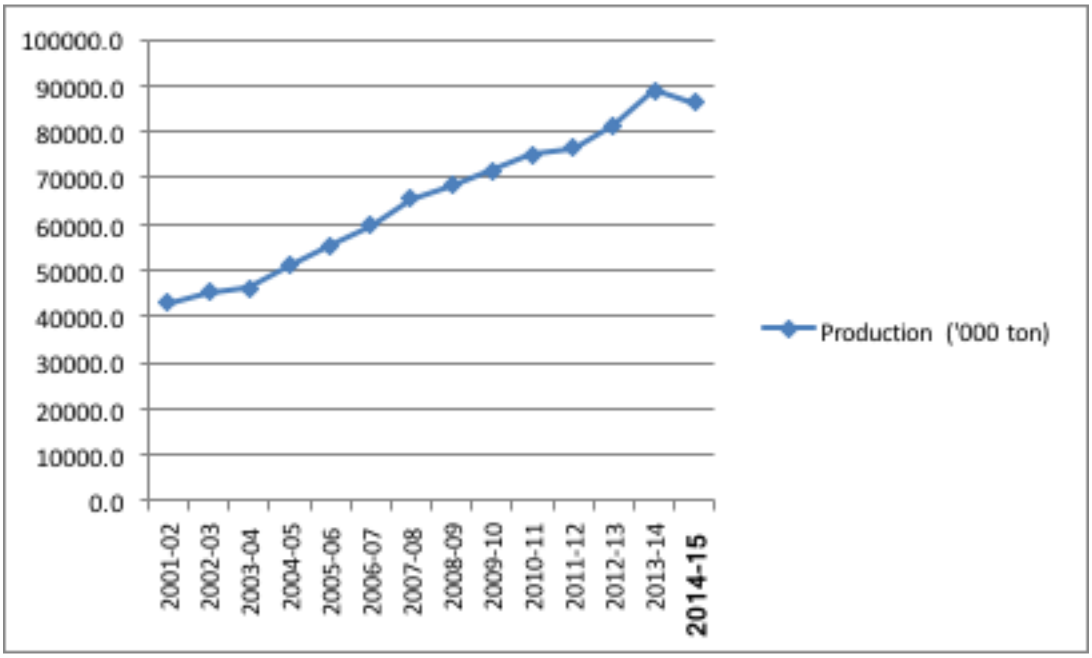
- In the eight years between 2007-8 and 2014-15, the average area under fruit crops is 64.47 lakh hectares and average production is 766.7 lakh tonnes
- In these eight years, the highest areas under fruits are under mango (36% of area under all fruit crops), `other fruits' (19%), citrus fruits (15%) and banana (12%)
- The highest production is of banana (36%), mango (21%), citrus fruits (12%) and `other fruits' (11%)
- There is considerable fluctuation in the annual growth rate of area and production of fruits over this eight year period

Figure 3: Area under fruit production in India (2001-02 to 2014-15)



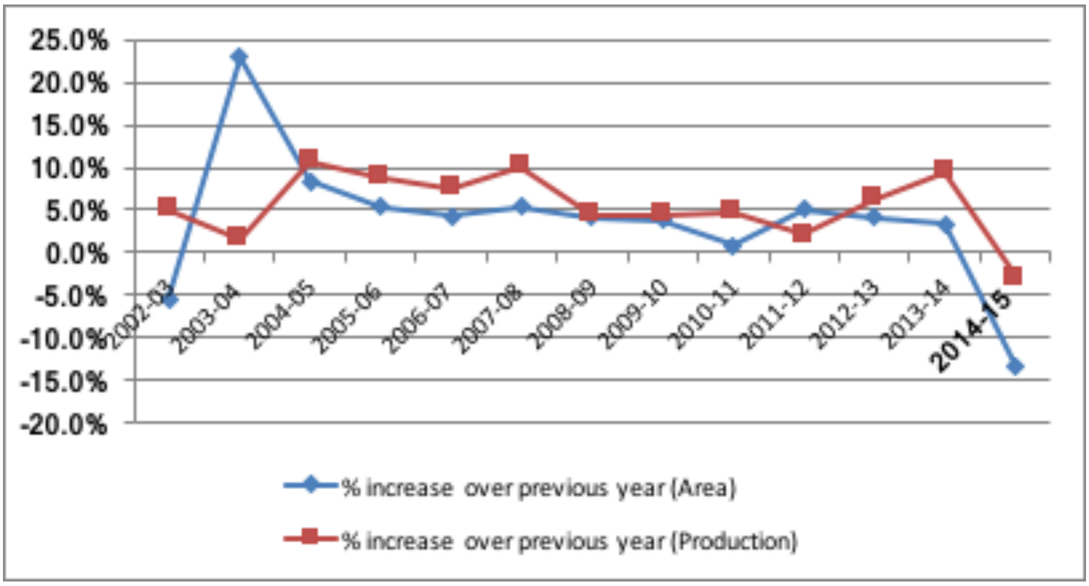
Source: Based on data from Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, New Delhi.

Figure 4: Production of fruits in India (2001-02 to 2014-15)



Source: Based on data from Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, New Delhi.

Figure 5: Annual percentage change in area and production of fruits in India (2002-03 to 2014-15)



Source: Based on data from Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, New Delhi.

- Between 2001-02 and 2013-14, there has been almost 80% increase in area and 107% increase in production under/in fruits
- But in the same period, the annual growth rate in area and production shows considerable variation
- The leading fruit-producing states between 2009-10 & 2014-15 are Andhra Pradesh, Maharashtra, Gujarat, Tamilnadu, Karnataka and Uttar Pradesh

Appendix 2: Status of APMC reforms in States and UTs

Table A2.1: Status of APMC reforms in States and UTs (November 2016)

S. No.	States & UTs	Private Market	Direct Marketing	Contract Farming	E –trading	Farmer Markets	Single Point Levy	Unified License	Deregulation /Exemption of Market Fee on F&V (as of April 2015)
1	Andhra Pradesh	✓	✓	✓	✓	×	✓	✓	No
2	Arunachal Pradesh	✓	✓	✓	×	✓	×	×	No
3	Assam	✓	✓	✓	×	✓	×	×	F & V de-notified 13.01.2014
4	Bihar	APMC Act Repealed in 2006							
5	Chhattisgarh	✓	✓	✓	✓	✓	✓	✓	Market Fee exempted 8.11.2012
6	Delhi	×	×	×	×	×	×		Deregulated in 3 market areas 2.09.2014
7	Goa	✓	✓	✓	✓	✓	✓	✓	No
8	Gujarat	✓	✓	✓	✓	✓	✓	✓	Yes
9	Haryana	×	×	✓	✓	×	×	✓	Market Fee exempted 7.02.14
10	Himachal Pradesh	✓	✓	✓	✓	✓	✓	✓	Market Fee exempted (except apple) 14.01.14
11	Jammu & Kashmir	APMC Act not reformed							
12	Jharkhand	✓	✓	✓	✓	✓	✓	×	
13	Karnataka	✓	✓	✓	✓	✓	✓	✓	Only User Charge collected 4.01.2014
14	Kerala	No APMC Act							

Table A2.1: Status of APMC reforms in States and UTs (November 2016)									
S. No.	**States & UTs**	**Private Market**	**Direct Market-ing**	**Con-tract Farming**	**E –trad-ing**	**Farmer Markets**	**Single Point Levy**	**Unified License**	**Deregulation /Exemption of Market Fee on F&V (as of April 2015)**
15	Madhya Pradesh	×	✓	✓	✓	×	✓	✓	Deregulated outside mar-ket yard (ex-cept banana) 27.01.2012
16	Maharashtra	✓	✓	✓	✓	✓	✓	✓	By Ordinance in July 2016, marketing of fruits, vegetables outside market needs no license or permission
17	Manipur	No APMC Act							
18	Meghalaya	APMC Act not reformed							Delisted F&V except potato 15.01.2014
19	Mizoram	✓	✓	✓	✓	✓	✓	✓	No
20	Nagaland	✓	✓	✓	×	✓	✓	✓	Exempted Market Fee 6.08.2013
21	Odisha	✓	×	✓	×	×	×	×	Delisting from F &V w.e.f. 16.03.2015
22	Punjab	✓	✓	✓	×	×	✓	×	No
23	Rajasthan	✓	✓	✓	✓	✓	✓	✓	Market Fee reduced to 0.01% 2013
24	Sikkim	✓	✓	✓	✓	✓	✓	✓	No
25	Tamil Nadu	✓	✓	✓	✓	✓	✓	✓	No
26	Telangana	✓	✓	✓	✓	×	✓	✓	NA
27	Tripura	✓	✓	✓	×	✓	×	×	No
28	Uttar Pradesh	×	×	×	✓	×	✓	✓	NA

Table A2.1: Status of APMC reforms in States and UTs (November 2016)									
S. No.	**States & UTs**	**Private Market**	**Direct Marketing**	**Contract Farming**	**E –trading**	**Farmer Markets**	**Single Point Levy**	**Unified License**	**Deregulation /Exemption of Market Fee on F&V (as of April 2015)**
29	Uttarakhand	✓	✓	✓	✓	✓	✓	×	NA
30	West Bengal	✓	✓	×	×	✓	×	×	Delisting from F &V w.e.f. 27.11.2014 (Except onion and potato)
31	Andaman & Nicobar Islands	No APMC Act							
32	Chandigarh	✓	✓	×	×	×	×	✓	NA
33	Dadra & Nagar Haveli	No APMC Act							
34	Daman & Diu	No APMC Act							
35	Lakshadweep	No APMC Act							
36	Puducherry	APMC Act not reformed							
Sources: SFAC (2015) and DMI (2016)									

Table A2.2: Fruits and vegetables in APMC regulations across States & UTs					
	Reform indicator/ State	**Fruits and vegetables out of APMC reg.**	**Provision in the Act**	**Notified**	**Fee/service charge**
1	A.P.	Not Followed	No	No	Yes
2	Arunachal Pradesh	Not Followed	No	No	Yes
3	Assam	Followed	Yes	Yes	Exempt
4	Bihar	Not Followed	No	No	Yes
5	Chhattisgarh	Partially Fol-lowed	-	-	Exempt
6	Goa	Not Followed	No	No	Yes
7	Gujarat	Followed	Yes	Yes	Exempt
8	Haryana	Partially Fol-lowed	-	-	Exempt
9	HP	Partially Fol-lowed	-	-	Partial Exempt
10	J&K	Not Followed	No	No	Yes
11	Jharkhand	Not Followed	No	No	Yes
12	Karnataka	Partially Fol-lowed	-	-	Service charge
13	Kerala	Not Followed	No	No	Yes
14	MP	Partially Fol-lowed	-	-	Partial Exempt
15	Maharashtra	Partially Fol-lowed	-	-	Exempt
16	Manipur	Not Followed	No	No	Yes
17	Meghalaya	Followed	Yes	Yes	Yes
18	Mizoram	Not Followed	No	No	Yes
19	Nagaland	Partially Fol-lowed	-	-	Exempt
20	Odisha	Followed	Yes	Yes	Exempt
21	Punjab	Not Followed	No	No	Yes
22	Rajasthan	Partially Fol-lowed	-	-	Exempt
23	Sikkim	Not Followed	No	N	Yes
24	Tamil Nadu	Not Followed	No	No	Yes

	Reform indicator/ State	Fruits and vegetables out of APMC reg.	Provision in the Act	Notified	Fee/service charge
25	Telangana	Not Followed	No	No	Yes
26	Tripura	Not Followed	No	No	Yes
27	Uttar Pradesh	Not Followed	No	No	Yes
28	Uttarakhand	Not Followed	No	No	Yes
29	West Bengal	Partially Fol-lowed	-	-	Exempt
30	A & N Islands	Not Followed	No	No	Yes
31	Chandigarh	Not Followed	No	No	Yes
32	D&N Haveli	Not Followed	No	No	Yes
33	Daman & Diu	Not Followed	No	No	Yes
34	Delhi UT	Partially Fol-lowed			
35	Lakshadweep	Not Followed	No	No	Yes
36	Puducherry	Not Followed	No	No	Yes

Table A2.2: Fruits and vegetables in APMC regulations across States & UTs

Source: Chand & Singh (2016)

Box A2.1: State-wise status on deregulation/ delisting and exemption of market fee on Fruits &Vegetables

1. Assam has cancelled Fruits and Vegetables from the relevant Schedule of the State APMC Act on 13.1.2014.
2. Delhi has ceased regulation outside redefined market yard'/ sub-yards' area of APMC, MNI, Azadpur, APMC, Keshopur and APMC Shahdara w.e.f 02.09.2014.
3. Chhattisgarh has exempted the market fee on Fruits and Vegetables w.e.f 19.12.2012 till further order.
4. Gujarat has cancelled Fruits and Vegetables from the schedule appended to the APMC Act on 16.04.2015 and has recently imposed user charge.
5. Himachal Pradesh has on 14.1.14, exempted mandi fee on all Fruits and Vegetables except Apple. Later on State imposed service charges in place of market fee.

6. Haryana on 7.2.2014 reduced market fee (1%) and HRDF (1%) on all Fruits and Vegetables from 1% to 0%.
7. Karnataka amended its State APMC Act on 04.01.2014 providing therein that no market fee is leviable on Flowers, Fruits and Vegetables. Instead, the Market Committee may collect user charges in respect of above articles
8. Madhya Pradesh has on 27.01,2012 put Fruits and Vegetables outside the ambit of market regulation when purchased or sold outside the notified market yard while continuing regulation on trade transactions taking place in the notified market yard. Subsequently, vide notification dated 8.11.2012, de-regulation on marketing of banana outside notified market yard was withdrawn.
9. Maharashtra through an ordinance on 5th July, 2016 made the provision in the Act that marketing of fruits, vegetables and condiments, spices and others (ginger, garlic, coriander and chillies) by any person outside the market shall not require any license or permission, and marketing of above agricultural produces shall not be regulated by Market Committee.
10. Meghalaya has omitted Fruits and Vegetables (except Potato) from the Schedule of the Meghalaya Agricultural Produce Market Act, 1982 on 15.01.2014.
11. Nagaland has on 06.08.2013 exempted collection of market fee on all Horticultural Commodities.
12. Odisha has excluded Fruits and Vegetables from the definition of notified agriculture produce on 16.02.2015.
13. Rajasthan has on 05.06.2013 reduced market fee to 0.01 % on Fruits and Vegetables and later imposed user charge.
14. West Bengal has excluded Fruits and Vegetables from the Schedule of the State APMC Act for the purpose of not levying the market fee in the State on 27.11.2014.

Note: In Bihar, Kerala, Manipur and Union Territories (except Chandigarh), there is no APMC Act hence there is no regulation on marketing of Fruits and Vegetables. Further, in Sikkim and J&K, APMC Act is not implemented.

Source: Answer to Lok Sabha question by Minister of State (independent charge) for Planning, Shri Rao Inderjit Singh on 2nd August 2017; http://164.100.47.194/loksabha/questions/QResult15.aspx?qref=56082&lsno=16, accessed on 4 September 2017.

ANNEXURE 16

THE SUCCESS STORY OF MAHARASHTRA'S HORTICULTURE

Vishwanath Giriraj , IAS[1]

Maharashtra Government pioneered the famous Employment Guarantee Act in 1977 whereby it guaranteed work to rural unskilled manual labourers needing work. Initially, only public works like roads, irrigation tanks, other water conserving structures and works in the forest department were offered. But it came to notice that there is scope to increase rural employment opportunities (and small and marginal farmer's farmlands, which constitute almost 75% of farm holdings) by improving their farmlands. This comprises about 85% of the lands in Maharashtra, where rain-fed, cereal and other crops were slowly becoming unviable and outputs were unpredictable due to the vagaries of the monsoon.

It was then that the Maharashtra Government introduced the horticulture scheme (popularly EGS horticulture) in 1990. It was an instant success from the first year. The scheme envisages financial support to the farmer for three years, 50% in the first year, 30% in second year, and 20% in the third. The critical inputs like good quality planting material (QPM), fertilizers, etc. were provided by the agriculture department and the cost deducted from the farmer's subsidy. In fact, the planting material was developed substantially in the nurseries of the four agricultural universities of the state. The most important feature of the scheme was funds were released in the second and third year only on basis of the plants' survival. Thus, second year releases were made only if there was a 75% survival rate and third year only if they had a 90% survival rate. All payments were made directly to the farmers' bank accounts.

The cost norms for each fruit crop were evolved, and it varied from one fruit to another. Slowly, more varieties were added to the earlier list and the three-year cost norms were made available. At present the following is the list:

Dryland horticulture: Mango, cashew, bher, sitaphal, tamarind, awala, jack fruit, kokam, among others.

Irrigated horticulture: coconut, oranges (both santhra and mosambi), chikoo, pomegranate, grapes, peru, anjir, lime, supari, among others.

1 Additional Chief Secretary (Expenditure) - Department of Finance, Government of Maharashtra

Other crops: jejoba, jatropha, rubber, spice, medicinal, bamboo, etc.

Before the start of the programme in 1990, about 2.42 lakh hectares were under fruit crops. Now in 2016-17 about 18.55 lakh hectares are under fruit crops, an increase of 900%. Around twenty-one lakh farmers have benefitted from this scheme over the years.

The Mahatma Gandhi NREGA was introduced in 2006. The state has shifted to NREGA in the last few years, as the same scheme is also available under NREGA, and the funds are now available from the Government of India. However, the experience is that the handling of NREGA is more complicated, since an elaborate attendance record of labourers have to be kept, whereas the earlier scheme was simpler.

The horticulture scheme has helped improve the farmers' income substantially. It greatly improved the economy of coastal Maharashtra districts (Konkan areas) and there was a sudden increase in mango, cashew and chikoo production. It reduced migration to Mumbai from Ratnagiri and Sindhudurg districts. It also improved the economy of Western Maharashtra (districts like Nasik, Ahmednagar, Solapur, Pune, Satara, Sangli). The local political leadership developed forward linkages for storage, marketing, and exports through cooperatives and entrepreneurs. Today Maharashtra is the No.1 state in fruit production in India.

ANNEXURE 17

DAIRY FARMING IN INDIA: A NOTE FOR THE FUTURE

Compiled by Prof. N. Punniamurthy[1]

(With inputs from Dr. Marimuthu Swaminathan and Dr. S. Satheshkumar)

[1] Professor and Head, Veterinary University Training and Research Centre, Ethnoveterinary Herbal Training and Research Centre, Thanjavur, Tamil Nadu

INTRODUCTION

Indian agriculture is a finely tuned farming ecosystem consisting of a delicate mosaic of land, animals and farmers. The farm animals are not mere animals; indeed they are companions, livelihood assets, saving banks, insurance for the future, religious symbols, energy and nutrient suppliers for crop cultivation, family food security systems, source of employment and cash income. This is more pertinent with cattle and buffaloes. Some aspects of synergy between crop production and livestock have been weakened in the present agriculture production system, one of the prominent examples being the reduced dependency on animals for farm draft power. The rapid growth of the livestock sector, especially the cattle and buffalo production system, is towards dairying and factors like growing demand for milk. Income changes and urbanization favours this growth. The livestock sector is indispensible in sustaining rural economy and livelihood.

- As per the report of the working group on animal husbandry and dairying – 11th five year plan: 2007-12, the livestock sector employs eight percent of the countries labour force, including many small and marginal farmers, women and landless agricultural workers.
- Milk production alone involves more than 30 million small producers, each raising one or two cows or buffaloes.
- The organic fertilizer produced by the sector is an important input to crop production, and dung from livestock is widely used as fuel in rural areas.
- Livestock also serves as an insurance substitute, especially for poor rural households. They can easily be sold during time of distress (Islam *et al.*, 2016).

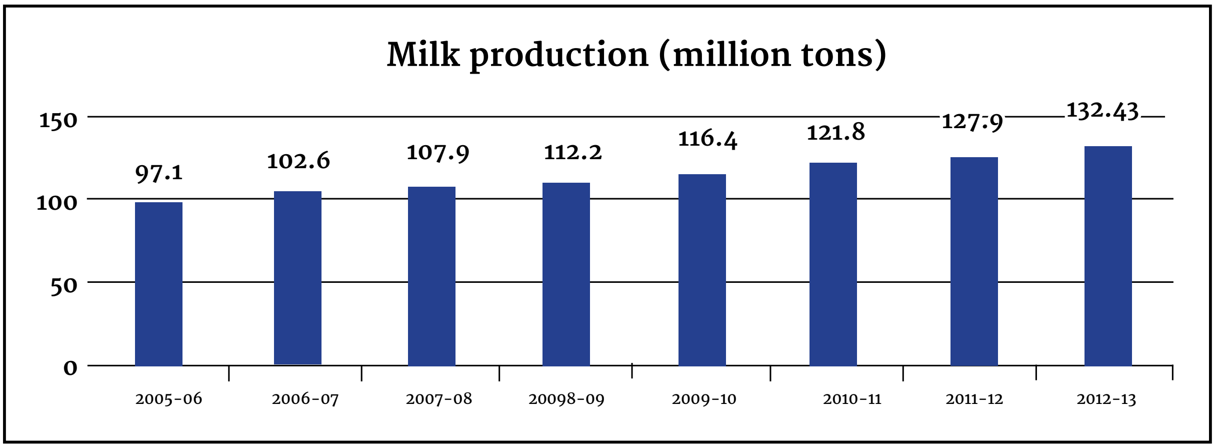
1. LIVESTOCK POPULATION

As per the 19th livestock census, 2012 (GOI, 2014) India's livestock sector is one of the largest in the world with a holding of 11.6% of the world livestock population, which consists of buffaloes (57.83%), cattle (15.06%), sheep (7.14%), goats (17.93%), camels (2.18%), horses (1.3%), pigs (1.2%), chickens (4.72%) and ducks (1.94%).

