
SUSTAINABLE
LAND & ECOSYSTEM
MANAGEMENT
SOME BEST PRACTICES
FROM INDIA

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SOME BEST PRACTICES FROM INDIA

Edited by
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प्रकाश जावडेकर
Prakash Javadekar

सत्यमेव जयते

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Government of India

Desertification is a major environmental problem like climate change. It adds to, and worsens the impact of climate change. At present around two billion people around the world are affected by desertification and degradation of land, which is caused by deforestation, over- grazing, over – cultivation, logging, industrialization and poor land use practices. In India also, the deserts are undergoing rapid expansion. While a large part of the country is dry land, almost one fourth of the geographical area is undergoing desertification, and more than one third of India's total land area is affected by various kinds of land degradation. Our country therefore has high stakes and stands strongly committed to tackling desertification, land degradation and drought.

The battle against desertification calls for long-term commitment and investment and people's participation is crucial in reclaiming lands. Appropriate land use and sustainable management of the country's natural resources and agro-ecosystems are the avenues to meet the challenges and to sustain environmental services.

The Sustainable Land and Ecosystem Management (SLEM) Programme supports adoption and implementation of sustainable land and ecosystem management practices, the essence of which is to apply a multi-sectoral approach to land management, biodiversity conservation and climate change/adaptation issues. This SLEM best practice compilation is developed to upscale some of the best practices possessing replicability potential with respect to agro-ecological regions in India.

It is commendable that ICFRE, SLEM-Technical Facilitation Organization (TFO), has come out with this best practices document through an extensive process of collection of best practices from various field projects across the country, analyzing them and meticulously presenting them in this excellent format. I am sure that it will be an extremely enriching and beneficial knowledge product for all stakeholders and contribute towards up-scaling and mainstreaming the best practices developed by the SLEM project partners and other such projects outside the SLEM Project areas throughout the country. I congratulate the entire team of the Desertification Cell, Ministry of Environment, Forests and Climate Change, SLEM-TFO, Directorate of Extension, ICFRE, all SLEM Partners and funding agencies for collaborating together in bringing out this useful publication.

Prakash Javadekar

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सत्यमेव जयते

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India has almost 47% of land under cultivation, with about 70% of population dependent on agriculture. While a large part of the country is dryland, almost 24.8% of the geographical area is undergoing desertification, and more than 32% of India's total land area is affected by land degradation. India therefore has high stakes and stands strongly committed to implementing the UNCCD.

Appropriate land use and sustainable management of the country's natural resources and agro-ecosystem are the avenues to meet the challenges and to sustain environmental services. Profitable and sustainable land use and ecosystem practices can thus be the principal means for protecting India's significant environmental assets and alleviating poverty in the poorest segments of Indian society.

The sustainable Land and Ecosystem Management (SLEM) approach is a joint initiative under the Country Partnership Programme (CPP) of the Government of India (GOI) and Global Environmental Facility (GEF). The multi-stakeholder Programme is led by the Ministry of Environment, Forests and Climate Change at the national level, and collaborates closely with State government authorities and other stakeholder groups at the local level. It supports adoption and implementation of sustainable land and ecosystem management, the essence of which is to apply a multi-sectoral approach to land management, biodiversity conservation and climate change/ adaptation issues in several states of India. One of the major tasks of the SLEM Technical Facilitation Organisation (TFO) anchored at ICFRE is identification, collection and documentation and dissemination of best practices in the areas of land management, water resources conservation, ecosystem service enhancement, biodiversity conservation, climate change adaptability, livelihood generation etc. The SLEM best practice document has been developed to upscale some of the best practices possessing replicability potential with respect to agro-ecological regions in India.

It is commendable that the SLEM-TFO under the Directorate of Extension has come out with the best practice document through an extensive process of collection of the best practices from various field projects across the country, analyzing them and meticulously presenting them in this excellent format. I am certain that it will be an extremely enriching and beneficial document for all stakeholders and contribute towards up-scaling and mainstreaming the best practices developed by the SLEM project partners and other such projects outside SLEM-CPP. I congratulate Shri Saibal Dasgupta, DDG (Extn.), Dr. Tajinder Pal Singh, Project Director, SLEM and the entire team of the SLEM-TFO for this outstanding publication.

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India with 2.3% of world's total land area supports 18% of the human population and 15% of the world's livestock population. Land degradation is a major concern for India as nearly 32 percentage of India's land area is affected by land degradation. The Twelfth Five Year Plan of the Government has placed high priority on raising agricultural productivity to achieve an annual agricultural growth of around 4 percent with a focus on conservation, harnessing and development of natural resources. Rural poverty is largely a result of low productivity and unemployment leading to chronic poverty, low investment in land and finally urban migration in search of livelihood. Given the dual existence of high levels of poverty and dependence on local common resources, improved natural resources management can form the basis of poverty alleviation policies in rural India.

The Indian farming tradition is replete with several examples of conservation of soil and water, rich agro-diversity and community practices for participatory natural resource management. Several of these practices have withered away or have been forgotten over time. While several of these practices needs to be revitalized and mainstreamed, quite a few innovative practices seen across the country needs to be up-scaled for improving land productivity and enhancing livelihoods. The Sustainable Land and Ecosystem Management (SLEM) project of Ministry of Environment and Forests and anchored at ICFRE has taken a positive step in that direction and played a crucial role in identifying, documenting and collating best practices related to land and water management, agro diversity, Climate change adaptations, livelihood enhancement and other innovation for improving land productivity from various parts of the country and has brought out an excellent document encapsulating these best practices from access the country.

My compliments to Shri Saibal Dasgupta DDG(Extn.), and Dr. T.P. Singh, Project Director SLEM at ICFRE and Mr. Brij Mohan Singh Rathore, Joint Secretary & UNCCD National Focal Point as well as Dr. Vivek Saxena, Deputy Inspector General of Forests & India's Scientific Correspondent to UNCCD at MoEF for having brought out this excellent collection. Hope that this will help in generating awareness, fostering linkages between stakeholders, contribute towards integrating natural resource based enterprises with rural development and enhance off-farm livelihood opportunities, by up scaling and mainstreaming the SLEM best practices for the benefit of the SLEM practitioners and the community as a whole.

Susheel Kumar

ACKNOWLEDGEMENT

Poverty and a degraded environment are closely inter-related, especially where people depend for their livelihoods primarily on the natural resources base of their immediate environment. The survival needs of the poor force them to continue to degrade an already degraded environment. In India around one third of the land is undergoing various forms of degradation and one fourth of the geographic area is affected by desertification. As a party to UNCCD, India is obliged to mitigate the effects of desertification, land degradation and drought. Sustainable land and ecosystem management (SLEM) is a step in this direction. In this Project, there is a major focus in India on reducing poverty through enhanced productivity from irrigated as well as dry land ecosystems, which requires an approach with adequate emphasis on conservation of natural resources.

Profitable and sustainable land use and ecosystem practices can be the principal means for protecting India's significant environmental assets and alleviating poverty. Therefore, the Indian Council of Forestry Research and Education (ICFRE), SLEM-TFO has brought out this SLEM Best Practice document encapsulating a wide range of best practices for land and eco-system management from various parts of the country. The compilation is based largely on field visits and stakeholder interactions at the project sites of the SLEM-CPP project partners as well as other such projects across the country. The best practices have been documented with respect to land management, water resource conservation, ecosystem service enhancement, biodiversity conservation, climate change adaptability and sustainable livelihood generation. While the case studies capture the local essence, they are based on scientific, technical as well as practical and operational knowledge presented in a user-friendly manner. It is important to however note that these practices are not intended to be prescriptive or top-down, and in most cases can be improved and tailored to different situations. It is anticipated that the users would be able to adapt and modify the practices as per local knowledge, requirement and ingenuity.

We take this opportunity to express our sincere gratitude to Dr. S.S. Garbyal, Director General, ICFRE, Sh. Susheel Kumar, Additional Secretary & Chairman NSC, SLEM, MoEF, Sh. B.M.S. Rathore, Joint Secretary, MoEF and Shri Vivek Saxena, DIG (Desertification Cell), MoEF for having guided and advised us for smooth and appropriate delivery of the project objectives. We also would like to thank Dr. Anupam Joshi, World Bank for supporting us and ensuring that we are able to meet all our deliverables in a timely manner. We would like to show our appreciation and thank all the SLEM project partners for giving technical inputs and providing logistic support during our field visits. We also appreciate the inputs provided by and recognize the expertise of all the SLEM-TFO thematic consultants. Thanks are also due to the SLEM Project Manager Dr. Anita Srivastav and the staff of the SLEM TFO for having provided able and efficient logistic and administrative support.

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INTRODUCTION

Dry-lands cover 41 % of Earth's land surface and are home to approximately 38 % (2.7 billion) of the current global population of 7 billion. Significant tracts of dry-lands are affected by some degree of desertification, with adverse impacts on food and water security as well as the lives and livelihood of people. Dry-lands are vulnerable to land degradation because of coarse texture of soils, low organic matter content, low water and nutrient retention capacities, low inherent fertility and low resilience. This vulnerability is aggravated by land misuse, soil mismanagement and unsustainable exploitation.

Soil is the most significant geo-resource for ensuring water, energy and food security for present and future generations. Healthy soils are also vital for building resilience and adapting to climate change. Soil degradation impacts agricultural productivity, bio-diversity, groundwater and overall water availability. All these lead to a decline in the quality of life, eventually affecting the socio-economic status of the region. It has far-reaching consequences that affect lives and livelihoods of the population, leading to forced migration and socio-economic conflicts. Each year an estimated 75 Billion tons of fertile soil are lost. In the dry-lands, due to drought and desertification, 12 Million hectares of land are transformed into new man-made deserts each year. That is an area with the potential to produce 20 Million tons of grain every year. (UNCCD 2011b)

LAND DEGRADATION IN INDIA

In India almost 47% of land is under cultivation, around 70% of the country is dry land i.e. arid, semi-arid and dry sub-humid (Fig.1), 24.8% area is undergoing desertification, and more than 32 % of India's total land area is affected by various forms of land degradation. The agricultural land is shrinking at a faster rate due to urbanization and developmental activities. While agriculture is practiced on 46% of land, GDP from agriculture has gone down from 50% in 1950 to 14% in 2011.

Agriculture is no longer seen as a profitable activity by individual farmers and around 70% of the farmers are frustrated with their profession (Deshpande and Prabhu 2005).

Over exploitation of ground water has become serious problem not only in dry states but also in food producing states like Punjab and Haryana. About 85% of India's rural domestic water requirements, 50 % of urban water requirements and more than 50% of irrigation requirements are being met from ground water resources. In many groundwater irrigated areas, the decisions on cropping pattern and cropping intensity are being taken largely independent of the groundwater availability. Thus water intensive crops are being grown despite scarcity of water. Since groundwater is an open access resource, tragedy of commons occurs where everyone tries to extract as much as possible, leading to sharp degradation of the resource. There is therefore urgency about managing groundwater in a sustainable way, which is an important driver for the sustainable development and management of productivity in dry land areas (Wani et al. 2003).

Land in India suffers from varying degrees and types of degradation stemming mainly from unsustainable use and inappropriate management practices. Competing uses of land exert enormous pressures on the country's finite land resources. Such pressures influence land use patterns, cause land degradation and have adverse impacts

on forest resources and biodiversity. The Agriculture sector occupies center stage in Indian economy with the inherent potential to promote inclusive growth, enhance rural income, and sustain food and nutritional security. Technological breakthrough in agriculture during Green Revolution era helped achieve high productivity and food security to a large extent. About 70% population of India is rural and 80% of farmers are under the poverty line. However, as per Vashisht et al. (2003) the economic loss due to land degradation is estimated to be Rs 285.51 Billion annually and Rs 89.38 Billion during 1979-82 which is worked out to be around 12% of the total value of agricultural output of the country. The severity of the loss was reported to be high in rain-fed agricultural areas of the country. So land degradation have direct implications with respect to economic losses hence suitable policies need to be enacted related for the sustainable utilization of natural resources and adoption of SLEM best practices. Practices such as agro-forestry, tree based farming system, agro-horticulture and improved agricultural practices with respect to water utilization will significantly improve the condition and productivity of land. Moreover concerted and focused reclamation measures must be implemented to conserve land resources and also to reduce economic loss for the long term sustainability (Vashisht et al. 2003). The land reclamation and afforestation under the Green India Mission will significantly improve the condition of degraded forests of land while addressing the socio-economic issues of resource poor communities of the country.

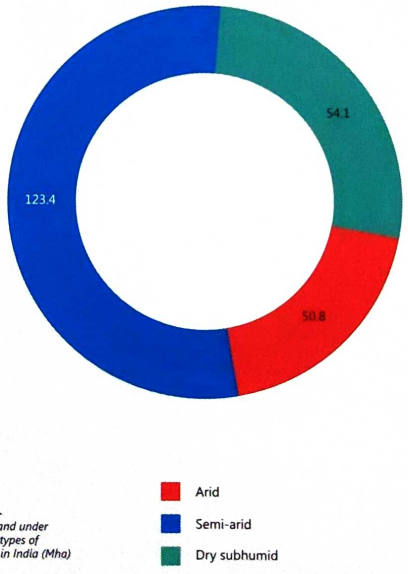


Figure 1.
Area of land under different types of drylands in India (Mha)

Land Degradation status in India

As per the latest estimate the total land area undergoing process of degradation is about 105.48 Mha, which constitutes about 32.07% of the total geographic area of the country (Ajai et al. 2009). The process wise land degradation mapping indicates that out of the total nine process considered by Ajai et al. (2009) four major processes causing land degradation includes: water induced erosion (33.5 Mha: 10.21% of the TGA), vegetal degradation (31.6 Mha: 9.63% of the TGA), wind erosion (17.5 Mha: 5.34% of the TGA), frost shattering (10.21 Mha). However the degradation induced by other process such as salinity/alkanity, mass movement, water logging and others is about 12.5 Mha (Figure 2).

Desertification status in India

In India desertified lands accounts for about 81.45 Mha out of which water erosion induced were 26.21 Mha, wind erosion caused were 17.77 Mha, vegetal degradation induced were 17.63 Mha and frost shattering accounts of 9.47 Mha (Ajai et al. 2009). Out of total desertified land 10.37 Mha is desertified by other process such as mass movement, salinity/alkanity, water logging etc (Figure 3).