- India has a huge livestock population of 512 millions, which mainly includes cattle, buffalos, goats, sheeps and pigs. The total livestock population in India has decreased by 3.33% over the previous census.
- During the last intercensual period, there was a decrease in the population of cattle, sheep, goats and pigs by 4.1, 9.07, 3.82 and 7.54% respectively, while the population of buffalo and poultry increased by 3.19 and 19%, respectively.
- **The population of exotic and crossbred cattle registered a significant increase of 20.18% while the indigenous cattle decreased by 8.94%.**
- The contribution of cattle, buffalo, sheep, goats, pigs and others in the total livestock population is 37.28, 21.23, 12.71, 26.4, 2.01 and 0.5%, respectively.
- The livestock population in India has increased substantially in Gujarat (15.36%), Uttar Pradesh (14.01%), Assam (10.77%), Punjab (9.57%), Bihar (8.56%), Sikkim (7.96%), Meghalaya (7.41%) and Chhattisgarh (4.34%).
- With an annual milk production of 146.3 million tons, India ranks first in the world and contributes about 16% to the world milk production (GOI, 2014).
- India's milk production continuously increased right from 1950-51, when the total milk production was 17 million tons.
- In India, Uttar Pradesh produces the maximum amount of milk followed by Rajasthan, Andhra Pradesh, Gujarat and Punjab.
- Tamil Nadu is the largest producer of exotic/crossbred cow milk in the country followed by Maharashtra.
- The state of Uttar Pradesh is the largest producers of indigenous/non-descript cow milk followed by Rajasthan.
- Buffalo milk production predominates in the states of Uttar Pradesh, Andhra Pradesh, Rajasthan, Punjab, Haryana, Gujarat, Madhya Pradesh and Maharashtra with highest buffalo milk production by Uttar Pradesh.
- Uttar Pradesh also produced the maximum goat milk followed by Rajasthan. The share of milk production in 2012-13 was the highest from buffaloes, followed by exotic/crossbred cows, indigenous/non descript cows and goats with 51%, 24%, 21% and 4% of the total milk production, respectively.

2. MILK PRODUCTION IN INDIA AND ECONOMIC CONTRIBUTION OF THE LIVESTOCK SECTOR

Globally, India ranks first in terms of milk production and produces about 17% of the world milk production. The milk production increased from 102.6 million tons at the end of the Tenth Plan (2006-07) to 127.9 million tonnes at the end of the Eleventh Plan (2011-12). The contribution of different species for the total milk production: crossbreds - 23%, indigenous – 20%, buffalos- 53% and goats – 4%. Milk production in the beginning of Twelfth Plan (2012-13) is 132.43 million tons with an annual growth rate of 3.54%. The per capita availability of milk is around 296 grams per day in 2012-13. Growth in milk production from 2005-06 to 2012-13 is shown in the following chart (DAHD, 2014)



The contribution of livestock and fishery sectors to the national economy in terms of GDP at current prices are 4.1% and 0.8%, respectively during 2012-13. Agriculture and allied sector alone contributed about 15.1% to the total GDP. Out of the total agricultural GDP, the livestock sector contributed about 27.25% during 2012-13. As per the report of the working group on animal husbandry & dairying - 12th five year plan: 2012-17, the livestock sector grew at an annual rate of 5.3% during the 1980s, 3.9% during the 1990s and 3.6% during the 2000s. Despite deceleration, growth in the livestock sector remained about 1.5 times higher than in the crop sector, which implies its critical role in cushioning agricultural growth. The value of output in 2012-13 from the livestock sector was Rs. 53,75,370 million at current prices. Livestock has been an important source of livelihood for small farmers and has contributed about 16% to their income (Planning Commission, 2012).

- The traditional milk sector has enormous size, spread, reach and impact potential.
- Traditional vendors are present in large proportions even in places where a number of players in the organised sector are present.
- With increasing urbanisation, the proportion of milk handled by traditional vendors in the market is diminishing but still substantial quantities are handled and are expected to continue to do so for long.
- The traditional sector provides an important livelihood option for a large number of smallholder dairy farmers and milk vendors.
- In production points where there is no organised sector due to difficulty in access or unviable quantities for operation, vendors play an important role.

3. PER CAPITA AVAILABILITY OF MILK IN INDIA

The per capita availability of milk in India has increased from 130g per day in 1950-51 to 299g per day in 2012-13, which is a little above the recommendation of ICMR i.e. 285g per day. Per capita per day availability of milk is maximum in Punjab (961g) followed by Haryana (767g), Rajasthan (555g), Tamil Nadu (541g) and Gujarat (476g).

4. COMPARISON OF NATIVE LIVESTOCK WITH IMPORTED IN MANAGEMENT

- In the past two decades the increase in demand was met mainly by expanding the livestock population.
- However, declining land areas per agricultural population forces India to intensify livestock production.
- The emphasis so far has been on disease management, labor efficiency, management practices and increasing yields.

- Today, we are faced with an extraordinary set of challenges of increasing food production of animal origin with all the other limitations like land, water, weather, etc and the question is how would we meet these demands.
- Most of the feed comes from grazing, although a small portion of concentrate feed containing various feed additives for enhancing milk production is being given to cattle.
- Most of the feed manufacturers in India make both poultry as well as cattle feed. The demand for usage of cattle feed will grow if the feed is economically viable.
- The challenge is to make a nutritionally competent feed using low-grade fibrous crop residues, which are mainly byproducts from other industries, along with feed additives.
- The cost of milk production is much higher with the crossbreeds. However, the crossbreeds are high-maintenance animals and are disease-prone.
- The feed requirements of native breeds are very minor. Their feed-to-milk conversion is good. Farmers in Kerala have endorsed their short breed, Vechur, saying they have the potential to produce highly-priced milk even with kitchen scraps and leftovers.

5. NEED FOR PROTECTION AND IMPROVEMENT OF NATIVE LIVESTOCK

Part of the productivity increase is due to the introduction of crossbreeding policies, which allowed farmers to favour certain traits in their livestock. But selective breeding is not without its drawbacks: over time, too much focus on productivity can lead to other genetic traits being phased out – including those that make traditional breeds uniquely adapted to their local environments. Traditional livestock are more adaptable to local conditions and environmental challenges. Hence scientists along with farmers are working against the clock to save traditional breeds before they disappear in favour of more productive crossbred cows.

The cost of inputs starting from the cost of the cow to the day-to-day expenditures of the crossbred cows is always high. Sustainability is the key issue.

Longevity is another important issue favouring native breeds, despite their apparently low milk yield.

With the promise of short-term productivity, many rural farmers prefer crossbreeds, rather than locally adapted livestock. But the morbidity and mortality of non-native animals is high because they are poorly adapted to the local climate, and are vulnerable to local diseases. For example, Holstein Friesian crossbred cows threatened by Foot and Mouth disease causes wasting and death in up to a million livestock animals each year. Cows of the native breed carry genetic resistance to the disease.

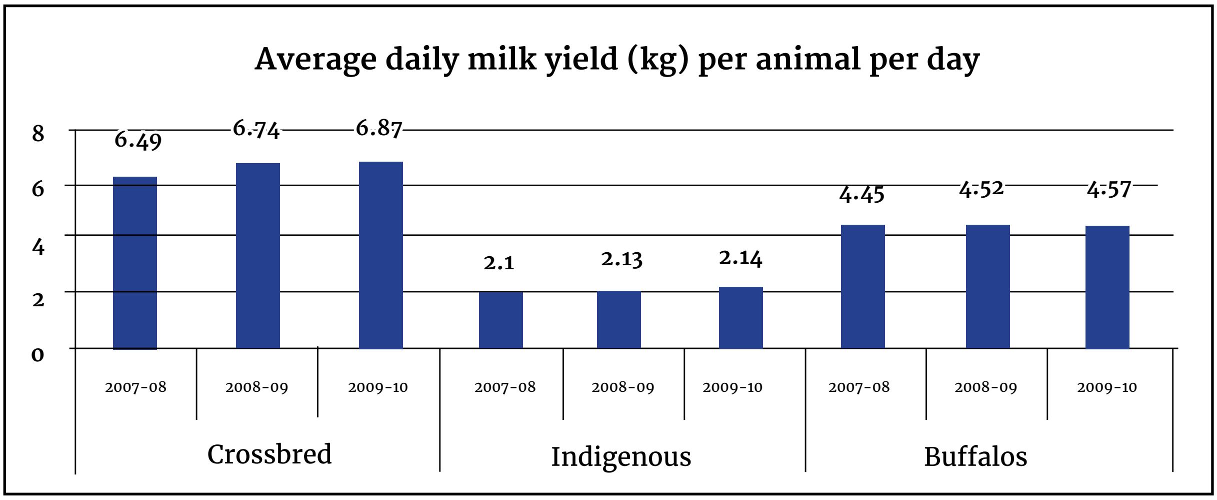
A 2012 report by Kerala state Animal Husbandry Department stated that the State's new breeding policy limited exotic [that is, non-native] germplasm to 50 percent of cattle and encourages propagating of native breeds by adopting artificial insemination programs with the semen of native bulls. It also stated that the milk of the Vechur breed has medicinal qualities recorded by Ayurveda ages ago. In more recent times, studies at the Kerala Agricultural University have also shown the percentage of fats and total solids of the Vechur cow to be higher than those found in crossbred cows. The smaller size of the fat globules in the Vechur's milk makes it more suitable for infants and the sick.

Hence, maintaining the genetic diversity of traditional livestock breeds is a more urgent problem in developing countries than it is in developed nations.

6. POLICY RECOMMENDATIONS FOR PROTECTING AND IMPROVING NATIVE LIVESTOCK

We need to develop emergency plans for endangered breeds in the case of epidemic outbreaks, and build up gene banks for native livestock. We need to encourage more breeders to take part in conservation programmes. Striking a balance between traditional genetic adaptations and modern productivity traits is essential for future livestock breeding programmes. *An optimal breed is one that is well adapted to local conditions, able to feed mostly on available (fodder) resources, and able to produce quality products.*

To conserve the genetic resources of native livestock:



(1) it is necessary to keep them in the form of live animals and/or

(2) in the form of sperm, oocytes, embryos, cells, chromosomes and genes that can be stored by applying cryogenic techniques.

Each method has some advantages and disadvantages. Cryogenic samples which are collected and frozen can be permanently preserved and, except for accidents within the storage system, they remain available under the same conditions as those at the time of sampling, any time in the future. Although it is expensive to initiate frozen collections, once they have become established, the cost associated with equipment maintenance, such as liquid nitrogen supply, is low.

Live animal conservation has a number of advantages over frozen cryo-preservation for the following reasons:

(I) cultural-historical reasons

(2) the opportunity to investigate topical or new traits in the population all the time.

(3) maintaining people's awareness of the existence of the breeds and interest in the frozen materials (Obata and Takeda, 1993).

- As a variety of native livestock have played important roles in the history and development of their respective area of origin, these breeds should be conserved.

- It is important to train people who are interested in native livestock.
- To reduce inbreeding in a small population, it may be desirable that individual farmers become organized in associations to control the breeding of the animals.
- Such associations which maintain the same pure breed need to appeal to public opinion to obtain appropriate subsidies for production along with programs of conservation.

7. ETHNOVETERINARY MEDICINE FOR LIVESTOCK HEALTH CARE

Man has no power of altering the absolute conditions of life; he cannot change the climate of any country. He adds no new element to the soil but he can remove an animal or plant from one climate or soil to another, and give it food on which it did not subsist in its natural state. From a remote period, in all parts of the world, man has subjected many animals and plants to domestication or culture.

Domesticated livestock have been contributing to food and agriculture for more than ten millennia, providing meat, milk products, eggs, fibre, manure for crops, fuel and draught power. As of today it is estimated that, directly and indirectly, domestic animals supply one third of total human requirements for food and agriculture and also reduce farmers' exposure to risk and generate employment.

Globally, the resource-poor rural farmers rely on ancestral folk herbal knowledge to deal with the diseases of their livestock and poultry. Veterinarians show considerable interest in the medicinal plants employed in traditional systems. Qualified veterinary physicians around the world require orientation on the traditional folk veterinary medicine systems.

This emerging trend in favour of herbal medicine is partly due to the issues related to the antimicrobial drug resistance and drug residues in foods (milk/meat/eggs) of animal origin. Farmers having either one or two cattle, goats, sheep or chicken need affordable access to primary veterinary healthcare at the earliest. These scattered livestock holdings provide subsistent income for landless labourers, especially farmwomen even in drought conditions. Commercialization of these components of animal husbandry could undermine this important income generation source of the rural poor.

There is an urgent need to promote use of Ethnoveterinary medicine (EVM) on a wider scale for sustainable livestock production. Popularising EVM on pragmatic lines will help conserve biological diversity. EVM is a cost effective and environmentally sound idea for sustainable livestock production in the villages.

The Indigenous Technical Knowledge (ITK) is regarded as the information gained over a period of time passed on from generation to generation. ITK is a community-based functional knowledge system, developed, preserved and refined by generations of people through continuous interaction, observation and experimentation with their surrounding environment. It is a dynamic system, adopting and adjusting to the local situations and has close links with the culture, civilization and religious practices of the communities. The communities have developed the indigenous knowledge system to conserve and utilize the biological diversity of their surroundings. It provides useful clues for planning projects for conservation of biological diversity, sustainable uses of natural resources, indigenous health practices, as well as World Bank and FAO-run programs focusing on indigenous knowledge.

Socially conscious groups support rural people to appreciate, test and improve their own indigenous traditional values and practices. About two thirds of the biologically active plant derived compounds currently used globally have been discovered through ethno-medical leads. In India, efforts for pharmacological and clinical validation of Ethnoveterinary herbal preparations have resulted in a number of publications on EVM, but have not been widely followed clinically.

The Tamil Nadu Veterinary and Animal Sciences University has taken a lead in this direction and has government-sponsored programs (Part II scheme of Government of Tamil Nadu and ICAR network programme) to train farmers and veterinarians in EVM for primary health care of livestock. Many of the EVM preparations are readily available and found to be location specific, as well as environment friendly - making the resource-poor livestock farmers self-reliant in primary healthcare of livestock. A decade long work by the Centre for Ethnoveterinary Herbal Training and Research at Tamil Nadu Veterinary and Animal Sciences University on the use of various fresh herbal recipes under field conditions proved to be successful clinically for a variety of ailments across a host of species of the livestock / poultry. Over 5000 farmers and 500 veterinarians have been shown to use EVM-based herbal preparations for the primary health care of livestock, in a standalone mode.

TANUVAS has been associated with the Trans-Disciplinary University (FRLHT), Bangalore, India in mainstreaming ethnoveterinary practices into modern veterinary curriculum and research and has launched a Post-Graduate diploma in Ethnoveterinary Practices (EVP) for veterinarians around the world through distance learning since 2011-2012. This effort will help traditional expertise in the long run to be more readily integrated with current medical knowledge in addressing local, regional and global healthcare issues of livestock and also help produce drug-residue free milk, meat and eggs for the food basket.

Understanding foraging as the dynamic quest to achieve homeostasis will lead to implementing management programs (wherever possible) where herbivores have access not only to diverse and nutritious foods but also to secondary metabolites of medicinal plants. Traditional production systems have viewed animals as partners in taming nature. Herbivores adapt to the external environment and to their changing internal needs not only by generating homeostatic physiological responses, but also by operating in the external environment. Most natural landscapes are diverse mixes of plant species that are literally nutrition centers and pharmacies with vast arrays of primary (nutrient) and secondary (pharmaceutical) compounds.

Following the ban on the use of antibiotics and other chemicals, fearing the risk caused to humans by chemical residues in food and by antibiotic resistance being passed on to human pathogens, scientists have intensified efforts in exploiting plants, plant extracts or natural plant compounds as potential natural alternatives for enhancing livestock productivity.

Natural products, such as primary and secondary metabolites of plants, plant-derived alkaloids, terpenes, sesquiterpene lactones and phenolics can benefit herbivores by, for instance, combating internal/external parasites, controlling populations of fungi and bacteria, and enhancing nutrition.

The simplification of agricultural systems to accommodate intensive livestock production, coupled with a view of secondary compounds as toxins, has resulted in a selection of biochemical balance in forages favouring primary (mainly energy) and nearly eliminating secondary compounds.

Ecto-parasites (e.g., mites, lice, flies, and ticks) can distract livestock from grazing, damage hides, cause infections, and transmit diseases. Current parasite control methods rely on a combination of management methods and chemotherapeutics (insecticides and repellents).

Alternatives to the commonly used chemotherapeutics are needed for several reasons:

- The available treatments against parasites/microbes are becoming less effective. Parasites/microbes are becoming increasingly resistant to almost every chemical class of available compounds.
- Plant-derived alkaloids, terpenes, sesquiterpene lactones and phenolics can benefit herbivores by, for instance, combating internal/external parasites.
- There are environmental pollution and human health concerns with the available treatments. For example, ivermectin (endectocide) can potentially kill beneficial soil microorganisms and parasites develop resistance against it rapidly. Many of the chemicals for ecto-parasite treatments are organophosphates, which are cholinesterase inhibitors.
- There is a growing desire among the general population for more natural and environmentally friendly farming systems and they are looking for (organic) residue-free foods of animal origin.
- Use of fresh herbs empowers farmers (especially women) in times of need, wherever early intervention is crucial in livestock health care, especially rural areas.

CONCLUSION

The availability of alternative system of medicines such as herbal medicines and ethno-veterinary practices together with the existence of significant levels of genetic variation in respect to disease resistance and susceptibility within the indigenous cattle and buffalo breeds provides an opportunity to control the use of antibiotics in dairy production. TANUVAS has perfected traditional veterinary practices to deal with various disorders and infections of livestock.

Therefore, integrating appropriate breeding strategies and genetic improvement programs using the cattle breeds which are genetically resistant to infections, with systematic application of traditional veterinary practices such as ethno-veterinary systems of animal treatment will definitely pave the way for developing a dairy production system which is free of synthetic drug residues and antibiotics.

In India, where the dairy production is one of the important income sources for the farmers and the state, the combined approach of targeted breeding and traditional systems of veterinary medicine is a crucial factor to ensure a sustainable dairy production. In realization, Government of India has established a program (Gokul Mission) for promotion, conservation and sustainable utilization of Indigenous Animal Genetic Resources with emphasis on cattle genetic resources.

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ANNEXURE 18

FRUITS: HEALTH BENEFITS

Authors: Ms. Lovely Gupta and Dr. Priti Rishi Lal
Department of Food and Nutrition, Lady Irwin College
Correspondence: drpritirishilal@gmail.com

INTRODUCTION

In a dual burden in India, the prevalence of chronic energy deficiency ranges from 33.2% -49% and the prevalence of chronic diseases due to over nutrition ranges from 4.8 - 40.0%.[1,2] As a triple burden, it is reported that almost one third population is suffering from vitamin and micronutrient deficiency. [2] While the availability of different food groups (per caput/g/day), in India, as per ICMR, reports the availability of food grains to be sufficient, it does not mention fruit availability or consumption. The National Institute of Nutrition (Indian Council Medical Research, 2017) formulated the dietary goals and guidelines for the consumption of plenty of vegetables and fruits.[1] Furthermore, World Health Organization (WHO) recommends an intake of five to eight portions (400–600 g) daily of fruits and vegetables to reduce risk of cardiovascular disease, cancer, poor cognitive performance, other diet-related diseases as well as for the prevention of micronutrient deficiencies.[3]

Fruits are a rich source of a variety of nutrients and biologically active compounds that can have complementary and overlapping mechanisms of action, including detoxification, enzyme modulation, antioxidant effects, functioning as antioxidants, phytoestrogens, and anti-inflammatory agents.[4]

NUTRITIONAL COMPOSITION

Fruits and vegetables are generally low in energy density with the nutritional contribution of standard servings of fruits and vegetables varing widely. They are relatively low in calories and fat, have no cholesterol, are rich in carbohydrates and fiber, contain vitamin C and carotene and some are a good source of vitamin B6. Fruits and vegetables are relatively low in sodium and high in potassium.[4] The consumption of different fruits play basic roles in human health care and exhibit beneficial effects owing to the presence of vitamins, trace minerals, fructose, dietary fiber and chemical compounds called phytochemicals.[4,5] Hence, they may prove to be a promising tool for the prevention and/or amelioration of a wide range of diseases.

RECOMMENDED DIETARY ALLOWANCES (RDA)

The Expert Committee of the ICMR, taking into consideration the nutrient requirements, has recommended that every individual should consume at least 300 g of vegetables (GLV : 50 g; Other vegetables : 200 g; Roots & Tubers : 50 g) in a day with a minimum consumption of 100g fresh fruits per day for Indian adult population. It further formulates a guideline to increase consumption for the elderly and increase the RDA of 100g of leafy vegetables to meet additional requirements of iron and folic acid among pregnant women. Moreover, high calorie vegetables and fruits are recommended to be restricted for over weight/ obese subjects.[1,5]

PROTECTIVE COMPONENTS

As per ICMR, fruits and vegetables are hub of protective components such as flavonoids, folic acid, selenium, dithiolthiones, glucosinolates, indoles, isothiocyanates, coumarins, protease inhibitors, plant sterols, isoflavones/ lignans, saponins, inositol hexaphosphate, allium compounds, limonene.[1,4] They also provide phenolic acids (flavonoids, stilbenes, coumarins, and tannins), alkaloids, nitrogen-containing compounds, organosulfur compounds, phytosterols, and carotenoids.[6] The protective mechanisms of fruit and vegetables include their alkaline properties, electrolyte properties also besides functional properties, such as low glycemic load and energy density.[7]

BENEFICIAL EFFECTS

Since vegetables and fruit include roots, leaves, stems, fruit, and seeds from >40 botanical families, they have the potential to contribute significant variety and complexity to the human diet.They slow or prevent the onset of cardiovascular disease, several common cancers and other chronic diseases. The phytochemicals in cell-culture systems and animal models provide a wealth of information on the mechanisms by which a diet high in fruit and vegetables may lower the risk of chronic disease in humans. Protective effects are demonstrated (besides fibre), for alpha-tocopherol against prostate cancer; combinations of retinol and zinc and b-carotene, a-tocopherol, and selenium against stomach cancer; and selenium against total, lung, and prostate cancers.[8,9,10]

Fruits and vegetables, being rich sources of vitamins such as vitamins C and E, fiber, minerals, folic acid, a-tocopherol, vitamin A precursor b-carotene, zinc and selenium, strongly reduce the risk for cancers of the mouth and pharynx, esophagus, lung, stomach and colon while moderately reduce cancers of the breast, pancreas, and bladder. They function to modify the metabolic activation and detoxification/ disposition of carcinogens, or even influence processes that alter the course of the tumor cell.[7,10] ⊠-Carotene is an excellent dietary antioxidant which may prevent lung cancer.[6] The liver superoxide dismutase and catalase activities, erythrocytes glutathione peroxidase and thiobarbituric acid-reactive substances are significantly reduced by fruit juices and increased HDL cholesterol.[11] Substantial intake may cause subsequent favourable changes in anthropometry and insulin levelsin combination with improved nutritional markers and health benefits in the long term.[12]

Grapefruit (Citrus paradisi) is used in traditional medicine as an antimicrobial, antifungal, anti-inflammatory, antioxidant, and antiviral, as an astringent solution and as a preservative agent. As an excellent source of many phytochemicals and nutrients like vitamin C, folic acid, phenolic acid, potassium, calcium, iron, limonoides, terpenes, monoterpenes, and D-glucaric acid, it also contain varieties also contain beta-carotene and lycopene, antioxidants that the body can convert into vitamin A. The flavonoid present has the greatest concentration of naringin, which humans metabolize into naringenin. Evidence support its beneficial role in cellular regeneration, cholesterol reduction, the detoxifying process, in the maintenance of heart health, in rheumatoid arthritis, for the control of body weight, and in cancer prevention.[13]

Blueberries/cranberries (Vacciniumspp)has been beneficial in cardiovascular diseases, neurodegenerative diseases and other diseases associated with aging, in obesity, and in some human cancers (mainly esophageal and gastrointestinal with the possible agents responsible being diverse phenolic-type phytochemicals such as flavonoids (anthocyanines, flavonols, and flavanols); tannins [condensed tannins (proanthocyanidins) and hydrolyzable tannins (ellagitannins and gallotannins)]; stilbenoids and phenolic acids. Oxidative stress (OS) and dysfunction of cellular immunity are important indicators in the pathogenesis of hepatic diseases caused by diverse xenobiotics. The anthocyanins present show antioxidant, anticarcinogenic, and anti-inflammatory biological activity.[13]

Grape (Vitisvinifera L)- The leaves, as well as the fruit, are a stupendous source of vitamins and minerals and other active ingredients responsible for exhibiting laxative, astringent, diuretic, cicatrisant, immunological stimulant, anti-inflammatory, hypocholesterolemic activities, as well as chemopreventive activity against cardiovascular disease and some cancers (mainly prostate and colon).[13]

TABLE 1: POTENTIAL DISEASE-PREVENTIVE MECHANISMS OF ACTION EVIDENCED IN HUMAN DIETARY STUDIES[5,8,11,13]

Antioxidant activity	Unfavourable balance between free radical generation and antioxidant defences leads to oxidative damage Free radicals are formed endogenously as a result of normal oxidative metabolic reactions; exogenously as components of tobacco smoke, diet, drugs, and other environmental pollutants; and indirectly through metabolism of certain solvents and by radiation If not quenched by antioxidants, these free radicals alter the structure and function of several cellular components, such as lipid-containing cell membranes, lipoproteins, proteins, carbohydrates, RNA, and DNA It leads to cardiovascular disease, cancer initiation, cataract formation, the aging process, inflammatory diseases, and a variety of neurologic disorders Theantioxidantdefense system prevent radical formation, remove radicals before damage can occur, repair oxidative damage, eliminate damaged molecules, and prevent mutations. Fruits and vegetables are significant sources of the antioxidant enzymes (metalloenzymes) the antioxidant vitamins C and E and b-carotene and flavonoids decrease plasma lipid peroxide concentration. Ascorbic acid, a-tocopherol, polyphenols, and fruit and vegetable extracts inhibit N-nitroso compound formation by destroying nitrosating agents
Modulation of detoxification enzymes	Numerous constituents of plant foods, including flavonoids, isothiocyanates, and allyl sulphides may modulate of the CYP monooxygenases (which catalyze oxidation, hydroxylation, and reduction reactions—convert hydrophobic compounds to reactive electrophiles in preparation for their reaction with water-soluble moieties to improve excretion)
Stimulation of the immune system	Nutrients and other constituents of fruit and vegetables can affect almost all aspects of the immune system Nutrients and phytochemicals tend to affect Natural killer (NK) cells activity without influencing cell number which is a component of the antitumor host defenses during tumor growth and metastasis Supplementation with vitamins C and E results in a transient increase in cytokine production

Decrease in platelet aggregation	Grape juice may favorably modulate platelet aggregation and eicosanoid production, the anti-aggregatory actions of the polyphenols resveratrol and quercetin on platelets from humans
Alteration in cholesterol metabolism	Isolated dietary fibers from vegetable and fruit sources(like pectin) show hypocholesterolemic action in humans Addition of pectin- and fiber-containing foods to experimental diets also lowers plasma cholesterol to varying degrees Possible mechanisms include increased excretion of fecal bile acids and neutral steroids, altered ratios of primary to secondary bile acids, increased fecal cholesterol and fatty acid excretion and indirect effects, such as high-fiber foods replacing fat- and cholesterol-containing foods in the diet
Modulation of steroid hormone concentrations and hormone metabolism	Lowers circulating concentrations of sex steroid hormones, increase fecal excretion of estrogens and different hormonal profiles May influence metabolism of endogenous steroid hormones Alter the potency of testosterone, estrogen, and their derivatives via oxidation and hydroxylation reactions
Blood pressure reduction	Maintenance of normal blood pressure helps to prevent heart disease, kidney disease and stroke Higher intakes of dietary fiber and minerals from fruits and vegetables help to to reduce blood pressure
Antibacterial and antiviral activity	Cranberry juice is believed to treat urinary tract infections in women

ALKALINE PROPERTIES OF FRUITS AND VEGETABLES

The metabolic, enzymatic, immunologic, and repair mechanisms function at their best when an alkaline environment is maintained in the body. Most vegetables and fruits act as mineral-buffering reserves containing higher proportions of alkaline-forming elements that are essential to the maintenance of sustained health. Increased fruits and vegetables may improve the K/Na ratio, help prevent plaque formation in blood vessels, stop calcium from accumulating in urine, prevent kidney stones, build stronger bones, and boost the immune system. It helps to balance body pH, reduce morbidity and mortality from numerous chronic diseases or ailments such as hypertension, diabetes, arthritis, vitamin D deficiency and low bone density. It causes more alkaline urine pH level which helps protect healthy cells and balance essential mineral levels. The resultant increase in growth hormone may also improve many outcomes from cardiovascular health to memory and cognition. It may lead to increase in intracellular magnesium, which is required for the function of many enzyme systems, may reduce acid load leading to preservation of muscle mass in older men and women and may further activate vitamin D to provide its beneficial effects in the vitamin D apocrine/exocrine systems. Additionally, it may provide added benefit for some chemotherapeutic agents requiring a higher pH.[14,15]

LIMITATIONS AND FUTURE DIRECTIONS

Data on fruit cultivation, availability and consumption in India is limited and more studies to highlight this important area are required.

It is not always clear whether the effects in animals can be readily extrapolated to humans.

It is not clear whether the biology that appears to influence disease risk in animals fed compounds is functional to the same degree or in the same manner in humans consuming realistic doses as part of a habitual diet.

The studies in cell culture are conducted before knowing the process, mechanism of absorption and metabolism of the phytochemicals and its availablity to the tissues.

CONCLUSION

Vegetables and fruits, owing to the potent effectors of biological systems in humans, are shown to modify antioxidant pathways, detoxification enzyme profiles, and the immune system, as well as alter cholesterol and steroid hormone concentrations and metabolism. Future studies should be done to study the individual components present in fruits and its beneficial effects on prevention and control of diseases in human beings.

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ANNEXURE 19

PROJECT GREENHANDS

"Trees and humans are in an intimate relationship. What they exhale, we inhale, what we exhale, they inhale. This is a constant relationship that nobody can afford to break or live without."[1]

~ Sadhguru

Project GreenHands (GreenHands) had been considered to be a grassroots ecological initiative that created green consciousness among the populace of Tamilnadu (TN), a state in the Southern part of India. This initiative planned to promote sustainable living, by planting 114 million (11.4 crore) saplings in the shortest span possible.

Planting 25,000 saplings in the Tusnami affected coastal districts of Tamil Nadu marked the beginning of the project in the year 2005. In the following year, Through three days in the month of October 2006, 256,289 people volunteered to plant 852,587 saplings in 6,284 locations across 27 districts in TN, and with this initiative, GreenHands made an entry to Guinness World Records **(Refer Annexure – I)**. By the end of 2013, Greenhands had planted 19.7 million saplings, on a cumulative basis.

GreenHands worked under the aegis of Isha Foundation[2] (Isha), a non-governmental organization that worked with a mission towards the betterment of the individual, society and the world. The success of the project had been attributed to the inspiration of Sadhguru Jaggi Vasudev (Sadhguru), partnerships with corporate organizations, Non-Governmental Organizations (NGOs), community involvement and a commitment shown by volunteers associated with the project. Implementation of the project had been an inspiration to many. A comment at the website of GreenHands mentioned, "The Project Green Hands is great inspiration to the younger generation. It is great service to the humanity. The overwhelming dedication of the volunteers is to be greatly appreciated. We can surely create a greeny earth". In 2010,[3] Government of India (GoI) awarded Greenhands with the *Indira Gandhi Paryaavaran Puraskaar*, the highest award given by GoI to individuals and organizations that have made significant and measurable contributions in the field of environment protection and improvement. In the same year, Project GreenHands won the Beyond Sport award for the category "Sports for Environment" at a summit in Chicago, US. This award is given to organizations that use sports as a tool to mobilize community for their social cause. On April 5th, 2012, the Department of Environment of the Tamil Nadu State Government awarded Project GreenHands with the "Environmental Award – 2010".On 13th July, 2013 PGH was awarded the LASSIB Society, *Honorary award* on social responsibility for its valuable service in the field of environmental and ecological restoration.

1 Quote taken from the website of Project Greenhands
2 www.ishafoundation.com
3 For year 2008

EVOLUTION OF GREENHANDS

Greenhands had its root in Vanashree Eco Project, which was started in 2002 to conserve and protect the Velliangiri Mountain range, where Isha Yoga Centre is located. Isha volunteers used to sow lakhs of seeds to propogate the native species in the area to revive the ecology and biodiversity of the mountains. The formal initiation of Greenhands started in 2004.

It was in December 2004 that TN, along with other states of India, witnessed major devastation in the coastal regions due to the Indian Ocean Tsunami[4]. The lore is that the Isha volunteers, who were rehabilitating the affected people, observed that coastal areas that have enough tree cover were damaged less as compared to those areas that have less tree cover. Soon, Isha volunteers started using trees to connect with people affected by grief and tragedy. Saplings were presented in white cloths accompanied by roses, to grief struck families and they planted those saplings for their loved ones. More than 1000 saplings were thus planted. Once the project met the objective, volunteers idealized to scale up the project. “Prodded by the project director, we then kept a plantation target of 5000 saplings. While the earlier plantation happened within residential areas, these saplings were planted within residential compounds,” mentioned Anand, a plant biologist, and a full-time volunteer of Greenhands who has been coordinating with the plantation activities since the beginning of the project. **On December 25, 2005, Greenhands planted 5000 saplings in the seashores of the tsunami affected villages of** Periyakuppam, Pettodai, Aiyampettai, Nayakarpettai, Thamananpettai and Nanjalingampettai in Cuddalore district. (The district collector, Gagan Dheem Singh Bedi was the chief guest). In addition, Greenhands also planted 5000 saplings on the roadside, 5000 at villages and 10,000 saplings at lands belonging to Panchayats.

“Isha Foundation wanted to do it large-scale. When we shared our stories of sapling plantation with other members of Isha, they chipped in. Swami Prabodha said that he will mobilize resources to plant one lakh trees. Such commitment was received from a number of people. We came to know that Sadhguru wanted to speak to the Chief Minister of Tamilnadu about this endeavor,” conveyed Anand. Greenhands soon came of age.

In 2006, the project entered the Guinness World Book of Records. The launch of the 2007 planting season started at Chennai, capital of TN on Sunday, 23rd September. In 2007, Greenhands decided to showcase some of its endeavors, and thus started focused plantation zones in seven districts. The plantation zones had been functioning with the support of corporate organizations like Suzlon and Yves Rocher. In November 2008, the TN forest department and Greenhands planted 25,000 saplings at the 22,000 reconstructed houses in TN, as part of the Tsunami Rehabilitation project.

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4 The Indian Ocean Tsunami, which occurred on December 26, 2004 caused approximately 225,000 deaths in eleven countries, inundating coastal area with waves as high as 30 meters or 100 feet.

SCOPE OF THE PROBLEM AND DESIGN CONSIDERATIONS TO THE RESPONSE

"When I traveled around Tamil Nadu, I realized that the landscape was changing so rapidly that it would turn into a desert much before the projection of 2025. I saw thousands of palm trees with their crowns having fallen off. Palm trees can survive even in a desert but in Tamil Nadu they were losing their crowns because of the exorbitant exploitation of ground water. In Coimbatore city, about 15 years ago, one had to just dig 125-150 feet to find water for a well, and now one has to go 1400-1500 feet down to find water. Earlier the rain water was scarce, now it's in excess and so the degeneration was happening rapidly. Then as part of global warming system the southern peninsula is seeing a very excessive level of rainfall.... without vegetation, excessive rain can accelerate the desertification process because the top soil runs off."[5] ~ Sadhguru

Speaking about conceptual underpinnings about the project, Ethirajulu, the concept designer for Greenhands had this to say, "We have become an energy intensive civilization. On keen observation, we can find that what we eat is not food, but fossil fuels. The food that we eat has become poisonous, the air that we breathe is getting poisoned, and it is the same with everything that we intake. By simple, logical deduction we can conclude that man and the world has to go extinct. Man is the problem. I was into the design of structural systems. For me, a solution is built into the problem itself. If man is the problem, then man is the solution. Man's extinction is one solution. The only other solution that exists is that man has to do something about the troubles he has created for himself." When Greenhands assessed the spread of forest cover in TN, they found that it was only 17.5%, based on the data available with the forest department, while the national and global benchmark was 33%.

Greenhands team assessed how much trees needs to be planted to increase the green cover in TN by another 10%. Thus, the 114 million (11.4 crore) number was born. The belief was that the remaining 5-6% would be done by the self-propagation capability of trees. In an interview, Sadhguru said, "Actual statistics and practical logistics may come in the way, but the rationale is very simple - with the right kind of focus and motivation, the gap between what is needed and what is possible could be very small" Greenhands believed that if every individual of TN can raise two saplings, which will not bring any major financial burden on the individual or the state,[6] the target of 114 million can be surpassed. "Each and everyone had felt in the Isha Yoga classes that we are the parents of the entire world and the divine manifests in each and everything surrounding us," remarked Boris Bhim A (Bhim), a part-time volunteer with Greenhands. Citing the role of Greenhands, Bhim continued, "I could feel that I am responsible for every thing happening around me".

5 http://www.kavitachhibber.com/main/main.jsp?id=sadhguru-Dec2007
6 The estimated population of Tamilnadu, as of March 2008, was 6.64 crore (66.4 million).

ENGAGING VOLUNTEERS

"We wanted to make it a people's event. The project needed to be owned by volunteers. Opportunities were provided to all" said Anand. Some of the ways through which Greenhands mobilized people was by providing them with opportunities to:

create awareness about the initiative (engaging the community through events, presentations, meetings and stalls, putting up posters, talking to family, friends and corporations),

be part of the planting process (seed sourcing, creation of nurseries, distribution and planting of saplings), and

support the project by offering resources (donations, fundraising, sponsorship, partnership, offering material resources for supporting the project, creation of social responsibility initiatives among corporate etc.).

One of the attributes that attracted volunteers to Greenhands was the genuineness associated with the project. "There is no cooking up of figures here – internally or externally. I cannot work in an organization which cooks up stories," quipped Anand.

PROCESSES INVOLVED

AWARENESS CREATION

Thus creation of awareness about environmental degradation was the initial step that Greenhands needed to undertake. Greenhands communicated that trees were an essential part of our lives and not an entity distinct from us. The relationship with trees was to be enhanced in order to enhance one's own sense of well-being. Through the years, Greenhands had been undertaking massive campaigns with the objective of taking the message across all strata of population. The part-time volunteers focused primarily on their own localities and conducted presentations, processions, video shows, games and talent competitions for students, and nature awareness tours and hill cleaning initiatives. in order to generate and attract interest towards Greenhands. This practice of giving away saplings free of cost has been changed. Now PGH charges a minimum commitment fee of Rs.5/- for the saplings. In our experience we have felt that when we charge a minimum amount even if it is as less as Rs.5/- people take more responsibility and make sure they do not waste the sapling. Not just that, this contribution from general public becomes the seed money for sustenance of nursery in the ensuing year. In the earlier years, many nurseries could not operate continuously because the volunteers were not able to raise funds for the nursery operations. So we wanted to make the nursery self sustainable. The volunteers do not have to spend time on fund raising for buying the inputs needed for the nursery.

Volunteer meetings were organized to share information and learning.

In cities, awareness was created through multiple media channels like newspapers, advertisement on television channels, posters, banners, hoardings and fund-raising concerts. Greenhands also used Isha music CDs, Sadhguru's programmes on radio and TV channels and Isha events to create awareness about the project. (**Refer Annexure II, III and IV for campaign related details)**

In villages, volunteers did door-to-door campaigns, public announcements and meetings. In 2007, Isha Agro Movement (IAM), a sub project under Project GreenHands was launched to address the concerns facing the farming community in India, especially in the context of farmer suicides that was happening in India. This movement combined agro-forestry with organic farming practices. In addition, IAM also provided education programmes. Greenhands volunteers stayed with the villagers and met farmers. They also worked in co-ordination with organizations that were in the field trying to help the farmers. Brochures were distributed in more than 3200 villages. Isha's social outreach programmes came in handy. Isha *Gramotsavam* (village festival), an event for people belonging to 3200 villages in the state of TN was used to promote Greenhands. The festival consisted of sports and games activities ("Rural Olympics"), rural food festival that offered more than 250 culinary preparations, rural cultural show that exhibited native art forms and handicrafts, a musical programme and a Satsang with Sadhguru. Events like Agri-fest 2007 and "Rural Olympics" promoted interest at the grassroots level.

Awareness meetings in villages were given much importance. In the meetings with villages, Greenhands communicated the importance of trees. "The basic energy for sustenance of life on this planet is coming from the sun. The energy transfer happened because of the existence of plants and trees. By destroying the trees, we destroyed our source of food. The kind of food we take in is very important – it is like medicine. It can nourish us or it can kill us. Self-healing capacity is there in us, it is there in the nature. I am a diabetic patient since 30. For the past 25 years, I have not taken any medicines. This self-healing capability is not communicated to the humanity, probably because there is no money making possibility in human well-being," said Ethirajulu. Awareness meetings were an ongoing process and Greenhands believed that these meetings had resulted in almost 1.5 million people being aware of the project.

Decision makers, like politicians and bureaucrats, were introduced to the project by inviting them to involve in inaugural and closing ceremonies of planting and distribution of saplings. They were also given individual presentations about the project.

NURTURE AND DEVELOPMENT

"While on our visits, we saw people – be it tribals or people from other sections of the society, performing a number of rituals to bring rain. Destroying nature and then doing prayers will do no good. It was in this context that the idea of starting a nursery came about. Our nurseries started very small. We used to put 10 seeds in 10 packets daily. This initiative was more of a personal interest. It was in 2004 that nursery activities started picking up momentum," said Swami Nagaroopa (Swami), Nursery co-coordinator, Greenhands.

Greenhands had to nurture and develop the saplings along with the awareness campaigns. The first step was sourcing healthy seeds. The selection of saplings was based primarily to two aspects: (1) Quality and speed of growth (2) Commercial value for the tree/ products from the tree. For rural areas, seeds of fence trees, fruit trees, fodder trees and timber trees were nurtured. For urban areas, avenue trees and medicinal tress were nurtured. Seeds of pioneer trees were nurtured for land development. **(Refer ANNEXURE V for the list of trees whose saplings were grown in the nurseries of Greenhands).**

Greenhands developed hundreds of nurseries – through sourcing of healthy seeds, creation of seed pockets and beds, distribution to planting zones - with the help of its partner organizations. Greenhands classified nurseries under four types – regional nurseries, corporate nurseries, nurseries maintained by educational institutions and centralized nurseries. Centralized nurseries were fully managed by Greenhands. While all types of saplings were grown in centralized nurseries, the number of saplings nurtured in the first three types of nurseries was limited. The corporate nurseries were established in 2007 and centralized nurseries in 2008.

Training was given to volunteers on creating nurseries. The first nursery for Greenhands came up at Isha Foundation Centre at Velliangiri Hills, near Coimbatore. The nurseries were small, with a capacity of producing 1,000-10,000 numbers of saplings. In 2006 February, the first nursery outside Velliangiri Hills started. In 2007, Greenhands started nurseries that could produce 50,000 saplings. In the same year, Greenhands produced 40 lakh saplings (4 million). In 2008, it was 21 lakh (2.1 million) and in 2009, Greenhands produced 25 lakh (2.5 million) saplings and since then on an average, nearly 2.5 million saplings are produced every year through these nurseries.