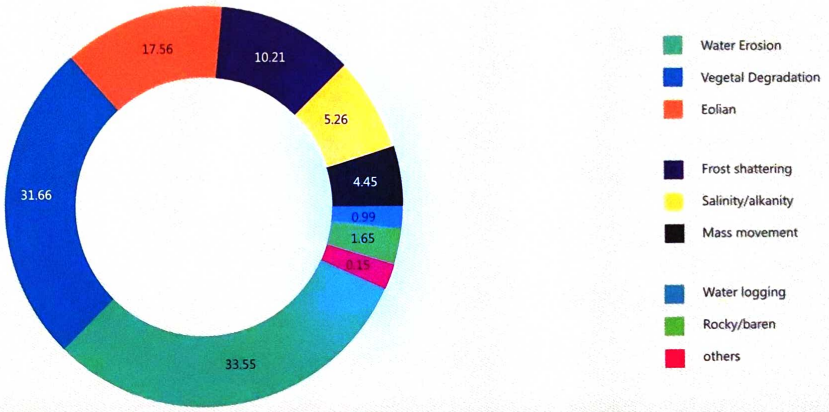


Figure 2.
Process wise land degradation in India (area in Mha)
Source: *Ajai et al. 2009*

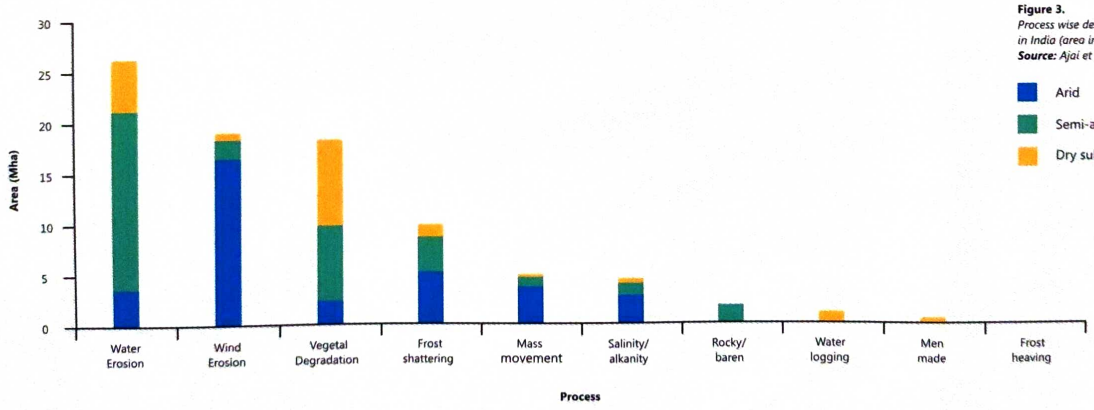


Figure 3.
Process wise desertification in India (area in Mha)
Source: *Ajai et al. 2009*

Major causes of desertification and land degradation

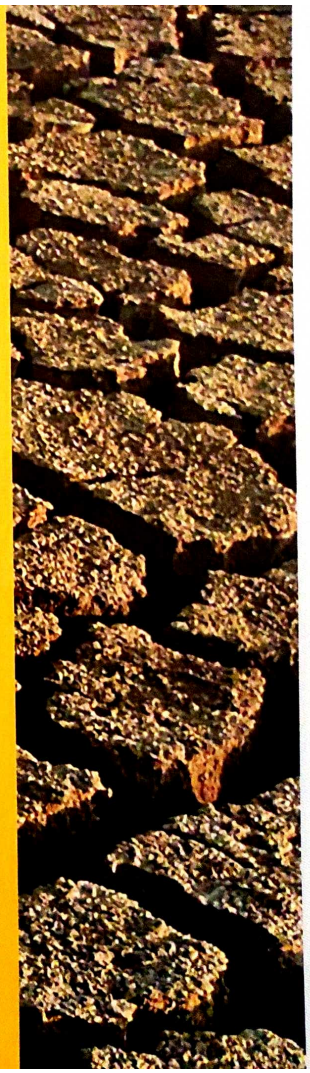
The major factors for land degradation in India are unsustainable water management, poor agricultural practices, human and livestock pressure on land, deforestation, climate change and industrialization. These concerns would multiply many folds if these were juxtaposed with the fact that 72% of India's population is rural and depend mainly on land and water resources and that at present 80% of all Indian farmers are under the poverty line. Northern & western parts of the country are the worst affected. Water erosion is the most pronounced (affecting 10.21% of the TGA), reducing vegetation cover (9.63%) and wind erosion (5.34 %). Rajasthan has the largest area (21.77% of TGA) undergoing land degradation, followed by Jammu and Kashmir (12.79%), Maharashtra (12.66 %) and Gujarat (12.72%). The major causes of land degradation in India are as follows: -

- Water and wind erosion are major causes of land degradation. However wind induced erosion induced degradation is a major problem in the state of Rajasthan and other drylands of the country.
- Drought, a naturally occurring phenomenon is a major causative factor for land degradation in arid and semi-arid regions, causing crop failures and then famines. Recurrent droughts cause lower biomass production, poor grain yields and scarcity of fodder. Scarce water resources in dryland regions limit green coverage and also during drought years it leads to enhanced grazing pressure by livestock.
- Unsustainable agricultural and resource management practices such as intensive cultivation, excessive chemical nutrient use, poor irrigation practices, overgrazing, excessive use of fertilizers, pesticides, inappropriate agricultural technologies, etc are other major factors.
- Industrial agriculture now uses 2-3 times more fertiliser and 1.5 times more pesticides for the production of 1 kg of food than it did 40 years ago.
- Industrial effluents discharged into barren lands and inland water bodies degrade the land and the water table. The effluents discharged into non-perennial streams and rivers leading to contamination of water resources and impacting the local agriculture.

Challenge to achieve Zero Net land degradation (ZNLD)

In India, there is a major focus on reducing poverty through enhanced productivity from irrigated as well as dry land ecosystems, which requires an approach with adequate emphasis on conservation of natural resources. Appropriate land use and sustainable management of the country's natural resources and agro-ecosystem are the potential avenues to sustain environmental services. The challenge is to achieve ZNLD by arresting further degradation and restoring and rehabilitating degraded land, pursuing sustainable land management, avoiding degradation of non-degraded lands, involving community-based and traditional approaches, and improving payment for ecosystem services. This is possible through sustainable land management (SLM) policies and practices. In the past, such a goal was probably unattainable. But today, scientific findings and technical know-how indicate that we can achieve a land degradation neutral world. Zero net land degradation is scientifically sound, technically feasible, and economically advantageous. It is not only possible, but prerequisite for sustainable development. SLM may be defined as land use and soil / vegetation management practices that create a positive carbon, water, and elemental balance in the used land, enhance net primary productivity, mitigate climate change by absorbing atmospheric CO_2 and sequestering it in biomass and soil, and can be adapted to environmental conditions.

There are significant opportunities for improving land management practices in order to improve productivity and reduce land degradation. Profitable and sustainable land use and ecosystem practices can be the principal means for protecting India's significant environmental assets and alleviating poverty in the largest and poorest segments of Indian society. Given this background, the Eleventh Five Year Plan of the Government placed high priority on raising agricultural productivity to achieve an annual agricultural growth of more than 4.1 percent. This goal cannot be achieved with the ongoing shrinking and degradation of the country's natural resources, and therefore, it is imperative to stress upon conservation, harnessing and developing natural resources. Moreover the additional challenges resulting from current climate variability, and expected extreme climate conditions are also been recognised.