During the collection of seeds, the health and maturity of mother tree was taken into consideration. Seeds from those trees that were young or old were avoided. 70% of the seeds were collected during the months of April, May, and June – the months before the rainy season. Volunteers and self-help groups collected 40% of the seeds for the avenue and fodder trees. The rest of the seeds were made through purchase. "In the initial phases of the project, we did not have any contacts or money. Substantial amount of effort came from volunteers, and their mobilization was an important aspect. I was talking too much during this period," laughed Swami. On collection of seeds, they were brought together to an area where they were cleaned, selected, packaged and sent to appropriate nurseries.

The idea was to develop a nursery close to a planting zone in order to limit transportation as it entails transportation costs and risk of damage to the saplings. Greenhands carried out a loading technique through which 8-10 layers of saplings were transported, with a maximum capacity of 10,000 to 12,000 saplings. An additional 10% sapling was carried as a buffer in each truck, in order to account for any damage to the sapling or any possible replanting need. The transportation was done a minimum of 10 days prior to the planting day, in order to account for a seasoning period.

Planting times varied. For jack fruit, there was the necessity for the planting to occur within two days from the time of seed collection while it was two months for oil seeds. In order to ensure the healthy existence of the seed, especially for those with a short time span, they were soaked in hot/ cold water, or were soaked in *panchakviam*[7]. Some of the seeds were taken through anaerobic pre-germination before they were sowed in the motherbed[8]. Development of the sapling included processes like Preparation and cleaning of the land, Motherbed settlement, Creation of Mist Chambers[9], Germination of seeds, Preparation of planting pockets, Transplantation of germinated seeds, Nurturing in shade for two weeks with daily watering, Exposure to sunlight to stimulate growth with alternate day watering, Rearranging to curb root growth, Weeding (3 weeks after transportation and once during next 2 months), Transportation and Planting. “Growing a sapling is like growing a child. Experiencing everything as one is Spirituality,” voiced Swami.

SAPLING DISTRIBUTION AND PLANTING

“Of all economic activity that happens in a nation, agriculture is the most fundamental and also of paramount importance. A nation that neglects its farmers is bound to dislocate its basic life sustaining infrastructure.”[10] ~ Sadhguru

The mission of Greenhands is to inspire people and enable them to plant trees. Greenhands distributes saplings to third parties, who do the planting. In this model, plantation is done throughout the year. The responsibility of nurturing and monitoring the saplings that were planted were given to individuals/ groups who took the onus of planting the saplings. Awareness generation was the key in the success of this model. “Individuals and concerned groups had been approaching Greenhands as the preferred destination for saplings,” said Anand. Through this model, 1,434,382 saplings were nurtured.

The other model followed by Greenhands was the Agroforestry model. These were funded projects. Explaining the Agroforestry model, Ethirajulu said, “Soil is the basic entity that we have to protect. It takes thousands of years to create top soil. Trees play a major role in the creation of top soil; Plant trees to protect top soil. That was the origin of Project

7 An organic manure made up of cow dung, cow urine, sugar, milk and tender coconut.
8 The place where seeds are grown. The motherbed is made out of a mixture of river sand, red soil and cow dung.
9 Chambers with temperature and humidity control facilities
10 From the website of Project Greenhands

Greenhands. If soil has to be protected, it has to be done at the farmers' land. That was the beginning of Agroforestry model. Our belief is that trees can be a solution to everything. It gives back to man the connection to life that that he lost. This project is an attempt to make that connection." The agro-forestry model was started in 2007. "Farming is like gambling now. Farmers are concerned and insecure. Initially they had concerns that planting trees at their fields would reduce them of their income generation and the productivity of the land will go off, though the reality is otherwise. In order to alleviate farmers out of their concerns, we ask the farmers to grow the trees in the boundary. As the trees mature – it can be a fruit tree or a timber tree – it becomes like insurance. This campaign started working. This formed the basis of our agro-forestry model. We are now very clear on where trees should be planted and not planted," mentioned Anand. Till 2012, nearly 2 million saplings have been planted through this agro-forestry model.

From 2009 onwards, Greenhands has been conducting systematic training programme on agro farming for farmers. This training, which will have modules on organic/ natural farming, will be delivered by experts to volunteers, who will then deliver the same to the farmers.

Baseline surveys and need assessment surveys were done before plantation was done. Greenhands distributed the saplings to those with commitment towards the project. Presence of local dignitaries and popular personalities attracted attention to the project and provided awareness to people about the objective of Greenhands. These meetings were also used to encourage people to be part of this project. Planting zones were designated in areas of local support. In recent times, majority of the planting was done in these zones. The opportunity to plant the saplings were given to the volunteers of the rural community. This helped Greenhands to generate enough support and commitment in those areas.

Farmlands, Schools, Residential areas, Water catchment and waste land areas and roadside were chosen as areas of focus. Farmlands were usually protected from invasion from cattle. Saplings of fruit trees, fodder trees, fuel trees and timber were planted on the farmlands. Preference was given to plant the saplings on the farmlands of those farmers who showed commitment, for e.g. by supplying compost, sand and vermin-compost. Tropical dry evergreen plants, which were native to TN and also drought resistant, were used in school grounds. "Live seed banks"[11] were also created in these schools. This helped in the conservation of a number of tree species. School children gave care to these plants. In addition to saplings, pitting materials were also supplied to schools by Greenhands. For residential areas, only saplings were provided by Greenhands. Pitting and planting were done by residents of these locations. It was the onus of the residents, who planted fruit and medicinal saplings, to prepare protective gear for the saplings planted. To plant saplings in water catchment and waste land areas, Greenhands used paid self-help groups.

11 Live seed banks are growing trees. They act as sources of seeds during seed collection.

Tropical dry evergreen forest species and water-tolerant species were used in the water

catchment and waste land areas respectively. All resources – saplings, pitting material, and protective gear – were provided by Greenhands. Saplings of avenue trees were planted at the roadsides by the local community, with saplings, pitting material and protective gear provided by Greenhands. **(Refer ANNEXURE VI for the tree planting procedure criteria and methodology following while pitting and planting).** Speaking about plantation on the roadside, A Murugesan, a Greenhands volunteer, who worked in Erode[12] based KGM Softwares Pvt. Ltd. said, "It is very difficult to find place to plant trees".

POST-PLANTATION CARE

Post-plantation care for the saplings included watering, organic manuring, pruning, replanting, and protecting the sapling from grazing animals. In water catchment areas and wasteland areas, Greenhands engaged paid self-help groups to provide this post-plantation care. In other areas, like farmland, schools, residential areas etc. the sapling planters were responsible for ensuring post-plantation care.

COMMUNITY INVOLVEMENT

"In the Indian culture there are temples for trees, people worship trees; it's a very common practice. It is not a question of a custom. It came from a certain experience and understanding. It is a certain depth of experience and understanding — you understand that whatever nurtures your life is worth worshipping."[13] ~ Sadhguru

It was realized that the success of the project depended on strong partnerships. The project focused on developing partnerships by energizing community, whether they were farmers, school going children, businessmen, academicians, parents etc. Community involvement thus became the essence of the project.

GreenHands volunteers visited villages and spoke to the farmers, assessing the interest of the people there. The villagers were showed documentaries and discussions were initiated among the villagers and with the villagers. When the volunteers felt that there was sufficient commitment among the villagers who owns lands, they were initiated into the next level – integrating trees along with the prevailing crops. At the district level, a regional office was set up and this hub was used to share resources during the project period. "The uniqueness of this project is that we are involving large number of people, common people, in planting trees. The volunteers – they are all joining because

12 Headquarters of Erode district in the state of Tamilnadu, India.
13 http://www.organicgreenandnatural.com/2009/04/08/project-greenhands-%E2%80%93-compensating-the-earth/

of Sadhguru. He is the heart of the project. He is like a super-hero for us. I cannot move a finger without him," said Swami Nagarupa.

Business organizations were contacted and Greenhands engaged them in making environmental care a part of their CSR initiatives (Refer Annexure VII that lists out some of the business organisations that has associated with Greenhands). Jacques Rocher, President of the Yves Rocher Foundation mentioned in his blog, "Out of this ecological initiative grew a human project. In fact, the people of Tamil Nadu are planting directly onto their parcels of land the trees that are most useful to them. They are planting fruit trees to meet an emergency food shortage and trees that reclaim the soil as a medium-term initiative. They are also planting construction wood to meet long-term goals."

GreenHands utilized the already established goodwill of Isha to spread awareness about the green initiative. In order to develop win-win partnership with other NGOs, the project offered the NGOs an array of activities that acted as a source of employment and income generation. This helped the NGOs to achieve their objectives. For GreenHands, the NGOs helped in taking the environmental initiative to large and diverse group of people. The NGOs also provided GreenHands with the needed manpower to implement the project.

PGH has also actively involved youth in its programs. Seeking to bring about a sense of awareness and reverence for nature in school and college-going kids, it has conducted various tree planting drives and mass awareness campaigns across schools and colleges. As a part of PGH's efforts to involve children in ecological restoration efforts, PGH launched the Green School Movement in the year 2011. The mission of the Green School Movement is to create "green consciousness" among school children through a change in their attitude, by involving them in sapling production and plantation. The project aims to create nurseries that will produce 18 million saplings by 2014, and will involve 450,000 school students from 9,000 schools in 32 districts of Tamil Nadu. In 2011 as a pilot, a total of 600 schools in Erode and Coimbatore districts were chosen to be a part of this program, with a target of producing and distributing 2,000 saplings each, every year. 25,000 school children from nearly 503 schools have contributed to the planting of 1.2 million saplings.

In 2012, the project was initiated in Erode, Coimbatore, Krishnagiri districts of Tamil Nadu and Union Territory of Pondicherry.

Some of the not-for-porfit organizations that GreenHands partnered with include Eranda Foundation of UK (through Integrated Rural Development Center (IRDC), Center for Low External Input Sustainable Agriculture (LEISA)[14], OAZONE[15], National Agriculturist

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14 An organisation whose mission was to promote organic farming
15 engaged in rural development through water management projects

Awareness Movement (NAAM)[16], The Rotary Club[17], The Lions Club[18], The Indian Red Cross[19], and Joint Action for Sustainable Livelihood (JASuL)[20]. Greenhands also associated with Grow your Trees Foundation, GVN Trust, Velicham, Go Sakthi, Best Trust etc. *Tamilaga Iyarkai Uzavar Iyakkam* (Tamilnadu Organic Farmers Movement), founded by Dr Nammazvaar[21], was another organization that GreenHands partnered with, to promote organic farming to farmers. Dr Nammazvaar visited many villages to promote awareness about GreenHands.

RESOURCE MOBILISATION

Bhim, who had done the Isha Yoga programme, felt that raising funds had been one of the difficult tasks. When Greenhands started preparing for the Guinness World Record endeavor, there was no money in the Greenhands account. There was no assured funding for the project. The initial support came from Isha Foundation. Greenhands spent approximately Rs 40 for nurturing the sapling, planting it and monitoring it for one year. Planting 114 million trees required substantial funding support.

"There is no assured funding. The theme of donor organizations varies every year. The risk is always there. We want to increase our focus on individual donors through web based fund raising," said K (Sekar), Project Director of Isha's Social Outreach programmes. Greenhands provided a number of contribution options for donors. From 2007 onwards, there was a gradual improvement in the availability of funds. Greenhands also came out with a "Gift of Trees" scheme were one can gift a donation of trees in the name of another person, with a monetary donation of fifty rupees for each tree sapling that needs to be planted (**Refer Annexure VIII for a sample of "Gift of Trees" certificate**). Greenhands delivered a gift certificate to the donor or to the person on whose name the gift was made. In an interview given to *Blue Planet Green Living*, Sadhguru had mentioned the need for cash as a limiting factor in expansion of the project. A similar sentiment was echoed by Swami who said, "Monetary support is necessary for the project. People are appreciative about the project. They now need to come forward and support the project." Greenhands

16 An India based national organization working towards new farming methodologies

17 Rotary Clubs are located across the globe and its purpose is to bring together business and professional leaders to provide humanitarian service, encourage high ethical standards in all vocations, and help build goodwill and peace in the world

18 Founded in United States, Lions Club motto is "We Serve" and the organization focus on activities related to sight conservation, hearing and speech conservation, diabetes awareness, youth outreach, international relations, environmental issues, and other programs that support the local communities where Lions live

19 A voluntary organization, which is part of the International Red Cross and Red Crescent organization. The Indian Red Cross engage in providing health and care to vulnerable people and communities

20 JASUL, based at Madurai, is a forum of several NGOs across Tamilnadu. The forum was created with the objective of preservation of natural water sources

21 A farmer and an agricultural scientist known for his experience in organic farming and agro-forestry

also came out with a 'World Environment Day' campaign where, for hundred rupees, one can plant a tree and Greenhands will do the planting, and post-planting care for two years till the tree sapling become self-sustainable. Through this campaign, the donor was also updated with the location co-ordinates where the tree sapling was planted and name of the farmer nurturing their trees.

PGH also explored partnership with for-profit organisations as an official tree planting partner. For its corporate partners, PGH provided them with detailed update about the farmers and farmlands where the agro-forestry saplings were planted. Post-planting status updates and digital photographs were shared with these patners. PGH asked for a minimum funding of five lakh rupees from these corporate partners, and in return, the corporate partner was able to list PGH as its official tree planting partner in the company website and other communication media.

PROJECT MONITORING

Greenhands had an advisory board that included experts in forestry, organic farming, tree plantation and related fields. They provided guidance to Greenhands at all levels of project implementation. Comprehensive records were maintained by Greenhands – starting from the collection of seeds, establishment of nurseries and development of planting areas. Prior to the plantation, Greenhands conducted surveys to understand the environmental, social and economic status of the region. Greenhands also did soil and water quality tests. Based on these studies, recommendations were made on the type of action Greenhands should undertake. Greenhands registered the names of land owners who showed commitment to the cause. The landowners were also asked to make a formal commitment to plant and maintain trees **(Refer Annexure IX for a copy of the commitment letter that a farmer has to sign)**. Greenhands also maintained a database of sapling distribution and planting. Follow-up and replanting requirements were done with the help of this database. Greenhands also maintained necessary support systems that helped in monitoring sapling development. These support systems included regular communication with regional offices **(Refer Annexure X for details about plantation coordinating centers in TN)**. It was decided that a quarterly report would be released by Greenhands team for projects that were funded by corporate organization. It was also decided that there would be continuous updation of the Greenhands website (www.projectgreendhands.org) with outcomes and statistics, and the organization would come out with an annual report every year. The following were the result areas and the indicators used by Greenhands.

RESULT AREAS	INDICATORS
Nursery	Quantity of saplings, species of saplings and survival rates
Planting	Number of trees planted, species, location
Green cover	Geographical Information System (In implementation phase)
Maintenance	Surveys on Sapling Survival and Growth
Volunteer Participation	Registration numbers
Skill acquisition	Evaluation tests at the end of training period
Public mobilization	Number of events, Participation numbers in events

Greenhands expected a number of challenges to the project, and these risks were classified under the following segments:

RISK	RISING UP TO THE CHALLENGE
Natural Calamities	To undertake surveys after the calamity. This would be followed by replanting of saplings.
Non co-operation of villagers	Selection of villages that were having a harmonious relationship with other activities of Isha Foundation. Obtaining official consent from authorities and village heads in advance.
Financial risk	Application for third party funding
Nurturing of saplings	Usage of quality seeds, training to people, regular maintenance of saplings and nurseries

There were situations when maintenance of documentation was difficult. "There are times when the usage of templates may not be effective. Volunteers come and go. There is also the necessity to ensure that information systems are aligned to local needs. Many grassroots level workers may not be having the system skills and basic English language skills. Due to the same, documentation was difficult during the initial stages of the project," mentioned Maheshwari, who coordinated with activities related to information systems. "Greenhands have strong reporting system. We should now strengthen the evaluation based on the data we collect – project analysis, impact analysis etc." continued Maheshwari. She also observed that the human aspect also had to be taken into consideration. Many volunteers had the inclination to be part of core activities and considered documentation related aspects as secondary. Swami echoed a similar sentiment. "Collecting data from the field volunteers is a difficult thing. The activity is done as a service and people do not want to keep a count on that. Even during the Guinness World Record initiative, we produced 11 lakh saplings, but we did not have documentation for that. We made a representation to the Guinness World Records only for 8.5 lakh because we only have records for 8.5 lakh sapling plantation."

Greenhands believe that it had been able to convert 65-70% of the saplings it had planted to trees. "Technically, it is not an easy job to assess the conversion figures. We did some random sampling. Based on the data we collected, we got technical inputs from a forest officer and from those inputs, we arrived at this figure. We would like the conversion rate to move up to 75%", mentioned Anand. To improve the conversion rate, Greenhands had been assessing the reasons on the variance in conversion rate at different regions. It found that conversion rate had been high in regions like Pudukkottai (as much as 80%) while it is much lower in areas like Trichy (approximately 40%). Greenhands had taken a decision that in regions like Trichy it will plant only saplings in watershed areas. Similar tailor made solutions were evolved for all districts of TN.

PEOPLE DYNAMICS

Sadhguru narrated[22] an incident that happened during his visit to Mysore for conducting a meditation program. There he met his English teacher from school times. "And after it (the programme) was over, she came and hugged me and said, 'Now I know why you didn't let me teach Robert Frost'. I said, 'Why would I not let you teach Robert Frost? I like Robert Frost.' 'No, no, do you remember you did not allow me to teach Robert Frost.' I said, 'Ma'am, why would I do that?' Then she reminded me and I remembered... She came and introduced Frost and she started, 'Woods are lovely dark and deep...'[23] I said, 'Stop it. Any man who calls a tree a wood, I don't want to listen to him.' She said, 'No, No, Robert Frost is a great poet.' I said, 'I don't care how great he is, If calls a tree, a wood, I don't want to listen to him.'"

The project started with the effort of a few people, and Greenhands did not have any

22 In a felicitation ceremony, when PGH won the *Indira Gandhi Pariyavaran Puraskar*, the highest award given by Government of India to individuals and organizations that have made significant and measurable contributions in the field of environment protection and improvement.

23 From the famous poem titled 'Stopping By Woods On A Snowy Evening'

formal departments. As the project started scaled up, there are now two divisions. One is the operations – headed by zonal coordinators (who are in-charge of the nursery, planting and monitoring work). The other is the Central Office team with the MIS, accounts and fundraising team.

"The intensity and dedication with which people work here is unique. Whatever goals are set by Sadhguru, people will implement it here, whatever the constraint may be. If we look at the Guinness Record endeavor, it was a handful of people who drove the whole initiative," mentioned Maheshwari. Anand recollected that he was sleeping only 4 hours during the months when Guinness World Record endeavor was going on. "Here, we do not compare one person with the other. If they are giving their best, that is enough for me," said Sekar. "People are working here for something higher, which may not be visible outside. We are here for spiritual growth. I left a comfortable job and came to Isha. I wish to be with Sadhguru, and that's why I am here. He has provided me with a platform to be with him", added Sekar. Sekar considered his role to be that of providing the volunteers with the basic needs like food and shelter and an activity platform where the volunteers can give their best.

Greenhands had found it challenging to get full-time volunteers who work exclusively on this project. "We've been building the base in the past 2-3 years. Isha is having a number of social projects. We need to give importance and encourage all the projects," opined Swami, in 2009 **(Refer Annexure XI for the organization structure of Project Greenhands)**.

TRANSFORMATORY NATURE

"What has been most encouraging is the enthusiasm with which people have responded. Even a laborer earning daily wages to survive is willing to forgo one day's work to help plant saplings."

~ Sadhguru

Greenhands had undergone major changes with its implantation approaches. In the earlier days of the project, Greenhands did not provide much focus on the type of trees that were provided to the villagers. Post 2005, the feedback was that villagers aspired for trees that were economically viable, like fruit trees and timber trees. "There are times when I perceive that whatever we've done in earlier years were not that effective. Villagers were asking 'Why are you bringing Neem trees that we can raise ourselves?'And thus we started focusing on fruit bearing trees. We've been learning quite a lot. From 2007 onwards, we stopped sapling plantation on the roadside, and decided that somebody has to take responsibility for the saplings that are planted. We also demarcated the whole of

Tamilnadu into eleven ecological zones, based on the soil condition and drought condition of the region. Then we listed down all drought resistant and economically viable trees that will grow in each of these zones. Later we selected those trees that grow in all these zones, except the Nilgiris Biosphere Reserve. Now, we distribute or plant only those trees," stated Anand. This decision had been expected to increase the sustainability of the trees as these trees are drought resistant.

The volunteers had been feeling the transformation in their own lives. "I feel I am fully utilized here. There had been immense personal growth here, as compared to my earlier work in a software firm. Earlier, I didn't know that I was ignorant, now I know that I am ignorant," mentioned Maheshwari. Anand went through situations where he had to take up important responsibilities. "This was during our preparation towards the Guinness Record endeavor. We've been meticulously planning for this (Guinness World Record) event for many months. We found, despite all our prodding and communication to villagers, that only 3.5 lakh – 4 lakh pits were dug by the end of September. Many of the villagers spent their time in political activities as the local body elections was coming up. Existence of pits gives a clue to how many saplings will be planted. A person who spent energy in digging the pit is certain to plant a sapling. With such a low number of pits dug, all of us were heartbroken. In one of the volunteer meeting I attended at St Joseph's college at Trichy, I saw young volunteers with tears on their eyes. Seeing all this, I told the group of volunteers that this initiative is not about breaking any kind of record. I told that we are here to give our 100%, we've been giving our 100% and we will give our 100%. I was only 21 then, and many of the volunteers there were much senior to me. I do not know from where such words came to me."

While a number of volunteers associated with Greenhands came to the project due to their affiliation with Isha, there were many who took interest in the project though they did not have formal affiliation with Isha. Jayakumar K, Senior Lecturer, Bannari Amman Institute of Technology came to know about this project through the World Wide Web. "Though I have never participated directly in the project, it has created a craving in me to find an opportunity to make my presence in its activities," said Jayakumar.

"There is a reason behind everything we do. Everything we do is logical. But the outcome is illogical. Our actions may inspire others in a number of ways, and we may not be aware of any of those. After our Guinness record endeavor, many people came forward with similar initiatives," remarked Ethirajulu. In the second half of 2007, government of TN came out with a 'Tree Cultivation in Private Lands in Tamilnadu' initiative. On August 7, 2008, people of Nokha Tehsil in Bikaner, Rajasthan, India planted 105,000 saplings in three minutes and fifty seconds. On July 11-12, 2008 in the village of Chautaki in Bongaigaon, Assam, India, 300 people (villagers, NGOs, government officials) came together to create a Guinness World record endeavor of planting 284,000 saplings in 24 hours. This record was later improved by Durango in Mexico where 348,000 saplings were planted in 24 hours by

300 people. On June 14, 2009, 300 soldiers of the 21 Jat regiment of Indian Army, with the support of district administration and the Forest department, planted 447,874 saplings in Sreegram reserve forest in Dhubri, Assam, thereby going beyond the record created by Mexico's National Forestry Commission (CONAFOR). "Anything which has to happen on a large scale, has to be a movement, not a project. My mother has never seen Mahatma Gandhi. But, when he died, she cried. A movement touches everybody," added Ethirajulu.

EXPANDING ENDEAVORS

"It (Greenhands) is definitely carried out on a very large scale, which no other project has done at least I'm unaware of. However, the project needs revamping... Too may people are doing it, lacks innovativeness. (There is a) Need for better outreach mechanisms," said Mangala Tewari (Mangala), Area Convenor & Associate Fellow, TERI (The Energy & Resources Institute), New Delhi. Responses to Greenhands' geographical expansion had been mixed. On March 22, 2008 Greenhands was launched in Hyderabad with the sowing of 6000 seeds at Nanakramguda. "Unfortunately the project never took off in New Delhi... if something materializes I will be the first one to take the lead in New Delhi," mentioned Mangala. "From where would we get the saplings? Which is best institution to target? And I'm still searching for my answers!!," added Mangala.

People at Greenhands were clear about the ill effects of the prevalent energy intensive agricultural model and environmental degradation. "If we have to do something, we have to do it now. Sadhguru suggested that if we have to do something, it has to be done within 6-8 years time so that by the next 15 years we would have about 30 percent green cover. We are sure that this project cannot be implemented if we wait beyond that time frame. If we become a desert land like Saudi Arabia, then our cost for nurturing saplings, planting them and monitoring them will spiral up, and we will not be in a position to implement this project," said Ethirajulu. The organization had started the process of bringing together NGOs with similar objectives under a same platform and helped them in capacity building and creating linkages.

ANNEXURES

ANNEXURE – I

The Guinness World Record certificate for the mass tree plantation drive of 2006


GUINNESS WORLD RECORDS

CERTIFICATE

The most trees planted
in three days was 852,587
in an event organised by
the Isha Foundation
called Project Green Hands.
Trees were planted in 6,284 locations
across 27 districts in Tamil Nadu, India,
on 17 October 2006

APPROVED

GUINNESS WORLD RECORDS LTD

ANNEXURE - II

Campaign materials used during the 2006 tree plantation drive

No. of Posters	40,000
No. of Handbills	8.5 lakh
Roadside hoardings	103
Mega Hoardings	4
Newspaper ads	120
TV/Radio Ads	5
Media Partner	Ananda Vikatan, Tamil weekly
Signature Campaign Forms	1.1 lakh
Celebrity Promotional Video	2
Radio Partner	Radio City

ANNEXURE – III

Invitation to a photo exhibition about Project Greenhands

ANNEXURE – IV

'Sounds of Isha' Music CD on Project Greenhands

ANNEXURE - V

Saplings of the following trees were created in the nurseries:

S.no	Local name	Botanical name	Type of tree
1	Teak	Tectona grandis	Timber
2	Malai vembhu	Melia azedarach	Timber
3	Mahogony	Swietenia Mahagoni	Timber + Medicinal
4	Red Sandels	Pterocarpus santalinoides	Timber
5	Kumil	Gmelina arborea	Timber
6	Vengai	Pterocarpus marsupium	Timber + Medicinal
7	Palaa	Artocarpus heterophyllus	Fruit
8	Eti	Dalbergia latifolia	Timber
9	Karumarudu	Terminalia tomentosa	Timber
10	Poovarasu	Thespesia populnea	Timber
11	Perumaram	Ailanthus excelsa	Timber
12	Koyya	Psidium guajava	Fruit
13	Aranelli	Garuga pinnata	Fruit
14	Madhulai	Punica granatum	Fruit
15	Lemon	Citrus limonum	Fruit
16	Kariveppilai	Murraya koenigii	Spices
17	Mahilam	Mimusops elengi	Avenue
18	Sorgam	Simarouba glauca	Avenue
19	Rosiya	Tabebuia rosea	Avenue
20	Jacaranda	Jacaranda mimosifolia	Avenue
21	Senbagam	Michelia champaca	Avenue
22	Iyalvagai	Peltophorum ferrugienum	Avenue

S.no	Local name	Botanical name	Type of tree
23	Racemosa	Colvillea Racemosa	Avenue
24	Mandarai	Bauhinia purpurea	Avenue
25	Avellendae	Tabebuia avellanedae	Avenue
26	Argentea	Tabebuia argentea	Avenue
27	Badam	Prunus dulcis	Fruit
28	Poomardhu	Lagerstroemia speciosa	Avenue
29	Sarakondrai	Cassia fistula	Avenue
30	African Mahagony	Khaya senegalensis	Timber
31	Manja Kadambai	Haldina cordifolia	Timber
32	Sandal	Santalum album Linn	Timber
33	Mungil	Bambusa vulgaris	Timber
34	Natuvagai	Albizia lebbeck	Timber
35	Vembu	Azadirachta indica	Avenue+Timber
36	Pungan	Pongamia pinnata	Avenue
37	Neermardhu	Terminalia arjuna	Avenue+Timber
38	Naval	Syzygium Cumini	Fruit
39	Thandrikai	Terminalia bellirica	Medicinal+Timber
40	Javani kondrai	Cassia javanica	Avenue
41	May flower	Delonix regia	Avenue
42	Sivakundalam	Kigelia pinnata	Avenue
43	Ven Kadambu	Anthocephalus cadamba	Avenue

S.no	Local name	Botanical name	Type of tree
44	Thaneerkai maram	Spathodea campanulata	Avenue
45	Elai -Porasu	Butea Monosperma	Avenue
46	Mangium	Acacia mangium	Tomber
47	Sisoo	Dalbergia sissoo	Avenue+Timber
48	Thanga aralli	Tecoma Stans	Avenue
49	Malli	Jasminum sambac	Avenue
50	Moringai	Moringa oleifera	Fruit
51	Maramalli	Millingtonia hortensis	Avenue
52	Nagalingam	Couroupita guianensis	Avenue
53	Karungali	Acacia catechu	Timber

ANNEXURE – VI

Tree Planting Procedure

Criteria for choosing a location for tree plantation:

1. The planting location should be at least 6 feet away from the edge of the Road/Fence/Compound wall. Multiple row plating is preferable. The space between each row is 4'. The adjacent row planting location will be Zigzag with respect to the previous or succeeding row.
2. The tree should not be placed below an electric line.
3. The location of the pit should not be where water logging takes place.
4. The tree should be planted either in protected area or in a place which is easy reachable for people to water and protect.
5. Watering and replanting should be scheduled and suitably monitored.
6. A minimum gap of 7 feet and maximum gap of 9 feet to be maintained between trees.
7. The seedling should not be planted in the shade of another grown tree.

Methodology of tree planting:

1. Pit preparation:

- For red soil and clay soil, the dimensions of the pit are 2’x2’x2’
- For sandy soil or loose soil the dimensions are 1.5’x1.5’x1.5’.
- The dug out pit should be refilled with a mixture of compost and dug out top soil.
- The compost should be evenly mixed with the soil.
- Green bio mass (leaves) or non-composted material should not be put into the pit.

2. Planting:

- The plastic cover should be removed carefully using blade or knife such that the clump of soil is not broken. This decides or ensures 70% survival of the plant.
- If roots are grown out of the packet, it needs to be carefully cut before planting.
- The entire soil clump, holding the plant should be place below ground level.
- After closing the pit, do not compress or harden the pit by stamping on it or by other means.
- Create a basin around the pit for better watering.
- Mulch the tree seedling after plantation with bio mass (leaves or dried plant material)

ANNEXURE – VII

International Partners

Yves Rocher Foundation, France ; Price Waterhouse Coopers, UK Give2Asia; Charity Aid Foundationa; ,Data Source Mobility, US; Greenberg Quinlan Rosner Research Inc UK,Monaco Modern Art, France; Association Arts & Environment, Germany, , Global Sports

National Partners

Suzlon Foundation, Indian Overseas Bank, L&T Construction, Chennai, Mahindra Satyam, Hyderabad, Mahindra & Mahindra, Hyderabad, IBM, Oncor, Axis Mutual Fund, Zoho, Chennai, Edelweiss, Mumbai, Open Text, Hyderabad, Aurobindo Limited,Hyderabad, IRIS, ESSAR, Ordain Healthcare, Chennai, Delphi,Banglore, BPCL, Mumbai, AT&T,Banglore, HAS India, Edenred, Mumbai, Albatross Fine Chemical (P)Ltd Ananda Vikatan, Apollo Hospitals, Aravind Herbal Labs Pvt., Ashok Leyland, Cavinkare, Cognizant Technology, Covanta Energy, E.I.D Parry India Ltd., EB Department, Vallur Camp, Ecologic Ventures, Everest, Everest Construction, Everest Industries Ltd., GB Industry, GMR, Power

Corporation, Henkel India Ltd., ICICI Lombard, Jayabharatham Furnitures, L&T Ltd., Life Insurance Corporation of India, Omkar Foundation, Orchid Chemicals & Pharma, PPN Power, Price Waterhouse Coopers, Raminium Builders, Bharat Petroleum, Sakthi sugars, Sakthi sugars, Salem Steel plant, SRF Gummidipoondi, State Bank of India, Suguna Poultry, Take Solutions, TTK, Tube Investments, Visteon

ANNEXURE – VIII

The Gift of Trees

In honour of ....Mr. R. N. Ajith Sankar..................

....10.... trees will be planted and nurtured by Project GreenHands of Isha Foundation in Tamil Nadu, Southern India.

This gift was made possible by...PSG Institute of Management, Coimbatore

"Trees and humans are in an intimate relationship. What they exhale, we inhale. What we exhale, they inhale. This is a constant relationship that nobody can afford to break or live without."

– Sadhguru Jaggi Vasudev

Project GreenHands: **Raising the green cover of Tamil Nadu by 10%** in order to reverse desertification, reduce soil erosion, counteract poverty, rebuild communities, restore self sufficiency, recreate sustainability and survive climate change. Through education, mass people participation and agro-forestry implementation, 10 million trees have been planted in 5 years by 1 million people. 100 million more trees are needed to achieve the goal. Thank you for your vital contribution.

To donate, join in or learn more please visit: www.projectgreenhands.org

PROJECT GreenHands

ANNEXURE - IX

Commitment letter to be signed by the farmer as part of the agroforestry programme

11. விவசாயம் மற்றும் மரம் வளர்ப்பில் பயிற்சி அளித்தால் கலந்து கொள்வீர்களா? : ஆம் ☐ இல்லை ☐

(i) ஆம் எனில்

அ) நன்றாக மரம் வளர்ந்த தோட்டம் பார்ப்பது ☐

ஆ) இயற்கை முறை விவசாயத் தோட்டம் பார்ப்பது ☐

இ) விவசாயத்தில் ஊடுபயிராக மரம் வளர்ந்த தோட்டம் பார்ப்பது ☐

ஈ) அடர்ந்த காடுகள் பார்ப்பது (மலை பிரதேசம்) ☐

உ) உள்ளூரில் நடக்கும் விவசாய முகாமில் கலந்து கொள்வது ☐

ஊ) விவசாய நிலத்தில் அடர்ந்த காடு உருவாக்கியவர்களின் தோட்டம் பார்ப்பது ☐

எ) 100% மரம் வளர்ப்பதற்கான பயிற்சியில் கலந்து கொள்வது ☐

12. மரக்கன்று நடப்படும் இடத்தின் விவரம் : விவசாய நிலம்/ வீடுகளை சுற்றியுள்ள இடங்கள்/ பள்ளி/ கல்லூரி/ நிறுவனங்கள்/ அரசு அலுவலகங்கள்/ சாலையோரம்/ தொழிற்சாலை வளாகம்

13. இத்திட்டத்தில் நடப்படும் மரக்கன்றுகள் எவ்வாறு பாதுகாக்கப்படும் : வேலி/ கூண்டு/ சுற்றுச்சுவர்/ வீடு

14. தேவைப்படும் மரக்கன்றுகளின் எண்ணிக்கை :..................................

உறுதி மொழி:

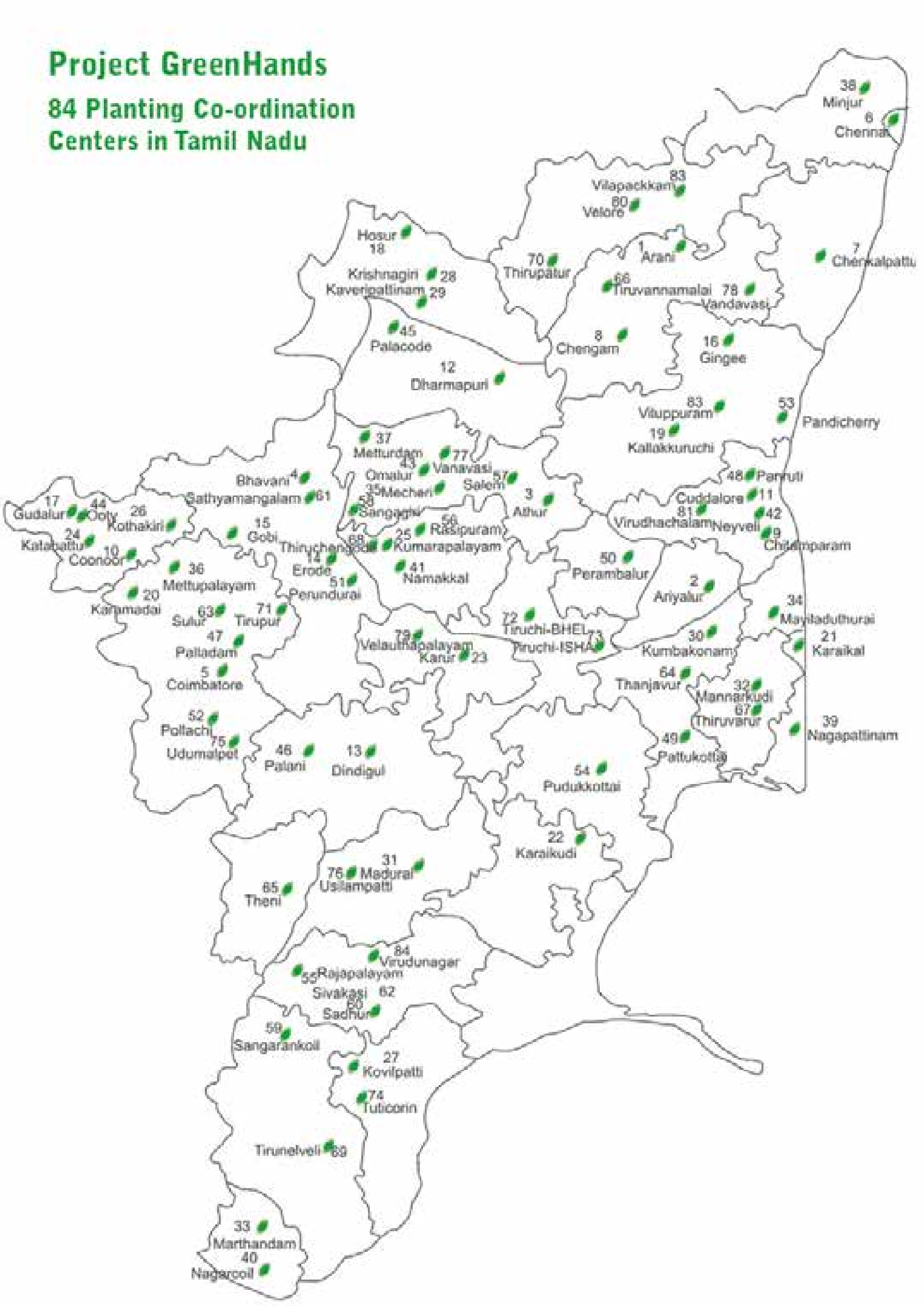
மர ஆர்வலராகிய ....என்னும் நான், இந்த மரக்கன்றுகளை குழந்தைகளைப் போல் பாவித்து முழுமையாக பொறுப்பேற்று பாதுகாப்பேன் எனவும், எங்கள் தாய் மண்ணை பாதுகாக்கவும், வருங்கால சந்ததியினர்களுக்கு அர்ப்பணிப்பாகவும் என்பங்கினை செலுத்துவேன் எனவும் உறுதியளிக்கிறேன்.

கையொப்பம்

முன்பதிவு செய்தவரின் பெயர்:	மரக்கன்றுகள் வாங்கியவர் விவரம்:
பெயர் :	பெயர் : ....
இடம் :	இடம் : ....
நாள் :	நாள் : ....
நேரம் :	நேரம் : ....
முன்பதிவு செய்த நபர்:	**மரக்கன்று வழங்கும் நபர்:**
பெயர் :	பெயர் : ....
கையொப்பம்	கையொப்பம்

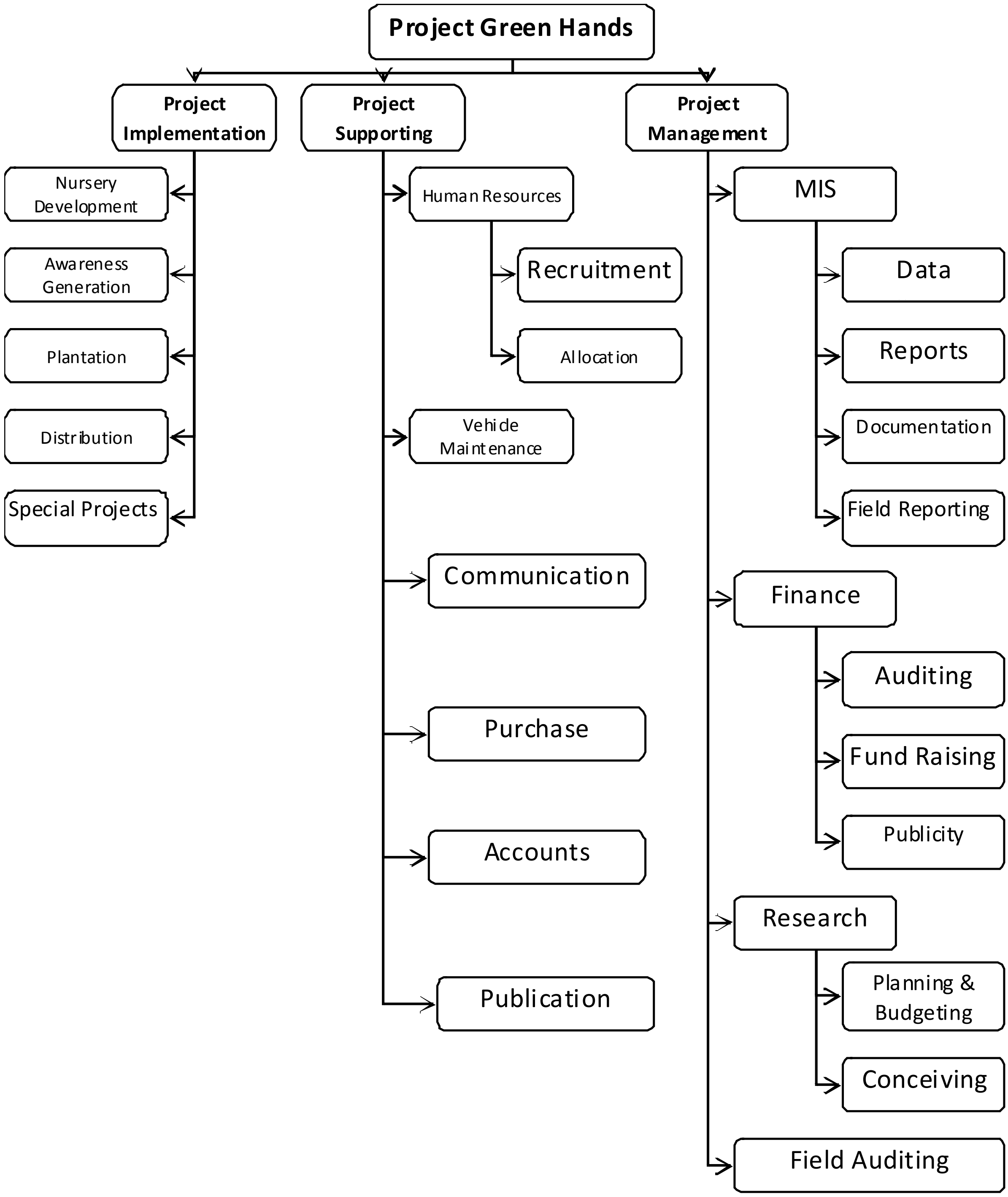
ANNEXURE - X

Planting co-ordination centres in Tamilnadu



ANNEXURE – XI

Organization Structure at Project Greenhands



TEACHING NOTE

SYNOPSIS

The case looks into the management aspects of Project Greenhands, an outreach initiative of Isha Foundation, a non-political non-religious organization founded by Sadhguru Jaggi Vasudev to promote well-being of the individual, society and the world. At a superficial level, the case looks into the objectives of Project Greenhands, its evolution, implementation of the project, the challenges it met (resource mobilization, land for plantation etc.), the impact of the project at the individual and societal level and the possible future endeavors. The case tries to explain how it gained much mind space among the population. We find that the project has been rooted in the universal values and rural ethos. At a deeper level, the case sheds light on the people dynamics behind the project and the role of Sadhguru Jaggi Vasudev. We find that Sadhguru's guidance has been the invisible force of inspiration for the people behind the project. This force made Project Greenhands to achieve Guinness World Record endeavors like planting 852,587 saplings in 6,284 locations across 27 districts in Tamilnadu through three days in the month of October 2006. It is faith and commitment that makes these people believe that they can achieve their objective of planting 114 million trees (11.4 crore) trees. Through this case, we gain an insight into the way a faith based organization function, when engaged in service to the society. Project Greenhands is an example of how alignment of purpose, people and processes will result in organizational excellence.