THE SLEM APPROACH IN INDIA

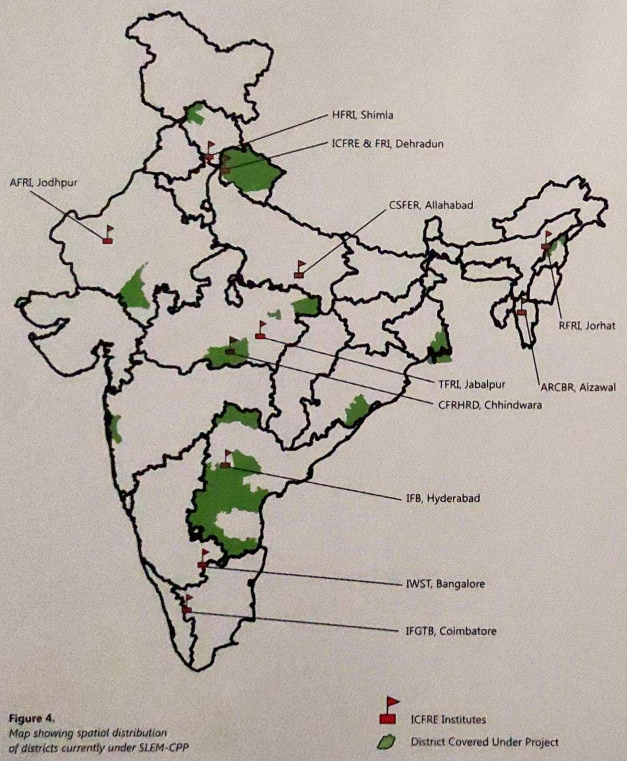


Figure 4.
Map showing spatial distribution of districts currently under SLEM-CPP

SLEM is a joint initiative under the Country Partnership Programme (CPP) of the Government of India (GOI) and Global Environmental Facility (GEF) (Fig.4). The Programme is led by the Ministry of Environment, Forests and Climate Change at the national level, and collaborates closely with State government authorities and other stakeholder groups at the local level. The SLEM-CPP conceived as a multi-stakeholder project supports adoption and implementation of sustainable land and ecosystem management, the essence of which is to apply a multi-sectoral approach to land management, biodiversity conservation and climate change/adaptation issues in several states of India. In order to do so, a number of organizations representing different capacities related to the issues at hand are participating in the program. These include government organizations at union and state levels, non-governmental and civil society organizations.

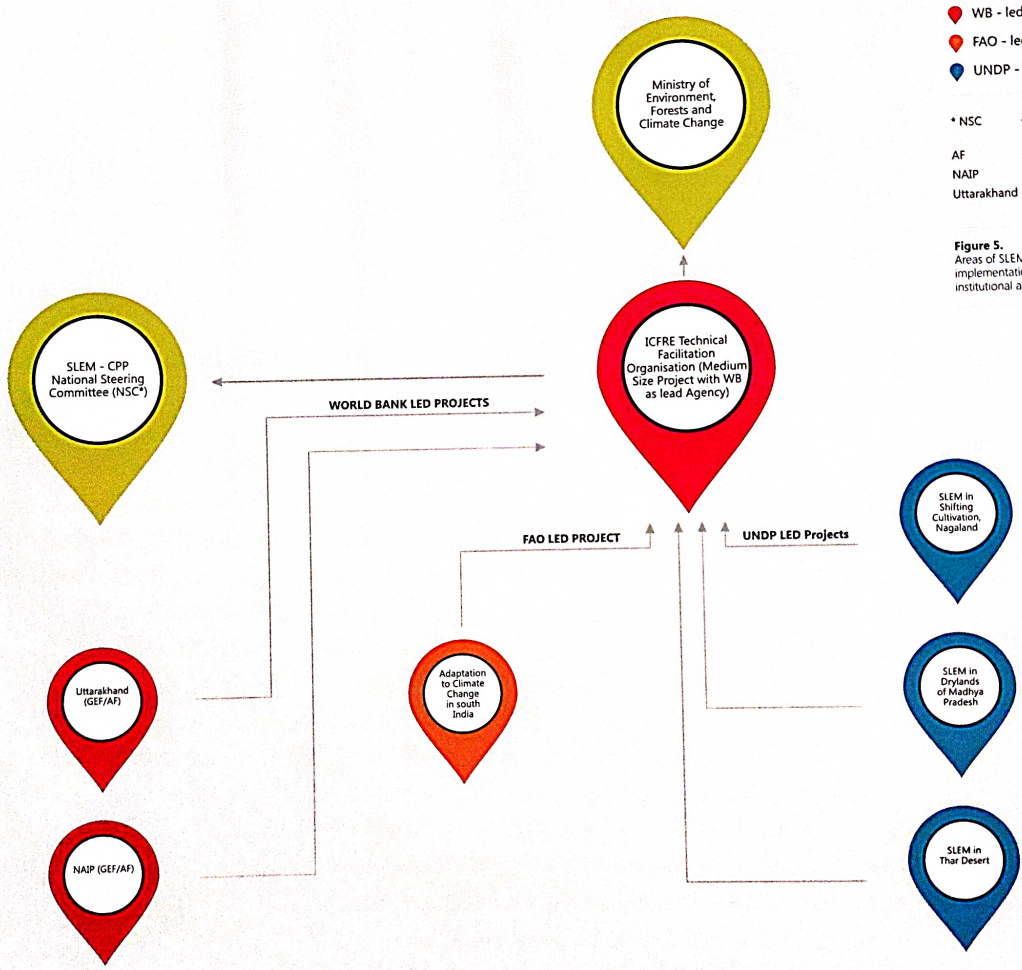


Figure 5.
Areas of SLEM-CPP implementation and institutional arrangement

Six SLEM projects were implemented in India with financial assistance from the World Bank, UNDP and FAO (Fig. 5). The project sites under SLEM-CPP cover diverse ecological zones including arid, coastal and mountain ecosystems and address diverse aspects of land and ecosystem management including coastal agriculture, shifting cultivation, watershed management, and groundwater management. The SLEM project on "Policy and Institutional Reform for Mainstreaming and Up-scaling Sustainable Land and Ecosystem Management in India" is anchored at the ICFRE, Dehradun. A technical facilitating organisation (TFO) headed by Project Director Implements the project under the Directorate of Extension. The project envisages identifying gaps and barriers to sustainable land management, and documenting best practices across the country, which could be up-scaled and mainstreamed. The project outcome will contribute towards harmonization of the institutional and policy framework, coordination and monitoring of interventions in agricultural and natural resource management strategies that promotes sustainable land management and enhances agricultural productivity while minimizing environmental impacts.

Integrated Land Use Management to Combat Land Degradation in Madhya Pradesh

The project is being implemented in nine forest divisions spread across five districts of Madhya Pradesh - Betul, Chhindwara, Sidhi, Singrauli and Umaria. These districts harbour rich biodiversity and are also home to some of the poorest human populations. The selected village clusters in these districts have a forest cover of roughly 45-50% of geographical area. The population is comprised of people from different ethnic groups, with significant numbers belonging to tribal groups. The literacy level in most of the project districts is below the state average. About 70% of the districts' population is classified as poor, based on a food poverty line, and 98% of the poor live in tribal/rural areas. Land degradation and fertility loss are important causes of poverty in the project districts. More than half of tribal/ rural families have less than two hectares of land and these lands are primarily rain fed lacking irrigation facilities. Unsustainable land management practices, especially deforestation and overgrazing, have been both cause and consequence of the livelihoods crisis among tribal and rural communities living in and around forest areas.

SLEM interventions

The project aims to remove barriers to promoting sustainable rural livelihoods that are ecologically sustainable and provide a broader range of livelihood options for the tribal/rural poor. The main objective of the project is Sustainable Land and Ecosystem Management (SLEM) through community participation, rehabilitation of degraded bamboo forests, Sustainable livelihoods development and Integration of watershed management, Joint Forest Management (JFM) and sustainable development.

Sustainable Land, Water and Biodiversity Conservation and Management for Improved Livelihoods in Uttarakhand Watershed Sector

The SLEM project in Uttarakhand aims scaling-up and mainstreaming the outcome of the activities under Uttarakhand Decentralized Watershed Management Project (UDWDP). It aims at enhancing their sustainability by restoring and sustaining ecosystem functions and biodiversity while simultaneously enhancing income and livelihood functions. The original project included provisions for the Participatory watershed development and management, enhancing livelihood opportunities and Institutional strengthening. The SLEM project focuses on protection of watersheds, along with community-level capacity building and promotion of livelihoods.

The mid-Himalayas cover about one third of the state and covers eleven out of thirteen districts of the state. The project is spread over an area of around 238,000 ha, ranging from 700 m to 2000 m altitude in 76 selected micro watersheds in the middle Himalayas. About 451 Gram Panchayats (GP) identified in 18 blocks of 11 districts participated in this project. A total population of 254,000, living in the project area is impacted. The SLEM project aimed at the consolidation of watershed activities in 20 micro-watersheds out of 76 identified micro-watershed in the UDWDP, and focused on a select number of watersheds that are experiencing intense erosion, low socio-economic status, most of them situated close to the agricultural frontier.

SLEM interventions

Community participation in rehabilitation of degraded watersheds, carbon emission reduction, biodiversity conservation and management, development of sustainable livelihoods and adoption of cleaner and energy efficient fuels, including rejuvenation of water mills (Gharats) has been one of the focal areas of the project.

Sustainable Land and Ecosystem Management in Shifting Cultivation Areas of Nagaland for Livelihood & Ecological Security"

Nagaland faces a major challenge in adapting land use and production systems to meet rising populations and changing lifestyles, while also maintaining its ecological sustainability. The SLEM project aims to address land degradation in shifting cultivation locations in three districts of Nagaland (Mokokchung, Mon and Wokha), covering 70 villages. The main objective of the management is to catalyze changes towards an enabling

environment (institution building, capacity building) so that existing government programmmes/schemes earmarked for shifting cultivation areas can be mobilized in support of a paradigm shift from "replacing jhum" to "improved jhum that integrates principles of SLEM". The project Implementing Partner is the Department of Soil and Water Conservation (SWC), Government of Nagaland.

Reversing Environmental Degradation through the Propagation of Sustainable Land Management (SLM) among resource poor communities in Southern India: A hydrological unit pilot project approach.

The Peninsular India region with a rainfall between 500 and 750 mm, is predominated by dryland farming. There is also an intensive use and extraction of surface water and groundwater leading to degradation of the natural systems. The degraded land and water systems are no longer as resilient in the face of extended drought periods. Current land use practices are already making dryland farming increasingly unviable, and studies show that climate change will further exacerbate the low and uncertain rainfall conditions in these areas. On the farms, soil erosion, declining soil fertility, low soil organic matter and reduced water holding capacity have impacted yields. Degraded farming conditions have grave social consequences like male migration as well serious

psychological consequences. Lowland soils are impacted by water-logging and salinity where management of soil structure and drainage has not kept pace with increased application of surface and groundwater for irrigation. The effect of drought or climate variability in Andhra Pradesh found to be in terms of loss of crop production output of five major corps; rice, maize, sorghum, groundnut, and sunflower (World Bank, 2006). Considering the impact of climate change in the next few decades, the mitigation costs are expected to be very high. Participation of vulnerable people in identifying the strategies of climate change adaptation and applying the lessons to support adaptation decisions can thus be more cost-effective approach.

SLEM interventions

The project focuses on land based activities and is comprised of land use planning plantation activities under Integrated Farm Development (IFD), alternate livelihood and income enhancement activities, land development activities, infrastructure development activities and micro finance initiatives like the agriculture revolving fund and creation of self help groups.

SLEM interventions

The SLEM project in Andhra Pradesh builds upon the experience gained in the Andhra Pradesh Farmer Managed Groundwater Systems project (APFAMGS) which made hydrological information accessible and usable for a large number of farmers in a set of established hydrological units. The project has established a set of nine pilot initiatives (Anantapur, Chittoor, Kadapa, Kurnool, Mahbubnagar, Nalgonda and Prakasam) across the region in selected, representative hydrological units to extend the environmental knowledge and propagate alternative land and water management practices to reverse environmental degradation through locally identified climate change adaptation measures. The success achieved with groundwater based farmers will be extended to rain-fed farmers under the SLEM project while also preparing them to adapt to the risks posed by climate change. The farmers' dependent on rain fed farming has been prioritized in 650 habitations of the region. As part of this approach the rain fed farmers in the pilot hydrological units are brought under the existing habitation level institution and their skills and capacities are built for optimizing the use of rainfall, improving soil moisture and work towards integrated soil, land, water, crop and animal system.

Sustainable Rural Livelihoods Security through Innovations in Land and Ecosystem Management

The Sustainable Rural Livelihoods Security through Innovations in Land and Ecosystem Management Project will strengthen the Indian Council of Agricultural Research (ICAR) in its role as a catalyst of change in the national agricultural innovation system. It will mainstream sustainable land and ecosystems management into the development and implementation of innovations in agriculture through collaboration among farmers, private sector, civil society and public sector organizations. Following the procedures developed under the NAIP, three consortia have been selected for the implementation of project initiatives in the three focal areas: land degradation, biodiversity and adaptation to climate change, focusing on specific tasks aiming at agricultural transformation and sustainable rural livelihood security; land degradation in degraded coastal lands, biodiversity conservation and agricultural intensification, and enhanced adaptive capacity to climate change in drought and flood prone areas.

SLEM interventions

The core objective of the activities, addressed through these three focal areas of GEF is the sustained improvement in the incomes and well-being of farm families in the mainly rain-fed, hilly and mountain, dryland, tribal dominated and coastal areas which have so far been left behind in the development process. Through this geographical and subject matter focus, the project has addressed the areas that are most at risk with regard to resource degradation in the form of land degradation and loss of biodiversity as well as vulnerability to climate variability and change specifically in the poorest regions of the country where poverty is linked to natural resource degradation and which are the weakest in terms of adaptability.

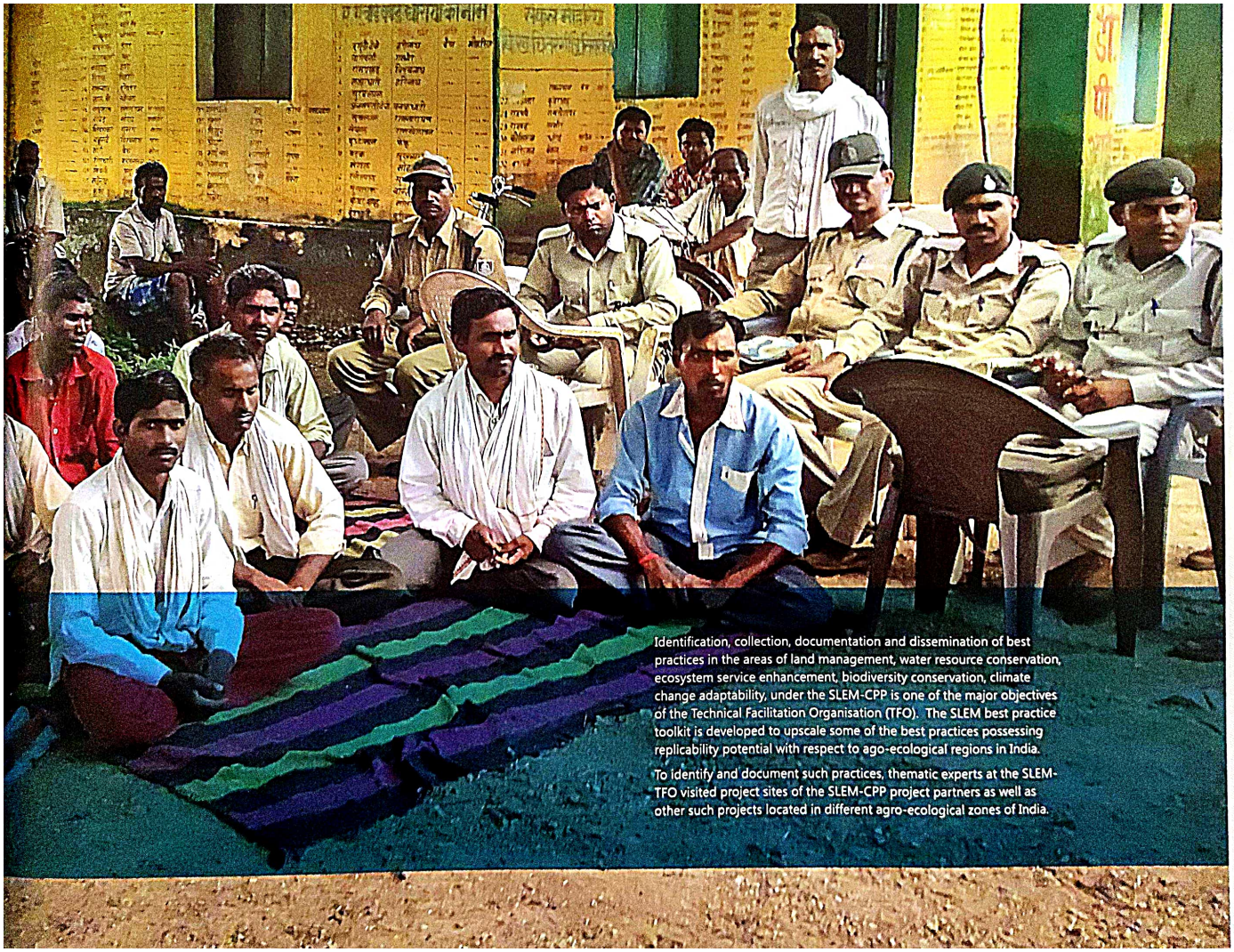
Sustainable participatory management of natural resources to control land degradation in the Thar desert of Rajasthan