TEACHING OBJECTIVES

The case will help the students understand:

- The need to have congruence of purpose, processes and people (3Ps) in achieving organizational excellence.
- The people dynamics in a faith based organization.
- The role of human values in project management.
- How public can be mobilized towards a cause and the role of public mobilization in making a movement successful.
- How projects that have a selfless goal creates ripples that are transformative in nature.

TEACHING STRATEGY, APPROACH AND TARGET AUDIENCE

The case can be used on courses related to Management of Non-governmental Organizations/ Faith-based Organizations, Project Management, Corporate Strategy, Management of Change and Transformation, Organization Development and Environmental Management. This case can be used effectively in classroom discussions as well as in distance learning programs. The case can also be used in management development programs that have Human Values and green issues as a component of the program.

Suggested Preparatory Assignment for the Students

1. Students/ users of this case study can be suggested to assess their individual ecological footprint by visiting www.myfootprint.org and their carbon footprint at http://no2co2.in/CarbonCalculator.php . The students can also be asked to calculate ecological footprints of individuals from different strata of the society by using dummy data. This sample can include celebrities like movie stars and sports personalities, politicians, business magnates and people who live below the poverty line. This assessment will help the students to have a new perspective about how an individual's lifestyle impacts the planet.
2. The students can be asked to read through the "Living Planet Report 2012" released by World Wide Fund for Nature, Zoological Society of London and Global Footprint Network. The report can be downloaded from the internet.
3. Students can also be asked to do some general reading related to Loss of Biodiversity, Global Warming, Gaia Hypothesis, and Deforestation.
4. A background reading about Sadhguru Jaggi Vasudev and Isha Foundation will add value to the student.
5. The students should be asked to read the case and come prepared to the class for discussion.

During case discussion

In a classroom discussion, the case moderator can engage the students by asking their perceptions about an organization that is ideal in character. Then the discussion can be turned into the present. Students can discuss the characteristics of organizations, which they know (if any) are ideal in character – whether it be for-profit or not for profit. Soon the moderator can personalize the discussion by asking the students to assess what role should students, as individuals, play in creating and sustaining an organization that is close to their ideal.

Once the introductory talks livens up the session, and give enough food for thought, the session co-coordinator may ask one or two students to sum up the content of the case. It is expected that students are already familiar with the case. From here detailed discussion can be started with the help of discussion questions.

POSSIBLE DISCUSSION QUESTIONS

1. “We wanted to make it a people’s event”. One of the unique aspects of Greenhands was its people mobilization practices. What do you think contributed to Greenhands’ ability to mobilize lakhs of people?

2. Prepare a SWOT analysis for Project Greenhands

AUDIO VISUAL SUPPORT

The website of Project Greenhands provides immense inputs related to the project. The below is the link to a video, available in the website.

http://www.projectgreenhands.org/main-video (About Project Greenhands)

The links to other videos that a student may be interested to watch/ that can be shown in the class session are:

http://www.youtube.com/watch?v=fMmAY_XZYto (Interview with Sadhguru Jaggi Vasudev, about Project Greenhands)

http://www.youtube.com/watch?v=a-I0gd1sZvI (NDTV News Spot with Sadhguru Jaggi Vasudev, about Project Greenhands)

http://www.youtube.com/watch?v=h706M8qduP8 (Nammalvar speaking about Project Greenhands)

http://www.blip.tv/file/867008/ (A promotional capsule on Greenhands by ‘Sounds of Isha’)

PROPOSED SESSION PLAN

The following example session plan gives the sequence of topics and the time allocated to each. This is a single session plan of 90 minutes given to MBA students. This plan can be refined based on time consideration and learning objectives. It can be noted that the case spends approximately 22% of its session plan on issue related to ethics and responsibility (introductory questions and personalized questions), though the word ‘ethics’ and ‘responsibility’ are not made explicit. The objective of the case authors has been to build a case on the foundation of human values, rather than the oft seen pedagogy of delivering values/ ethics/ responsibility as a study distinct from the core papers like business strategy.

1. 0 - 10 minutes: Introductory Questions - What would be the student's perception of an organization that is ideal in character?
2. 10 - 20 minutes: Personalized Questions - Role the case participants, as individuals, should play in creating and sustaining a organization that is close to their ideal
3. 20 - 30 minutes: Summing up the content of the case
4. 30 - 55 minutes: Case Discussion Question 1
5. 55 - 80 minutes: Case Discussion Question 2
6. 80 - 90 minutes: Wrap-up and Conclusion

ANALYSIS TO THE QUESTIONS POSED

1.

The core competency of Isha is mobilizing people. The role of Greenhands was to mobilize people in large scale, especially people from the rural areas, towards a green endeavor. Farmers from rural parts of India were undergoing tremendous suffering, and a number of suicides were getting reported. Farmers had been drained of hope in their own occupation. Project Greenhands wanted to bring back hope to the teeming millions in rural areas. There was also the drastic degradation in environment with water tables going down and variations in rainfall. While there had been many environmental initiatives, many such initiatives lacked a cohesiveness and community spirit. Many initiatives were more or less mechanical in outlook. Unlike many other tree plantation projects, Greenhands adopted a holistic approach to environmental restoration. Project Greenhands wanted to bring about a community spirit, nurture plants and bring in hope to farmers.

Addictive behavior is prevalent among many people in the villages of India and this creates disharmony in the village life. Through its service activities, Isha Foundation is trying to disengage people from narrow feelings like caste and communal feelings and addictions like alcoholism and drug abuse and engage them in productive activities like village festivals and sports events, which brought people together. Sadhguru Jaggi Vasudev has said that the fundamental goal of all activity on the planet is human well-being and that there is only one business on the planet and that is of human well-being. Isha has been aiming to promote individual and societal well-being through Greenhands too. Isha believes that connection with nature would disconnect one from the negativities an individual is associated with.

Isha Foundation was using trees as a tool to bring about a connection – the connection between man and his origin. The belief that drove Greenhands was 'If Love can be established inside, it can be established outside'. More than tree plantation, Greenhands was about mindset change. While planting trees may not be a panacea to the massive environmental degradation we are witnessing, it is certainly a universal first step towards a living that is harmonious with the planet. If we visit places like Auroville, we can find that the whole Auroville is centered around a banyan tree. Indian villages were earlier sensitive to such beliefs, and every village had trees as a source of veneration. Greenhands tried to bring back that sensitivity to our culture.

The approach of Greenhands was rooted in the rural culture and need and promoted sustainable use of resources like land and labor. Creating a community spirit is an important aspect at Greenhands. Without such a spirit, it would be impossible to achieve a multi-million sapling plantation initiative. Activities of Isha Foundation like Isha Yoga Programs, Village Olympics etc. helped in creating a community feeling. Pre-plantation and post-plantation resource management, livelihood opportunities, and the feeling of being part of a cause greater than oneself, created a community feeling among people associated with the project. Village food festivals, Sounds of Isha music concerts etc. attracted people living in the city too. Greenhands provided people at all levels with an avenue to contribute to the project.

An important reason that contributed to the success of the project was that the raison d'être for Greenhands was selflessness. This helped Greenhands to receive the support of people in the rural areas. Once the buy-in was received, the education and awareness programme helped in consolidating the mobilization. At a social level, Greenhands was able to mobilize people due to their affiliation with Isha Foundation. The receiver of the awareness campaign should be sensitive to the sufferings of the world and be open enough so that an urge for action emerges in the receiver. In this project, this was done by providing the villagers with tools that helped them to move towards a higher level of consciousness. By planting a tree and taking responsibility for its nurture and growth, every individual experienced a connection with the source that sustained their existence, the planet itself.

Greenhands also used attractive campaign tools and high profile objectives – like creating a Guinness World Record – to raise profile about the project. Designations like 'Project Greenhands Ambassador', promotional films and functions featuring celebrities increased the profile of the project among the masses.

2.

Weakness and Strength

By its inherent nature, Greenhands lacked the capability to build strong information systems based on volunteer feedback. Greenhands is a volunteer driven movement and not a project per se. People would not like to keep documentation of the service activities that they are engaging in for personal fulfillment. There is a possibility of an inertia setting in, now that Greenhands had achieved certain stellar achievements. The personal commitment of core volunteers played an important role in spreading this movement. The movement will not be able to sustain its energy but for these people.

A strength of Greenhands was its *affiliation with Isha Foundation*. It was only because of its connection with Isha Foundation that Greenhands was able to mobilize the community at the grass root level and a large scale. The association with Isha helped the ethos of this initiative to be *aligned to ancestral and local wisdom.* Greenhands initiative was developed in harmony with the knowledge prevailing among the local and rural populace. The knowledge that the trees had an important role in creation of the mists of the rainforests was available to our ancestors. Nurturing of sacred groves of mature trees to draw down the mists from the Western Ghats to facilitate the precipitation of enough rain to assure the quantity of water needed for both irrigation and drinking water. If one is raising a tree only looking at the commercial value, it means that the tree is bound to be felled the moment it is planted. It is only when one develops a connection with a tree, as if it's a part of oneself, then one start nurturing the tree from the heart. If we are rearing a sapling as our child, will we destroy it? Another strength of Greenhands was its capability to provide such sensitivity training to the common people. When such sensitivity is developed, sustainability develops by itself.

Responsive Design Models - The agro-forestry model supported farmers, as saplings were planted as poly culture crops. Caring for the trees was made the responsibility of those who planted them. What was lacking in terms of system and technical support was easily compensated through commitment and energy shown by the volunteers.

Superlative people practices - Greenhands is a clear example of Douglas McGregor's Theory Y aspect of management where employees view work as being natural as rest or play, and exercise self-direction, self-responsibility and self-control if committed to the objectives. Ample freedom was given to people in executing the project. At the same time, responsibility was also thrust on them. Project design and Project economics went together. Greenhands was created with the purpose of bringing about a connection between human beings and their source of existence. The core volunteers of Greenhands all had deep faith in the conceptual underpinnings in the project. Their commitment to the project was superlative – many of them working seven days a week, sleeping only 4 or 5 hours a day, only taking an honorarium and not a salary etc. Under normal conditions, such peak performance is not sustainable. (While writing this case, the case author also found that the volunteers take food only twice a day, footwear is left outside the place of work, and all members of the organization refers to each other as brother/ sister.) This indicates that Greenhands do not fall into the league of a typical organization that we come across. By working on a project that had lofty goals, volunteers felt that they were doing something worthwhile and their contribution mattered. We can connect these people practices to the *Role of Sadhguru* in the lives of volunteers and the organization. Sadhguru Jaggi Vasudev has been the common bond for the organization. People associated with the project - from the director of the project to a volunteer planting a sapling in the village - the desire to be with Sadhguru brought them together. From the expressions of the volunteers, their personal transformation and the impact the project had created, we can conclude that Sadhguru is a transformational leader.

Threats and Opportunities

Every natural system has a threshold limit. Observing the prevalent and predominant human behavior, it is as if the natural systems of this planet are accelerating towards the threshold limit of extinction. The project will become irrelevant if the threshold limit is crossed. It seems that the actions of an organization like Greenhands is too little and too late.

We can witness that Greenhands had undergone a shift in its approach. From attention capturing initiatives like Guinness World Record initiative, it had moved into a less decibel yet ongoing campaign. This shift is also reflected in the lesser number of plants raised in the nurseries. Many people were attracted to Greenhands due to its catchy goals like creating a Guinness World Record. This may be an important reason for Greenhands receiving popularity, funding and participation support from the public. As increasing number of organizations start mass tree plantation, the novelty that was earlier associated with Greenhands wanes off.

What differentiates Greenhands from other organizations is the capability of Greenhands to promote the community spirit and the ability to gradually raise the level of consciousness of the people associated with the endeavor. By associating with organizations engaged in tree plantation, Greenhands can provide and expand their expertise to a larger segment of population. Bringing NGOs under a similar umbrella will also help in adding strength to the movement. Many international funding agencies are look into small scale agro-forestry in the developing world as a method of raising people above conditions of material poverty. Sharing resources and expertise will add strength to the movement.

There is increasing awareness about the need to inculcate value education among children and the youth. Discussions are also happening about the need to educate these groups about the necessity to manage the resources gifted by the planet in a responsible manner. By involving students in its projects and association with a number of educational institutions, Greenhands had proven itself as an organization that has the capability to inspire students towards a greener life. Greenhands can use this leverage to inspire students towards a greener consciousness in every aspect of their life – be it consuming ecologically friendly materials, recycling waste etc. While planting trees can be the first step, Greenhands has every potential to move into education that increases human sensitivity towards well-being.

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ANNEXURE 20

FOCUS GROUP DISCUSSION ON "REVITALIZATION OF INDIAN RIVERS"

Anandi Iyer[1]

27th August 2017, Isha Foundation, Coimbatore

The core group of volunteers at Isha foundation involved in the Rally for Rivers initiative has been deliberating with several experts from Forestry, agriculture, Industries, research institutions, farmer communities, geologists and water experts, to understand and gain inputs for the massive Mission undertaken under the guidance of Sadhguru. The voluntary group drafted the recommendations and refined it several times over the last 3 months. All this while, the focus has been to keep the issue of advocacy and raising consciousness of every citizen with respect to the serious depletion of rivers, firmly in focus. However, parallel to raising of awareness, it is pertinent and imperative to also develop implementable solutions that address the concerns without any delay. Since these solutions are highly complex, interconnected, multidisciplinary in nature, the process was equally intense and consultative.

In addition to individually talking to experts, who sometimes also brought in very different and indeed divergent points of view, a focus group discussion was organised. This afforded a constructive platform, to deliberate on the various recommendations in a comprehensive manner, ensuring that divergent points of view are elaborated, debated upon, and concluded with clarity and sense of purpose. The focus group discussion also enabled the identification of missing gaps, interconnections between the various thematic areas, and elaboration of success stories and failures. Awareness of ongoing programmes and activities within relevant institutions could also be drawn out and the alignment of recommendations to these activities could be established.

The Focus Group Discussion was conducted by Ms Anandi Iyer, Director Fraunhofer India, one of the world largest applied research organisations. The Visualisation methodology was used for multi stakeholder dialogue, a process

1 Head, Fraunhofer Representative Office India, Bengaluru

which is excellent for planning large and complex development projects, and which ensures active participation from all members. The participants , who are top experts from various fields, were invited for a whole day workshop at Isha Foundation Coimbatore, and the draft recommendations were shared with them in advance. The process involved developing critical questions that cover the various issues and concerns, in a neutral manner. The participants gave their inputs by writing on cards. The cards thus collected were then put up on the board and was deliberated and debated by all the participants. Only the cards that were accepted by the group unanimously were documented, while the others were discarded. The discussions were also recorded on video.

All the issues concerning Rivers , be it agriculture, animal husbandry, industry participation, soil conservation, finance and economics, research and data collection etc. were analysed and articulated in much detail. Attention was also paid to policy issues, technical issues, advocacy and outreach, implementation as well as crosscutting thematic areas. Linking the initiatives to existing government programmes, drawing upon the strength and available resources as well as expertise of the relevant organisations, was an important aspect that was covered at length. The conscious approach was not to reinvent the wheel or duplicate activities.

The final recommendations were then presented to Sadhguru who appreciated the excellent efforts of the participants and thanked them for the support. He underlined the importance to keep the recommendations simple and effective, and to ensure that the recommendations are long term, sustainable, and participative.

It is planned to continue the multi-stakeholder workshops in other cities as well, and through the planning and implementation phase, embark on a transparent, consultative and constructive process to achieve the ambitious vision of the Initiative.

ANNEXURE 21

REPORT ON FOCUS GROUP DISCUSSION HELD AT TRICHY ON 6TH SEPTEMBER, 2017

Archana Anand[1]

Focus Group Discussion (FGD) was conducted between farmer leaders and Sadhguru in Trichy on 6th September, 2017. The farmer leaders present in the discussion were:

1) Shri. Dhanabal - President, Cauvery Delta Farmer's protection Assocation (Nagapattinam)

2) Shri K. Sellamuthu -Chairman, Tamil Nadu Farmers Association & President, Uzhavar Uzhaippalar Katchi (UKK)

3) Shri. Engals Raja - StateCoordinator - Vaangam (Trust built by Dr. G. Nammalvar)

4) Shri 'Nell' Jeyaraman - State Coordinator - Save our Rice campaign & President -Tamil Nadu Organic farmers association

5) Shri 'Poochi' Selvam - Agricultural professor & Pest Management Expert

6) Shri. Ranganathan - General Secretary, Cauvery Farmers Association

7) Shri. Varadarajan - State Joint Secretary, Tamil Nadu Cauvery Farmers Association

8) Shri Thooran Nambi - Author & Promoter of organic farming

9) 'Dikshitar' Balasubramanian – Head, Cauvery Delta Irrigated Farmers Produce Protection Society (Trichy)

10) Shri. Vimalanathan - Secretary, Cauvery Farmers Protection Association (Thanjavur)

11) Shri. D.R Karthikeyan IPS – Former Director of Central Bureua of India

12) Shri. Vellamandi N. Natarajan - Honorable Minister for Tourism

1 Project Green Hands, Isha Outreach, Coimbatore, Tamil Nadu

INTRODUCTION

Sadhguru addressed the farmer leaders and speaks about the gravity of the water situation in India. He says "We have brought the country to such a situation that we are existing as though we live here without consuming food. This is a dangerous way to be. We have not protected the soil, we have not protected the water resources, we have not taken care of the farmer who is doing the marvelous job of converting soil to food. This is not an easy task. Earlier water used to be there in every village. Now we have to go in search of water.

Right now we need to go 2,000 feet deep to get water. Earlier, wherever we were, all around the year, there were places were water bodies never went dry. But now we have to go 2000 feet deep to get water. We somehow used borewells to go so deep. What we should understand is how will a worm or insect be able to go 2,000 feet deep into the soil? How will a tree root go 2,000 feet deep? If all the trees, worms, insects and other creatures in the land die, then what will be there in the soil? It will become sand. If it becomes sand, we will make it a desert. Till now, we have never come together and worked for a single purpose

So taking care of soil and water, and giving the needed support to the farmers is something we need to create. Just talking about this is not enough. A policy must be brought about in the national level. The Rally for Rivers has been happening for this purpose. If we stand strong with a single purpose, we can bring about a policy. We should bring about a policy which will be beneficial to all the stakeholders. We should not get stuck in trivial things in the process of creating this. That is all. I appeal to all of you to make this happen."

DELIBERATIONS

1) In a farmer land, if 5% of the land is planted with big trees, it will meet the mulching requirement of a farmer. If a tree is harvested, one can get 30 to 40 tons of leaves along with branches. If this is mixed with neem leaves and put as a layer for 8 inch thickness, a farmer will not get any pests. There will not be any use for chemical insecticides or fertilizers.

2) Isha has initiated talks with CII (Confederation of Indian Industries) to support farmers. CII has pledged its support to invest in industries. Such tie-ups are planned in 8 districts in Tamil Nadu.

3) Without taking care of the farmer, we cannot take care of the country. A farmer has suffered a great deal. If we conduct a survey among all farmers and ask them how many of them want their next generation to go into agriculture, not even 15% will answer positive. What this means is, the knowledge we earned in 10,000 years, we will lose it in another 25 years. Once this generation passes, there will be nobody to do agriculture.

4) Because of Isha Agro Movement, in the village P.S.Palayam, in river banks and around lakes, the villagers have planted nearly 10,000 to 15,000 trees. The fruits from the trees have ripened, bees have built hives, birds eat fruits and the ecology has improved By embracing nature , agriculture has improved.

5) Natural farming methods is not just for one's economic well-being. It is for the wellbeing of the country, the soil, and for the next generation.