The main objective of the project is the development and implementation of an integrated and participatory natural resource planning and management strategy is a selected arid region of the Thar desert in Rajasthan that is subject to recurrent droughts and the region which is most likely to face acute water scare conditions due to climate change. The activities of the project includes integrated land water livestock planning and management, development and adoption of sustainable use/harvesting practices of pastures and forest and empowerment of local community and strengthening village level institutions.

Expected Outcome of SLEM

In the SLEM program, the multi-sectoral approach to combating land degradation also takes account of the need to conserve biodiversity and consider the implications of climate variability and change, as additional factors that need to be considered to arrive at sustainable solutions. The project focuses on maintaining the integrity of watersheds and landscapes, increasing vegetative cover through agro-forestry, reforestation and afforestation and through ensuring sustainable extraction practices of natural resources. An overall decreasing trend in land degradation is expected along with enhancement in ecosystem services which includes provisional, regulatory services. The activities under taken by SLEM will also improve the carbon sequestration potential in above and below ground.

THE SLEM BEST PRACTICES DOCUMENT



Identification, collection, documentation and dissemination of best practices in the areas of land management, water resource conservation, ecosystem service enhancement, biodiversity conservation, climate change adaptability, under the SLEM-CPP is one of the major objectives of the Technical Facilitation Organisation (TFO). The SLEM best practice toolkit is developed to upscale some of the best practices possessing replicability potential with respect to ago-ecological regions in India.

To identify and document such practices, thematic experts at the SLEM-TFO visited project sites of the SLEM-CPP project partners as well as other such projects located in different agro-ecological zones of India.

Methodology for development of the document

This document has been developed through the following steps:

Field visits

For the data collection with respect to case study field visits were undertaken to the SLEM-CPP project sites as well as sites of other projects working for sustainable land and ecosystem management in India.

Analysis of the case study for consideration as best practice

The information collected was analysed with respect to their impact in improving the land productivity, biodiversity conservation, climate change adaptation and sustainable livelihood enhancement. In some instances cost benefit analysis was also carried out to access the feasibility in different areas.

Replicability of the best practice

Replicability and scope for up-scaling is an essential prerequisite for a best practice. The potential of the best practices has been analysed considering their inherent properties with respect to climate, topography and community participation etc.

Objective and focus areas of the document

The document has been developed for dissemination and to up-scale and mainstream the best practices developed by the SLEM project partners and other such projects outside SLEM-CPP. These best practices address issues related to increase in land productivity, sustainable utilization of biological resources, water resource management, long term sustenance of ecological goods and services, opportunities for off-farm livelihoods and sustainable livelihood generation (Fig. 6). It is targeted at stakeholders such as farmers groups, community based organizations, policy makers, agriculture and natural resource institutions/departments.