SHARINGS FROM FARMER LEADERS

1) There is a saying "You walked, Glory to you Kaveri!" That means only if Kaveri walks , the lands will be irrigated. If she runs she will flood. If she does not walk at all, it will be a drought. Today I pray "You walked, Glory to you Kaveri! Now you stopped, and forgot us Kaveri! Please recover and flow again Kaveri!" [Shri. Ranganathan - General Secretary, Cauvery Farmers Association]

2) The tradition in our households is that whenever guests come, the first thing we offer them is water to quench their thirst. If we go to a hotel, before we eat, they bring a glass of water and only after that they ask us what we want to eat. That was the culture. But today, the moment we go to a hotel, they place a bottle of water in front of us and charge Rs.20 for it. All the hills that were green once are now totally barren. That means all the trees there have been cut. The structure of the river ecosystem should be revived. In Trichy city, you have started this at the right place today. [Shri. Dhanabal - President, Cauvery Delta Farmer's protection Assocation (Nagapattinam)]

3) Reduction in rainfall and a drought we have not seen in our 141-year history. Sadhguru started this movement at Coimbatore on 3rd (September). After he started it in Coimbatore and left the city, the worst drought in 141 years vanished in one night and heavy rainfall happened and lakes and water bodies

filled up and Noyyal river also flowed. It is a wonderful beginning. After that wherever you went it rained, there was rain in Kanyakumari, there was rain in Madurai, there was heavy outpour in Trichy also. This will definitely succeed, this will save these people, save the farmers, and save the farming occupation. The initiative you have taken up for this is as big as the Himalayas. No sages, or seers or mutt leaders or any service organization has taken up this kind of initiative. All the farmers of the country congratulate and bow down to you for taking up this initiative. Just like the Mahatma who wore a simple dhoti and sent away the English who said that even the sun asked them and then only rose in the sky, you will definitely succeed in your initiative and revive our rivers. Every human being who consumes water should support this initiative. We will stand behind you as children of one mother in this initiative you have taken, and make this happen, and revive the rivers and save our country [Shri K. Sellamuthu -Chairman, Tamil Nadu Farmers Association]

4) I came eagerly to look at Kaveri river. I was hoping that water will flow at least there. A small quantity of water was flowing. I was happy that at least a small volume of water is running in the river. The person who accompanied me told me that it was not fresh water, it was sewage water. The rivers have been taken to this pathetic situation. Very soon, water is going to flow in abundance in this Kaveri river, we are going to see a golden period. [Renald Fernando]

5) This Rally for Rivers should become a huge success. [D.R.Karthikeyan, IPS]

6) If we do not do anything to the present situation, in 2050, not one seed that we plant will sprout. This is what the experts are saying [Thiru.Kumar]

7) Trichy is a land where there were poets whose life was all about singing in praise of Kaveri river. In a place where we praise, glorify and bow down to mother Kaveri, when we see the present state of the Kaveri river, tears well up in my eyes. In the Kaveri water that crawled along, people jumped and fell and swam across. Those scenes were a feast to the eyes. That kind of wonderful happenings should happen again in the coming years with the leadership of Sadhguru. There has been no history of anything that he has taken up ever failing. [Honorable Tourism Minister Thiru.Vellamandi N.Natarajan]

ANNEXURE 22

GOVERNMENT SCHEMES

Cdr. S. Lakshmanan Iyer (Retd.)[1]

OVERVIEW:

The proposed recommendations of creation of tree cover on private farm lands involves a transition for farmers from agriculture of conventional crops to organic horticulture and agro-forestry with drip irrigation. Each of these activities involve a major transition for the farmer, with associated risks, both real and perceived. The most fundamental among them is a loss of income until the trees come to fruition.

Most, if not all of these risks / requirements can be offset using existing Government Schemes. As on date, convergence of these schemes have rarely been achieved. But in the present context, in order to make the proposed initiative successful, this convergence is mandatory.

Although efforts have been made to shortlist all available schemes, those listed here may not be exhaustive, and it is possible that there are other existing schemes which may be of relevance in the present context.

1. LIST OF IMPORTANT SCHEMES:

(a) Mission on Integrated Development of Horticulture (MIDH)

(b) National Mission on Sustainable Agriculture (NMSA)

  (i) Paramparagat Krishi Vikas Yojana (PKVY}

  (ii) Sub Mission on Agro Forestry (SMAF)

(c) Pradhan Mantri Fasal Bima Yojana (PMFBY)

(d) Pradhan Mantri Krishi SInchai Yojana (PMKSY)

(e) Compensatory Afforestation Fund Management and Planning Authority – CAMPA

2. OTHER RELATED SCHEMES / ACTS OF RELEVANCE:

(a) NMAET - National Mission on Agricultural Extension & Technology

(b) RKVY – Rashtriya Krishi Vikas Yojana

(c) NFSM - National Food Security Mission

(d) SAGY - Saansad Aadarch Gram Yojana

1 Director, Anantha Naturals Pvt. Ltd., Coimbatore, Tamil Nadu

3. **SUMMARY OF INDIVIDUAL SCHEMES**

(a) **MISSION ON INTEGRATED DEVELOPMENT OF HORTICULTURE (MIDH):**

(i) **Information Source Document:** Operational Guidelines, April 2014

(ii) **Department:** Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) **Website:** http://midh.gov.in/

(iv) **Financial Outlay for 2017-18:** ₹ 2330 Crore (Approx)

(v) **Overview:**

(aa) Centrally Sponsored Scheme for the holistic growth of the horticulture sector

(ab) Covering fruits, vegetables, root & tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashew, cocoa and bamboo.

(ac) GoI contribution:

- 85% - Non-NE States
- 100% - NE States
- 100% - Development of bamboo
- 100% - Programmes of National Horticulture Board (NHB), Coconut Development Board (CDB), Central Institute for Horticulture (CIH), Nagaland and the National Level Agencies (NLA)

(ad) Sub-Missions:

Sl No	Name of Sub-Mission	Abbreviation	Applicability
1	National Horticulture Mission	NHM	All states & UTs except states in NE and Himalayan Region.
2	Horticulture Mission for North East & Himalayan States	HMNEH	All states in NE and Himalayan Region.
3	National Bamboo Mission	NBM	All states & UTs
4	National Horticulture Board	NHB	All states & UTs focusing on commercial horticulture
5	Coconut Development Board	CDB	All States and UTs where coconut is grown.
6	Central Institute for Horticulture	CIH	NE states, focusing on HRD and capacity building

(ae) MIDH will work closely with National Mission on Sustainable Agriculture (NMSA) to wards development of Micro-Irrigation for all horticulture crops and protected cultivation on farmers' field.

(vi) Mission Objectives:

(aa) Promote holistic growth of horticulture sector, including bamboo and coconut through area based regionally differentiated strategies, which includes research, technology promotion, extension, post harvest management, processing and marketing

(ab) Encourage aggregation of farmers into farmer groups like FIGs/ FPOs and FPCs to bring economy of scale and scope.

(ac) Enhance horticulture production, augment farmers, income and strengthen nutritional security

(ad) Improve productivity by way of quality germplasm, planting material and water use efficiency through Micro Irrigation.

(ae) Support skill development and create employment generation opportunities for rural youth in horticulture and post harvest management, especially in the cold chain sector.

(vii) Noteworthy Features:

(aa) State Level Executive Committee will organize base-line survey and feasibility studies for distinct areas/clusters to determine status and potential and demand

(ab) District Planning Committee and Panchayati Raj Institutions (PRI) will be involved in implementing the programme commensurate with their expertise and available infrastructure. They will have a role in:

- Identification of crops/species and beneficiaries in consultation with District Panchyats.
- Training, Extension and Awareness creation through Panchayats and Gram Sabhas (GS).
- Organization of PRI and GS meetings and giving feed back to the concerned officials with regard to implementation of MIDH.

(ac) Technology driven programmes to improve productivity and quality, such as:

- Introduction of improved varieties & Rejuvenation with improved cultivars.
- Bee-keeping for crop pollination
- Mechanization & Demonstration of latest technologies
- Post Harvest Management and cold chain
- Marketing infrastructure development

(ad) States will have a network of nurseries for producing planting material demand.

(ae) Planting material of seed origin for fruit crops which can be vegetatively propagated will not qualify for subsidy assistance.

(af) Assistance will be provided for setting up of individual mushroom production, spawn production and compost making units, as

(ag) Assistance for creating water sources through construction of community tanks, farm ponds/reservoirs with plastic / RCC lining to ensure irrigation to horticulture crops

(aa) Assistance for creating water source through construction of farm ponds/tube wells/ dug wells for individuals. in conjunction with MGNREGS

(ab) Adoption of organic farming techniques along with its certification.

(ac) Strengthen existing horticulture markets including wholesale and rural markets with focus on grading, standardization and quality certification of horticulture produce

(ad) Primary/ minimal processing units will be promoted under NHM. Large scale processing units will be promoted by Ministry of Food Processing Industries (MFPI), out of their ongoing Schemes.

(viii) Related National-level Agencies

(aa) National Horticulture Board (NHB), Gurgaon.

(ab) Coconut Development Board, Kochi

(ac) Small Farmer's Agri-Business Consortium (SFAC), New Delhi:

(ad) Directorate of Cashew and Cocoa Development (DCCD), Kochi

(ae) Directorate of Arecanut and Spices Development (DASD), Calicut

(af) National Committee on Plasticulture Applications in Agriculture & Horticulture (NCPAAH), New Delhi

(ag) National Horticulture Research & Development Foundation, Nashik

(ah) National Bee Board (NBB)

(ai) National Seeds Corporation, New Delhi

(aj) National Research Centre for Citrus, Nagpur

(ak) State Farm Corporation of India, New Delhi

(al) Hindustan Insecticides Ltd. (HIL)

(am) National Institute for Agricultural Extension Management (MANAGE), Hyderabad

(an) Fresh & Healthy Enterprises Ltd. (FHEL), New Delhi

(ao) Agricultural and Processed Food Products Export Development Authority (APEDA), New Delhi

(ap) Directorate of Marketing & Inspection (DMI), New Delhi

(aq) Ministry of Food Processing Industries (MFPI), New Delhi

(ar) National Medicinal Plants Board (NMPB), New Delhi

(as) Central Institute of Horticulture (CIH), Nagaland

(at) National Centre for Cold Chain Development (NCCD)

(au) National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Sonipat, Haryana

(b) NATIONAL MISSION FOR SUSTAINABLE AGRICULTURE (NMSA):

(i) Information Source Document: Operational Guidelines, 2014

(ii) **Department:** Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) Website: http://nmsa.dac.gov.in/

(iv) Financial Outlay for 2017-18: ₹ 923 crore

(v) **Overview:**

(aa) Formulated for enhancing agricultural productivity especially in rain fed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation.

(ab) Special emphasis on soil & water conservation, water use efficiency, soil health management and rain-fed area development.

(ac) Infuse judicious utilization of resources of commons through community based approach.

(ad) Will cater to key dimensions of 'Water use efficiency', 'Nutrient Management' and 'Livelihood diversification' through adoption of sustainable development pathway

(ae) Aims to promote location specific improved agronomic practices through soil health management, enhanced water use efficiency, crop diversification, progressive adoption of crop-livestock farming systems and integrated approaches like crop-sericulture, agro-forestry, fish farming, etc.

(af) NSMA has four major components:

- Rainfed Area Development (RAD)
- On Farm Water Management (OFWM)
- Soil Health Management (SHM)
- Climate Change and Sustainable Agriculture: Monitoring, Modeling and Networking (CCSAMMN)

(vi) **Mission Objectives / Strategy:**

(aa) Location specific Integrated / Composite Farming Systems.

(ab) Appropriate soil and moisture conservation measures;

(ac) Adopt comprehensive soil health management practices through efficient water management to expand coverage for achieving 'more crop per drop';

(ad) Develop capacity of farmers & stakeholders

(ae) Pilot models in select blocks for improving productivity of rain-fed farming

(af) Establish an effective inter and intra Departmental/Ministerial co-ordination

(ag) Enhanced soil carbon storage

(ah) Creating database on soil resources through land use survey, soil profile study and soil analysis on GIS platform

(ai) Promoting location and crop specific integrated nutrient management practices

(aj) Involve knowledge institutions and professionals in developing climate change adaptation and mitigation strategies for specific agro climatic situations

(vii) Noteworthy Features:

(aa) State Government may engage reputed NGOs for implementation of cluster/ village development plan

(ab) A dedicated subject expert/consultant on sustainable agriculture will be engaged each for 2 to 3 adjoining districts depending on the number of clusters taken up to look after the projects, give technical advice and assist in monitoring. These consultants to be engaged on contract basis and there remuneration is admissible from Mission.

(ac) Systems. Areas / Commodities developed developed under National Food Security Mission (NFSM), National Mission on Oilseed & Oil Palm (NMOOP), Mission for Integrated Development of Horticulture (MIDH), National Livestock Mission (NLM) can be supplemented with other productions systems from NMSA to make it an Integrated Farming System.

(ad) National Mission for Agriculture Extension & Technology (NAMET) can be appropriately made use of for capacity building, awareness generation, information support, farm mechanization, availability of seeds/planting materials etc.

(ae) Suitable linkage for agro-processing and Marketing may be established for the cluster. Possibilities of building post harvest and market linkage under PPP model may be explored. Funds from schemes like NADP, National Mission for Food Processing may be dovetailed for this purpose.

(af) At least 50% of the allocation is to be utilized for small, marginal farmers of which at least 30% are women beneficiaries/ farmers. Further 16% & 8% of the total allocation or in proportion of SC/ST population in the district will be utilized for Special Component Plan (SCP) and Tribal Sub Plan (TSP) respectively

(ag) RAD:

- Will adopt an area based approach for development and conservation of natural resources along with farming systems.
- Explore potential utilization of natural resources base / assets available/created through watershed development and soil conservation activities/ interventions under MGNREGS, NWDPRA, RVP&FPR, RKVY, IWMP etc.
- A cluster based approach of 100 hectare or more may be adopted. Farmers' Companies, Farmers' Producer Companies/Organizations, Registered Farmers' Societies, Farmers' Cooperatives would also be eligible for developing a cluster.
- The RAD clusters should have soil analysis/soil health card/soil survey maps to justify the interventions proposed.
- At least 25% of the farming system area will have to be covered under On Farm Water Management. Farming Systems.
- Creation and development of common property resources/assets/utilities like grain bank, biomass shredders, fodder bank, group marketing etc. will be encouraged.
- Emphasis on multi-cropping, rotational cropping, inter-cropping, mixed-cropping practices with

allied activities like horticulture, livestock, fishery, agroforestry, apiculture, conservation/promotion of NTFPs etc. to enable farmers not only in maximizing the farm returns for sustaining livelihood, but also to mitigate the impacts of drought, flood or other extreme weather events.

- Farmers would have the option to choose one or combination of farming systems suitable to the specific eco-system supported through local KVK, SAU, ICAR Centre, ICRISAT, ATMA etc., for maximizing agricultural productivity.

(ah) OFWM:

- Focus primarily on enhancing water use efficiency by promoting efficient on-farm water management technologies and equipment & effective harvesting & management of rainwater.
- Assistance for adopting water conservation technologies, efficient delivery and distribution systems etc.
- Emphasis to manage and equitably distribute the resources of commons by involving the water users associations, etc..
- To conserve water on farm itself, farm ponds may be dug using MGNREGA funds.

(ai) SHM:

- Soil health cards to be issued every 3 years, to all farmers of the country, so as to provide a basis to address nutrient deficiencies in fertilization practices
- Assistance for various improved package of practices based on land use and soil characteristics, generated through geographical information system (GIS) based thematic maps and database on land and soil characteristics through extensive field level scientific surveys.

- Provide support to reclamation of problem soils (acid/alkaline/saline).
- Public Private Partnership Model may be adopted to ensure that the soil testing is done in time and in the numbers required.
- "Paramparagat Krishi Vikas Yojana" is an elaborated component of Soil Health Management (SHM) of major project National Mission of Sustainable Agriculture (NMSA). Under PKVY Organic farming is promoted through adoption of organic village by cluster approach and PGS certification

(aj) CCSAMMN:

- Creation and bidirectional (land/farmers to research/scientific establishments and vice versa) dissemination of climate change related information and knowledge by way of piloting climate change adaptation/mitigation research/model projects in the domain of climate smart sustainable management practices and integrated farming system suitable to local agro-climatic conditions.
- Comprehensive pilot blocks will be supported to illustrate functional mechanism for dissemination of rainfed technologies, planning, convergence and coordination with flagship schemes/Missions like MGNREGS, IWMP, Accelerated Irrigation Benefit Programme (AIBP), RKVY, NFSM, MIDH, NMAET etc.
- Awarding of Studies, Documentation & Publication, Domestic and Foreign Training, Workshops/Conferences etc. will be supported

(viii) Departments under Department of Agriculture, Cooperation & Farmer's Welfare:

(aa) Soil and Land Use Survey of India (SLUSI)

(ab) National Centre of Organic Farming (NCOF)

(ac) Central Fertilizer Quality Control & Training Institute (CFQCTI) (ad) National Committee on Plasticulture Applications in Horticulture (NCPAH)

(c) **PARAMPARAGAT KRISHI VIKAS YOJANA (PKVY):**

(i) Information Source Document: Operational Guidelines, April 2017

(ii) Department: Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) Approximate Allocation for FY 17-18: 270 Crore

(iv) Overview:

(aa) "Paramparagat Krishi Vikas Yojana" is an elaborated component of Soil Health Management (SHM) of major project National Mission of Sustainable Agriculture (NMSA).

(ab) Centre State sharing pattern of funding:

- Himalayan & NE States – 90:10
- Other States – 60:40
- Union Territories – 100% by Centre

(v) Mission Objectives / Strategy:

(aa) Organic farming is promoted through adoption of organic village by cluster approach (minimum total area - 50 acres / 20 ha, as contiguous as possible) and PGS certification

(ab) Expected Outcomes envisaged:

- Promotion of commercial organic production through certified organic farming.
- The produce will be pesticide residue free and will contribute to improve the health of consumer.
- It will raise farmer's income and create potential market for traders.
- It will motivate the farmers for natural resource mobilization for input production.

(d) **SUB MISSION ON AGROFORESTRY (SMAF):**

(i) **Information Source Document:** Operational Guidelines, 2016

(ii) **Department:** Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) **Financial Allocation for FY 17-18:** 100 crore

(iv) **Overview:**

(aa) "Sub Mission on Agro Foresty" is sub-mission under National Mission of Sustainable Agriculture (NMSA)

(ab) The aim of the submission is to expand the tree coverage on farmland in complementary with agricultural crops.

(ac) The mission is focused to achieve the quantifiable benefits such as increase tree cover to enhance carbon sequestration, enrichment of soil organic matter, availability of quality planting material, improvement in livelihood, productivity enhancement of crop and cropping systems, development of an information system etc.

(ad) Centre State sharing pattern of funding:

- Himalayan & NE States – 90:10
- Other States – 60:40
- Union Territories – 100% by Centre

(v) **Mission Objectives / Strategy:**

(aa) Objectives:

- To encourage and expand tree plantation in complementary and integrated manner with crops and livestock.
- To ensure availability of quality planting material like seeds, seedlings, clones, hybrids, improved varieties, etc.
- To popularise various Agroforestry practices/models suitable to different agro ecological regions and land use conditions.
- To create database, information and knowledge support in the area of agroforestry.

- To provide extension and capacity building support to agroforestry sector.

(ab) Strategy:

- Expanding the coverage under tree plantation in arable land suitable to local agro climatic and land use conditions.
- Encouraging farmers to grow trees in their farmland along with crops/cropping systems and/or livestock as an integral component of farming system.
- Promoting setting up of new small nurseries and hi-tech big nurseries for producing quality planting materials.
- Promoting various Agroforestry practices/models suitable to different agro ecological regions and land use conditions (Agrisilvicultural, Silvipastoral, Agrisilvopastoral, Apiculture with Trees, Aqua forestry etc.)
- Promoting Peripheral and Boundary Plantation on farms.
- Low Density Plantation on Farm Lands including intermediate/strip plantation & High Density Block Plantation will also be supported.

(vi) Noteworthy Features:

(aa) Implementation of the scheme only in the states having liberalized transit regulations for transport of timber and will be extended to other states as and when such relaxations are notified by them.

(ab) Liberal transit rules will be a precondition for availing the benefit of the programme.

(ac) Mission Interventions:

- Nursery Development for quality planting material
- Peripheral and Boundary Plantation
- Low Density Plantation on Farm Lands - Ranging from more than 100 plants/ha to more than 500 plants/ ha without sacrificing the yield of the existing crops/

cropping systems

- High Density Block Plantation - Differential planting densities ranging from more than 500 plants/ha to 1500 plants/ha as intermediate blocks / strip plantations / wind breaks would be supported. Farmers
- Capacity Building & Trainings
- Demonstration of Agroforestry Models

(ad) Convergence with other schemes:

- Crop/cropping system/livestock development programmes like NFSM, RKVY, NMOOP, NMSA and other state funded agriculture programmes related to crop demonstration
- Oilpalm and TBOs are being promoted under NMOOP.
- Specific activities like nursery development for quality seeds/planting material, land & water management, reclamation of waste land/problem soils, precision irrigation, value addition and processing, conservation agriculture etc. shall be converged with the ongoing programmes like MIDH, RKVY, MGNREGA, PMKSY, NMSA
- Plantation measures of MoEF&CC, MoRD, Min of Commerce & Industries, Ayush, DONER etc. to be mapped in the cluster development plan of SMAF
- Neeranchal project is being implemented in selected districts of nine states viz., Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Telangana. Convergence implementing the sub-mission in these districts. Hydro-geologic tools and decision support system of Neeranchal project will be used in the planning process.
- Wherever possible, plantation of medicinal plants out of list of species provided by AYUSH Department will also be promoted for plantation

(ae) Soil Health Cards is to be made a pre-requisite for farmers in getting the benefit of the programme.

(af) Wherever feasible, during transfer of assistance particularly for farmer centric activities, Direct Benefit Transfer (DBT) may be adopted. Farmers benefitted under the programme may be linked with the AADHAR based information system.

(ag) Villages covered under Sansad Adarsh Gram Yojana and reward villages that have become free from open defecation may be given additional weightage in selection of clusters.

(ah) At least 50% of the allocation is to be utilized for small, marginal farmers of which at least 30% are women beneficiaries/ farmers. Further 16% & 8% of the total allocation or in proportion of SC/ST population in the district will be utilized for Special Component Plan (SCP) and Tribal Sub Plan (TSP) respectively.

(ai) Panchyati Raj Institutions as well as Farmers' participatory Approach will be involved actively while selecting the beneficiaries

(e) **PRADHAN MANTI FASAL BIMA YOJANA (PMFBY)):**

(i) Information Source Document: Operational Guidelines, April 2014

(ii) Department: Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) Website: Financial Outlay for 2017-18: 9,000 crore

(iv) Overview:

(aa) Aims at supporting sustainable production in agriculture sector by way of:

- Providing financial support to farmers suffering crop loss/damage arising out of unforeseen events
- Stabilizing the income of farmers to ensure their continuance in farming

- Encouraging farmers to adopt innovative and modern agricultural practices
- Ensuring flow of credit to the agriculture sector.

(ab) All farmers including sharecroppers and tenant farmers growing the notified crops in the notified areas are eligible for coverage.

(ac) All farmers availing Seasonal Agricultural Operations (SAO) loans from Financial Institutions (i.e. loanee farmers) for the notified crop(s) would be covered compulsorily. The Scheme would be optional for the non-loanee farmers

(ad) Special efforts shall be made to ensure maximum coverage of SC/ ST/ Women farmers under the scheme.

(ae) Panchayat Raj Institutions (PRIs) may be involved at various stages of implementation of crop insurance schemes particularly in the identification of the crops and beneficiaries, extension and awareness creation amongst farmers, obtaining feed-back of the farmers while assessing the claim

(v) Coverage of Crops

(aa) Food crops (Cereals, Millets and Pulses),

(ab) Oilseeds

(ac) Annual Commercial / Annual Horticultural crops

(vi) Coverage of Risks and Exclusions: Following stages of the crop and risks leading to crop loss are covered under the scheme:

(aa) Prevented Sowing/ Planting Risk: Insured area is prevented from sowing/ planting due to deficit rainfall or adverse seasonal conditions.

(ab) Standing Crop (Sowing to Harvesting): Comprehensive risk insurance is provided to cover yield losses due to non-preventable risks, viz. Drought, Dry spells, Flood, Inundation, Pests and Diseases, Landslides, Natural Fire and Lightening, Storm, Hailstorm, Cyclone, Typhoon, Tempest, Hurricane and Tornado.

(ac) Post-Harvest Losses: Coverage is available only up to a maximum period of two weeks from harvesting for those crops which are allowed to dry in cut and spread condition in the field after harvesting against specific perils of cyclone and cyclonic rains and unseasonal rains.

(ad) Localised Calamities: Loss/ damage resulting from occurrence of identified localized risks of hailstorm, landslide, and Inundation affecting isolated farms in the notified area.

(ae) General Exclusions: Losses arising out of war and nuclear risks, malicious damage and other preventable risks shall be excluded.

(vii) Preconditions for implementation of the Scheme

(aa) The main conditions binding on States/ UTs, are as follows:

- Conduct requisite number of Crop Cutting Experiments (CCEs) at the level of notified insurance unit area
- CCE based yield data will be submitted to insurance company within the prescribed time limit
- Make necessary budgetary provision in State/ UT budget, to release premium subsidy based on fair estimates, at the beginning of the crop season;
- Be willing to facilitate strengthening of weather station network.
- Adoption of innovative technology specially Smart phones /hand held devices for capturing conduct of CCEs

(viii) Notifications: State Government / UT to issue notification and its circulation to all concerned at least one month in advance of the commencement of the crop season, the following:

(aa) Notification of crops, areas and Implementing Agency (IA)

(ab) Notification of calamity year(s), if any for calculation of threshold yield

(ac) Seasonality discipline

(ad) Notification of Automatic Weather Stations (AWS)

(ae) Entry of data on Crop insurance Portal

(ix) Sum Insured /Coverage Limit:

(aa) Sum Insured per hectare for both loanee and non-loanee farmers will be same and equal to the Scale of Finance as decided by the District Level Technical Committee, and would be pre-declared by The State Level Coordination Committee on Crop Insurance (SLCCCI) and notified.

(ab) Sum insured for irrigated and un-irrigated areas may be separate.

(x) Premium Rates and Premium Subsidy:

(aa) The rate of Insurance Charges payable by the farmer will be as per the following table:

(ab) The Actuarial Premium Rate (APR) would be charged under PMFBY by implementing agency (IA).

(ac) The difference between Actuarial Premium Rate and rate of insurance charges actually payable by farmers will be Rate of Normal Premium Subsidy, which shall be equally shared by Centre and State. However, the States / UTs are free to extend additional subsidy over and above the stipulated subsidy.

S. No.	Season	Crops	Maximum Insurance charges payable by farmer (% of Sum Insured)
1	Kharif	All foodgrain and Oilseeds crops (all Cereals, Millets, Pulses and Oilseeds crops)	2.0% of SI or Actuarial rate, whichever is less
2	Rabi	All foodgrain and Oilseeds crops (all Cereals Millets, Pulses and Oilseeds crops)	1.5% of SI or Actuarial rate, whichever is less
3	Kharif and Rabi	Annual Commercial / Annual Horticultural crops	5% of SI or Actuarial rate, whichever is less

(f) **PRADHAN MANTRI KRISHI SINCHAI YOJANA (PMKSY)**

(i) **Information Source Document:** Operational Guidelines, April 2014

(ii) **Department:** Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) **Website:** http://pmksy.gov.in/

(iv) **Financial Outlay for 2017-18:** 3050 crore

(v) **Overview:**

(aa) Achieve convergence of investments in irrigation at the field level

(ab) Enhance the physical access of water on the farm and expand cultivable area under assured irrigation (Har Khet ko pani)

(ac) Integration of water source, distribution and its efficient use

(ad) Improve on-farm water use efficiency to reduce wastage and increase availability both in duration and extent

(ae) Adoption of precision-irrigation and other water saving technologies (More crop per drop).

(af) Recharge of aquifers and introduce sustainable water conservation practices

(ag) Ensure integrated development of rainfed areas using the watershed approach towards soil and water conservation, regeneration of ground water, arresting runoff, providing livelihood options and other NRM activities.

(ah) Promote extension activities relating to water harvesting, water management and crop alignment for farmers and grass root level field functionaries.

(ai) Explore the feasibility of reusing treated municipal waste water for periurban agriculture (aj) Attract greater private investments in irrigation.

(vi) Strategy & Focus Areas

(aa) Creation of new water sources; repair, restoration and renovation of defunct water sources; construction of water harvesting structures, secondary & micro storage, groundwater development, enhancing potentials of traditional water bodies at village level.

(ab) Developing/augmenting distribution network where irrigation sources are available or created

(ac) Promotion of scientific moisture conservation and run off control measures to improve ground water recharge so as to create opportunities for farmer to access recharged water through shallow tube/dug wells;

(ad) Promoting efficient water conveyance and field application devices within farm, such as underground piping system, Drip & Sprinklers, etc.

(ae) Encouraging community irrigation through registered user groups/farmer producers' organisations/NGOs

(af) Farmer oriented activities like capacity building, training and exposure visits, demonstrations, farm schools, skill development in efficient water and crop management practices through mass media campaigns

(vii) Programme Components:

(aa) Accelerated Irrigation Benefit Programme (AIBP)

- Focus on faster completion of ongoing Major and Medium Irrigation including National Projects.

(ab) Har Khet ko Pani

- Creation of new water sources through Minor Irrigation (both surface and ground water)
- Repair, restoration and renovation of water bodies; strengthening carrying capacity of

traditional water sources, construction rain water harvesting structures

- Command area development, strengthening and creation of distribution network from source to the farm
- Ground water development in the areas where it is abundant, so that sink is created to store runoff/ flood water during peak rainy season.
- Improvement in water management and distribution system for water bodies
- At least 10% of the command area to be covered under micro/precision irrigation.
- f) Diversion of water from source of different location where it is plenty to nearby water scarce areas irrespective of irrigation command.
- Creating and rejuvenating traditional water storage systems

(ac) Per Drop More Crop

- Promote efficient water conveyance and precision water application devices like drips, sprinklers
- Topping up of input cost particularly under civil construction beyond permissible limit (40%), under MGNREGS for activities like lining inlet, outlet, silt traps, distribution system etc.
- Construction of micro irrigation structures to supplement source creation activities including tube wells and dug wells which are not supported under other programme components of PMKVY
- Secondary storage structures at tail end of canal system
- Water lifting devices like diesel/ electric/ solar pump sets including water carriage pipes,

underground piping system.

- Extension activities for promotion of scientific moisture conservation and agronomic measures
- Capacity building, training and awareness campaign
- Information Communication Technology (ICT) interventions through NeGP-A and also to do intensive monitoring of the Scheme.

(ad) Watershed Development

- Effective management of runoff water and improved soil & moisture conservation activities on watershed basis.
- Converging with MGNREGS for creation of water source to full potential in identified backward rainfed blocks including renovation of traditional water bodies

(viii) Noteworthy Features

(aa) District Irrigation Plans (DIPs) shall be the cornerstone for planning and implementation of PMKSY.

(ab) National Rainfed Area Authority (NRAA) will be associated in preparation of State Irrigation Plan (SIP) and providing advisories to State Governments for comprehensive irrigation development.

(ac) A State will become eligible to access PMKSY fund only if it has prepared the District Irrigation Plans (DIP) and State Irrigation Plan (SIP)

(ad) States will be given additional weightage for levying charges on water and electricity for irrigation purpose, so as to ensure sustainability of the programme.

(ae) States will also give priority to villages identified under Sansad Adarsh Gram Yojana (SAGY) while implementing PMKSY.

(af) In order to ensure efficient use of water, extension services will focus at:

- Targeting in how to make best use of available water through crops/cropping system aligned to agro-ecological conditions and suitable agronomic practices
- In selected areas, few progressive farmers may be incentivised to experiment with changes in cropping pattern with available irrigation facilities. Farm school component of ATMA scheme would be suitably used to take up this activity.
- Cluster of 8 to 10 villages may be taken up in districts for saturating those as per the plan for showcasing potential augmentation of water and its efficient use. The success of these clusters in promoting such activities may be replicated in other parts of the district.

(ag) Extending the reach of micro irrigation to a larger coverage will be ensured by involving companies associated with precision irrigation for awareness campaign, demonstration, capacity building training, providing maintenance service, technical support etc.

(ah) State Level Sanctioning Committee (SLSC) may also co-opt members from experts in water sector, public/private agencies working in irrigation sector, reputed NGOs working in the field of irrigation, research institutions, leading farmers etc.

(ix) Convergence:

(aa) Related Schemes for convergence:

- Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS): Emphasis for de-silting of ponds, canals, defunct water bodies like old ponds, Jal Mandir, khul, Tanka etc.
- Rashtriya Krishi Vikash Yojana (RKVY)
- Jawaharlal Nehru National Solar Mission
- Rural Electrification programmes

- Rural Infrastructure Development Fund (RIDF)
- Member of Parliament Local Area Development (MPLAD) Scheme
- Member of Legislative Assembly Local Area Development (MLALAD) Scheme
- Sansad Adarsh Garm Yojana (SAGY).

(g) COMPENSATORY AFFORESTATION FUND MANAGEMENT AND PLANNING AUTHORITY – CAMPA

(i) **Information Source Document:** The Compensatory Afforestation Fund Act, 2016

(ii) **Department:** Ministry of Environment Forest & Climate Change

(iii) **Website:** http://egreenwatch.nic.in/

(iv) CAMPA Fund Transfer to States in FY 2016-17 : ₹ 676 crore

(v) **Overview:**

The Supreme Court in its order dated the 30th October, 2002, observed that a Compensatory Afforestation Fund be created in which all money received from the user agencies towards compensatory afforestation, additional compensatory afforestation, penal compensatory afforestation, net present value of the diverted forest land or catchment area treatment plan shall be deposited.

The Supreme Court directed that, besides artificial regeneration (Plantations), the Fund shall also be utilised for undertaking assisted natural regeneration, protection of forests, infrastructure development, wildlife protection and other related activities

In May, 2006, the Supreme Court observed that the funds thus collected were lying unutilised with the State Governments. Therefore, directed the Central Government that an ad hoc Authority should be constituted till the Compensatory Afforestation Fund Management and Planning Authority becomes operational.

On 2nd July, 2009, the Central Government formulated guidelines for formation of the State on the subject of State Compensatory Afforestation Fund Management and Planning Authority (CAMPA) for utilisation of funds lying with the ad hoc Authority

However, in order to have a permanent institutional mechanism for utilisation of funds collected by the State Governments and Union territory Administrations, the Compensatory Afforestation Fund Act, 2016 was passed. This Act proposed the creation of the National CAMPA that would work in conjunction with the state level CAMPA.

(vi) Key Aspects:

(aa) The Act extends to the whole of India except the State of Jammu and Kashmir.

(ab) A special Fund called the "National Compensatory Afforestation Fund" was created under the public account of India and under the control of the Central Government.

(ac) Similarly, a State Compensatory Afforestation Fund was created and brought under the control of each respective state.

(ad) Sources of income into National Compensatory Afforestation Fund:

- All money placed under charge of the ad hoc authority earlier created.
- 10% of the funds realised by State Governments from user agencies in respect of forest land diverted in their favour.
- Grants-in-aid received, if any, by the National Authority;
- Loan taken or borrowings made by the National Authority;
- Any other sums received by the National Authority by way of benefaction, gift or donations

(ae) The disbursement of the National Fund is as follows:

- 90% of the funds realised by State Governments from user agencies in respect of forest land diverted in their favour
- Balance 10% the fund available will be utilised for:
- Expenditure for management of the National Authority
- Expenditure incurred on monitoring and evaluation of works executed by the National and State Authority;

- Expenditure incurred on specific schemes approved by governing body of the National Authority.

(af) Sources of income into State Compensatory Afforestation Fund:

- Unspent balance of money transferred by ad hoc authority to State CAMPA
- 90% of the funds realised by State Governments from user agencies in respect of forest land diverted in their favour
- Money realised from user agencies towards compensatory afforestation, additional compensatory afforestation, penal compensatory afforestation, net present value, catchment area treatment plan or any money for compliance of conditions stipulated by the Central Government while according approval under the provisions of the Forest (Conservation) Act, 1980;
- Funds recoverable from user agencies by such State in cases where forest land diverted falls within the protected areas.
- Grants-in-aid received, if any, by the State Authority;
- Loan taken or any borrowings made by the State Authority;
- Any other sums received by the State Authority by way of benefaction, gift or donations.

(ag) The disbursement of the State Fund is as follows:

- Money received for compensatory afforestation, additional compensatory afforestation, penal compensatory afforestation, catchment area treatment plan and or any other site specific scheme may be used as per site-specific schemes submitted by the State along with the approved proposals for diversion of forest land under the Forest (Conservation) Act, 1980;
- Money received towards net present value and penal net present value shall be used for artificial regeneration (plantation), assisted natural regeneration, forest management, forest protection, forest and wildlife related infrastructure development, wildlife protection and management, supply of wood and other forest produce saving devices and other allied activities
- The interest accrued on funds available in a State Fund shall be

used for conservation and development of forest and wildlife

- Money realised from the user agencies in accordance with the decision taken by the Standing Committee of the National Board for Wild Life or the orders of the Supreme Court involving cases of diversion of forest land in protected areas shall form the corpus and the income therefrom shall be used exclusively for undertaking protection and conservation activities in protected areas of the State including facilitating voluntary relocation from such protected areas and in exceptional circumstance, a part of the corpus may also be used subject to prior approval of the National Authority
- 10% per cent. of amount realised from the user agencies, which has been credited directly into the State Fund in a year shall be transferred to the National Fund
- In case of trans-boundary forestry or environmental implication of diversion of forest land for non-forest purposes in a particular State, if found expedient and necessary by the National Authority, it may, in consultation with the concerned Sate Authorities order that such sum as may be justified for reparation of the trans-boundary effects, be transferred to State Fund of such State or States;
- State Authority shall release monies to agencies identified for execution of activities in pre-determined instalments as per the annual plan of operation finalised by steering committee of such State Authority and executive committee of the National Authority.

(vii) **Key Issues:** (Observations by PRS Legislative Research posted on PRS Website)

(aa) The Bill establishes the Funds for compensatory afforestation and forest conservation. However, there are several factors (other than administration of funds) which affect compensatory afforestation and forest conservation.

These factors are mentioned below.

(ab) A 2013 CAG report noted that state forest departments lack the planning and implementation capacity to carry out compensatory afforestation and forest conservation. With the share of funds transferred to states increasing from 10% to 90%, effective utilisation of these funds will depend on the capacity of state forest departments.

(ac) Procuring land for compensatory afforestation is difficult as land is a limited resource, and is required for multiple purposes, such as agriculture, industry, etc. This is compounded by unclear land titles, and difficulties in complying with procedures for land use.

(ad) A High Level Committee on Environment Laws observed that quality of forest cover has declined between 1951 and 2014, with poor quality of compensatory afforestation plantations being one of the reasons behind the decline.

(ae) The Bill delegates the determination of NPV (value of loss of forest ecosystem) to an expert committee constituted by the central government. As NPV constitutes about half of the total funds collected, its computation methodology would be important.

2. SUMMARY OF OTHER SCHEMES THAT MAY BE OF RELEVANCE:

(a) NMAET – National Mission on Agricultural Extension & Technology

(i) Information Source Document: Operational Guidelines

(ii) Department: Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) Website: http://extensionreforms.dacnet.nic.in/

(iv) Financial Outlay for 2017-18: ₹1,777 crore

(v) Overview:

(aa) Objectives:

- The aim of the Mission is to restructure & strengthen agricultural extension to enable delivery of appropriate technology and improved agronomic practices to the farmers.

(ab) Four Sub-missions:

- Sub Mission on Agricultural Extension (SMAE)
- Sub-Mission on Seed and Planting Material (SMSP)
- Sub Mission on Agricultural Mechanization (SMAM)

- Sub Mission on Plant Protection and Plant Quarantine (SMPP)

(ac) Related Activities / Institutions:

- National Institute of Plant Health Management (NIPHM)
- Central Sector Scheme Monitoring of Pesticide residue at National Level
- Strengthening and Modernization of Pest Management Approach in India

(b) RKVY – Rashtriya Krishi Vikas Yojana

(i) Information Source Document: Operational Guidelines

(ii) Department: Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) Website: http://rkvy.nic.in/

(iv) Financial Outlay for 2017-18: ₹ 4,500 crore

(v) Overview:

(aa) An additional Central Assistance Scheme to incentivise states to draw up a comprehensive agriculture development plan

(ab) Objectives:

- Incentivise states to increase public investment in agriculture and allied sectors
- Provide flexibility and autonomy to states in process of planning and executing agriculture and allied sectors
- To ensure preparation of Agriculture Plans for the districts and states based on agro-climatic conditions, availability of technology and natural resources.
- To ensure local needs / crops / priorities are better reflected in State Agricultural Plans
- To achieve goal of reducing yield gaps in important

crops

- To maximise returns to the farmers
- To bring about a quantifiable change in production and productivity in agriculture and allied sectors by addressing them in a holistic manner'

(c) NFSM – National Food Security Mission

(i) Information Source Document: Operational Guidelines

(ii) Department: Department of Agriculture, Cooperation & Farmer's Welfare, Ministry of Agriculture

(iii) Website: http://nfsm.gov.in/

(iv) Financial Outlay for 2017-18: ₹ 1,600 crore

(v) Overview:

(aa) Increasing production of rice, wheat, pulses and coarse cereals through area expansion and productivity enhancement in a sustainable manner in the identified districts of the country

(ab) Restoring soil fertility and productivity at the individual farm level

(ac) Enhancing farm level economy (i.e. farm profits) to restore confidence amongst the farmers.

(iv) Mission Components:

(aa) NFSM- Rice

(ab) NFSM-Wheat

(ac) NFSM-Pulses

(ad) NFSM-Coarse cereals

(ae) NFSM-Commercial Crops.

(d) SAGY – Saansad Aadarch Gram Yojana

(i) Information Source Document: Operational Guidelines

(ii) Department: Department of Rural Development Ministry of Rural Development

(iii) Website: http://saanjhi.gov.in/

(iv) Financial Outlay for 2017-18: ₹ crore

(v) Overview:

(aa) Goal: To translate this comprehensive and organic vision of Mahatma Gandhi into reality, keeping in view the present context

(ab) Objectives:

- To trigger processes which lead to holistic development of the identified Gram Panchayats
- To substantially improve the standard of living and quality of life of all sections of the population through:
  1. Improved basic amenities
  2. Higher productivity
  3. Enhanced human development
  4. Better livelihood opportunities
  5. Reduced disparities
  6. Access to rights and entitlements
  7. Wider social mobilization
  8. Enriched social capital
- To generate models of local level development and effective local governance which can motivate and inspire neighbouring Gram Panchayats to learn and adapt
- To nurture the identified Adarsh Grams as schools of local development to train other Gram Panchayats

(ac) Activities in an Adarsh Gram:

- **Personal development**
- **Human Development**
- **Social development**
- **Economic Development:**
  1. Promoting diversified agricultural and allied livelihoods, including livestock

and horticulture, through organic farming, crop intensification such as SRI, Soil Health Cards, Seed Banks, collection of NTFP, livestock development, micro-irrigation, agro service centre's etc.

2. Skill Development of all eligible youth for self-employment and placement

3. Village Tourism including eco-tourism

- **Environmental Development:**

1. Activities for a clean and green village consisting of:

    - Providing toilets in each household and in all public institutions and ensuring their proper use
    - Appropriate solid and liquid waste management
    - Roadside plantations
    - Tree plantation in accordance with local preferences in homesteads, schools and public institutions

2. Social forestry

3. Watershed management especially renovation and revival of traditional water bodies

4. Rainwater harvesting- rooftop as well as others

5. Reducing local pollution of air, water and land

- **Basic amenities and services**
- **Social Security**
- **Good Governance**