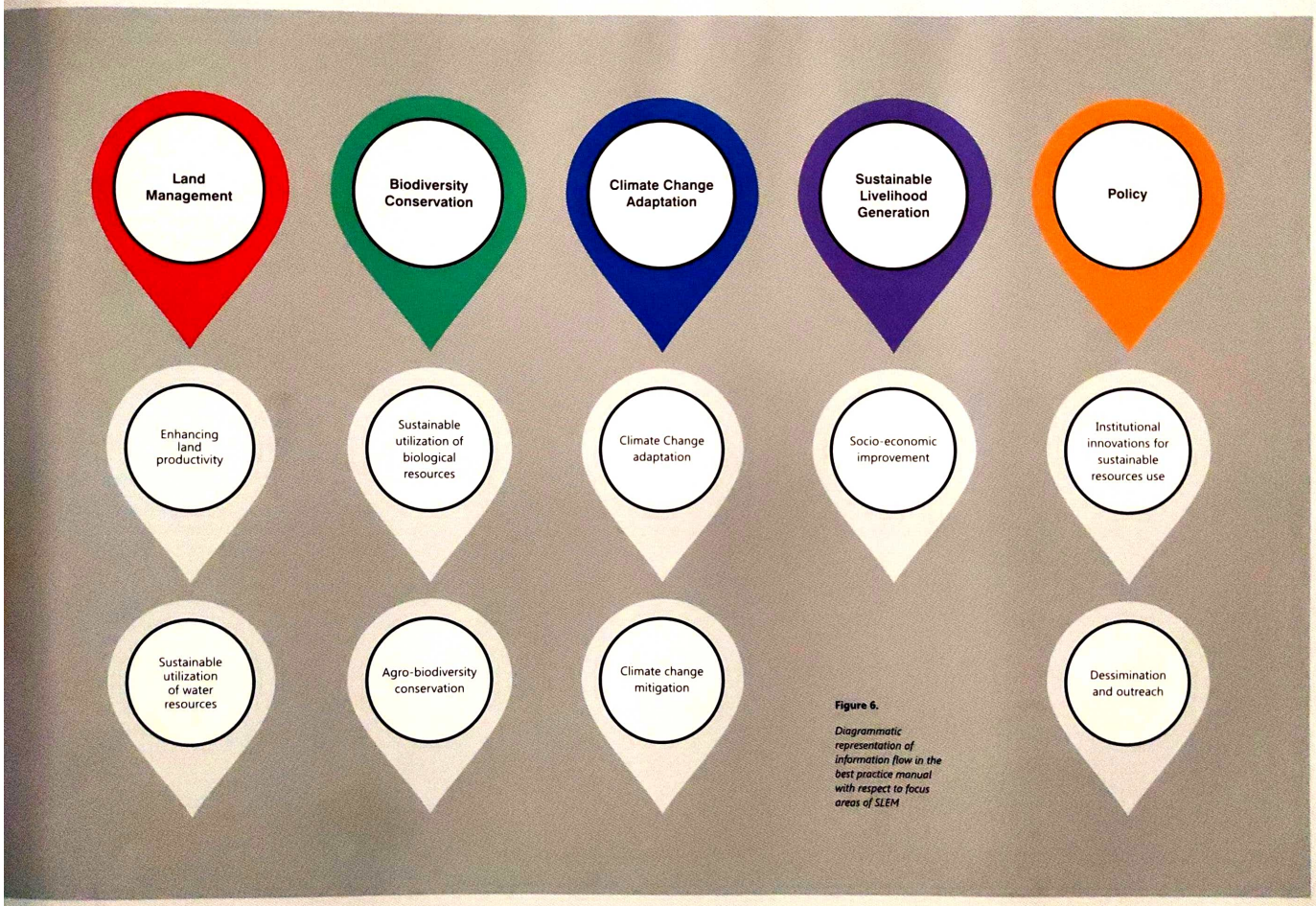
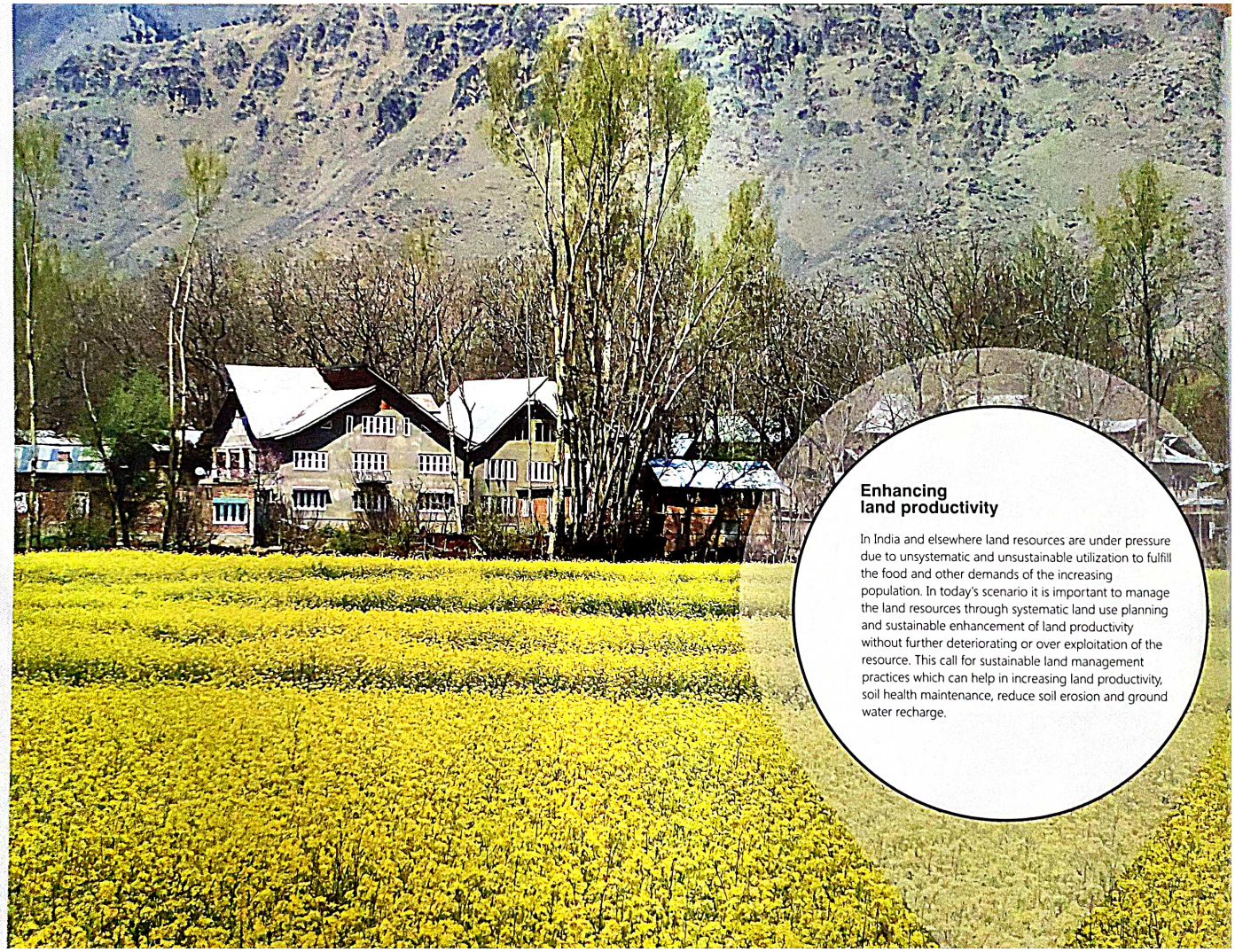


Figure 6.

Diagrammatic representation of information flow in the best practice manual with respect to focus areas of SLEM



Enhancing land productivity

In India and elsewhere land resources are under pressure due to unsystematic and unsustainable utilization to fulfill the food and other demands of the increasing population. In today's scenario it is important to manage the land resources through systematic land use planning and sustainable enhancement of land productivity without further deteriorating or over exploitation of the resource. This call for sustainable land management practices which can help in increasing land productivity, soil health maintenance, reduce soil erosion and ground water recharge.

Productivity of non-agricultural lands

The forests in India are widespread and diverse. Natural and man-made disturbances of the past have shaped both the vigor and quality of forests. The degraded forests, waterlands and orange areas have potential for productivity enhancement. The fringe forest areas also offer considerable opportunity with respect to enhancement of productivity. The agro-forestry practices can contribute in enhancing productivity and increasing provision of environmental services in many ways - through diversification, secured soil health and enriched fodder. Improved afforestation under the Green Indian Mission can significantly enhance the quality and productivity of degraded non-agricultural lands. The SLEM best practices with respect to agro-forestry landscape will enhance carbon sequestration capabilities and biodiversity richness which ultimately lead to enhancement or improvements of ecosystem services.

Productivity of non agricultural land depends upon the growth and biomass production of trees and grasses. For a first-rate growth of the trees, and for improving the grazing and pasture land use of techniques like improved planting material, soil working techniques, silviculture practices, reseeding of the land with improved seed material/ varieties of grasses, sowing of new areas at appropriate time and adequate water management strategies are fundamental and critical.

Productivity in rain-fed agriculture system

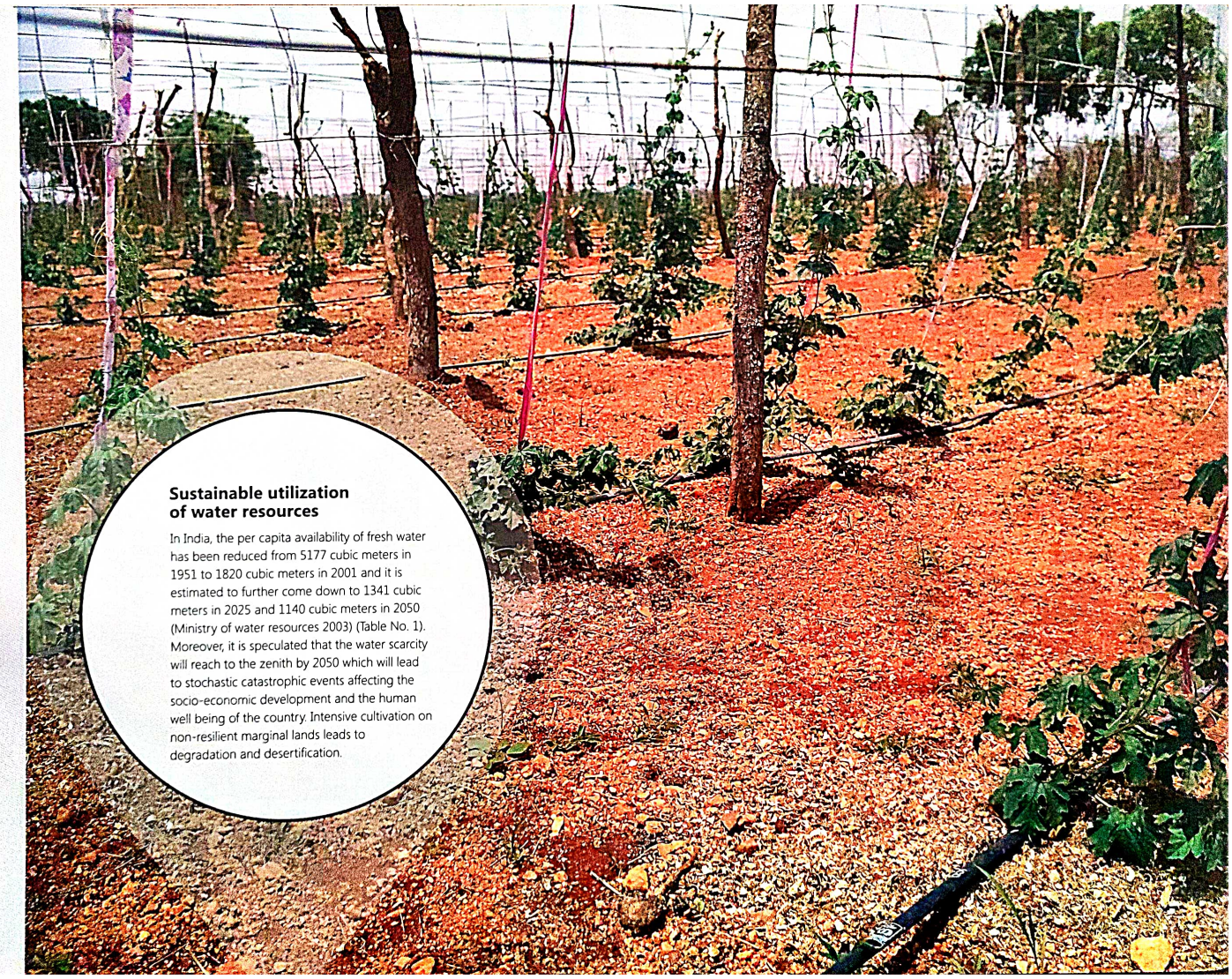
In India rain-fed areas are of special significance in terms of ecology, agricultural productivity and livelihood for millions of rural households in India. Such areas constitute considerable amount of land mass which is three-fourth of the land under arid, semi-arid and dry-humid zones and accounts for about 57% of the total agricultural land spread across the spatial extent of the country. India ranks first among the rain-fed agricultural countries in terms of both extent (86M ha) and the value of produce. Such a large amount of land under rain-fed agriculture has potential to contribute a large share in the food grain production. Such areas in India are highly diverse, ranging from resource rich areas with good production potential to resource-constrained areas with poor and marginal capability. Today the resource rich areas have adopted modern technology for enhancing productivity but on the other hand the resource poor areas with drier conditions are focusing on survival mechanism rather than productivity enhancement. Historically due to inherited risky nature the farming system was depended upon locally available inputs (seeds, manure, animal draft etc) and involved growing diverse crops to withstand recurrent drought like situations. However over the time the cropping systems have changed and presently farmers in these rain-fed areas with limited options have started cultivating high value crops which requires intensive use of costly inputs and find it difficult to manage the resources on their own. Moreover, over exploitation due to intensified agricultural activities has lead to degradation and desertification of such naturally less productive lands.

As per the Rain-fed Area Development Programme (RADP) holistic agriculture development through Integrated Farming System (IFS) provides an opportunity for development and integration of multiple components of agricultural system such as crops, horticulture, livestock, fishery, agro-forestry with agro-based income generating activities and value addition. The programme is intended to encourage exploitation of the potential of different farming systems based upon the natural resource assets/endowments (ponds, land development, nursery etc) created either by the farmers or through schemes like MNREGA, RKVY, NHM and Watershed Projects. This will act as a catalyst to accomplish the ultimate objective of enhanced productivity, minimizing the risk of crop losses due to climate uncertainties, harness efficiency of resources, assure food and livelihood / income security at farm level and strengthen the farmers' capacity to adapt to climatic changes.

Diversified agriculture and integrated farming system in rain-fed areas provides ample opportunities for faster agricultural growth as compared to irrigated areas that have reached an asymptote. The adoption of SLEM best practices including wise use of water, rainwater harvesting, mechanism for reducing the soil moisture loss can increase yields by a additional 5-15% on average across the rain-fed regions and reduce the variability in yield among the years. In situ water harvesting using simple technologies (vegetative barriers, gravel and stone mulching, compartmental bunding, cover cropping, inter-plot rainwater harvesting, dug-out ponds, percolation tanks, ridges and furrows, etc) enables greater water infiltration and prolongs the availability of moisture under rain-fed conditions. As per Venkateswarlu and Sanker (2009) compartmental bunding is a significantly important way to improve the yields and it can lead to an improvement up to 40-50% in the dry zones of Karnataka.

Potential and attainable yields (Kg/ ha) of some of rain-fed crops (Venkateswarlu and Prasad 2012).

Crops	Potential yields attainable	Actual yields (TE 2007-08)	Difference	Quotient
Sorghum	4560	902	3658	5.0
Maize	3870	2062	1808	1.9
Pearl millet	2870	906	1964	3.2
Groundnut	2590	1171	1419	2.2
Soybean	2850	1089	1761	2.6



Sustainable utilization of water resources

In India, the per capita availability of fresh water has been reduced from 5177 cubic meters in 1951 to 1820 cubic meters in 2001 and it is estimated to further come down to 1341 cubic meters in 2025 and 1140 cubic meters in 2050 (Ministry of water resources 2003) (Table No. 1). Moreover, it is speculated that the water scarcity will reach to the zenith by 2050 which will lead to stochastic catastrophic events affecting the socio-economic development and the human well being of the country. Intensive cultivation on non-resilient marginal lands leads to degradation and desertification.

Degraded and waste lands which constitute about 1/3rd of the geographical area of the country are potential source to meet the demands of various sectors and also reap required productivity. Natural hazards, indiscriminate use of agro-chemicals such as fertilizers and pesticides, improper planning and management of irrigation and over extraction of ground water in excess of the recharge are other major challenges.

The country is gifted with an excellent river system with tributaries, accounting for more than 50% of surface water resources. However groundwater is also an important source of water for drinking, irrigation, industrial uses accounting for about 80% of domestic uses and more than 45% irrigation requirements. The average annual Indian rainfall (1160 mm), though highest in the world for a country of comparable size, has uneven distribution. Nearly three-quarters of the rain pours down in less than 120 days, at times in few high intensity storms, while as much as 21% of the area of the country receives less than 750 mm annual rain, which includes large areas of peninsular India receiving less than 600 mm rainfall. Annual rainfall of less than 500 mm is experienced in hot arid regions of western Rajasthan and adjoining parts of Gujarat, Haryana and Punjab. Similarly, cold desert region in trans-himalayas also receive low precipitation.

Table No. 1.
Demand of water in various sectors

As per the projections agriculture will remain the major user of water followed by other uses such as drinking, industry, energy etc. It is imperative to enhance the water use efficiency in general but more specifically in agriculture sector.

Sector	Standing Sub-committee Report of MoWR			NCIWRD		
Year	**2010**	**2025**	**2050**	**2010**	**2025**	**2050**
Irrigation	688	910	1072	557	611	807
Drinking water	56	73	102	43	62	111
Industry	12	23	63	37	67	81
Energy	5	15	130	19	33	70
Others	52	72	80	54	70	111
Total	**813**	**1093**	**1447**	**710**	**843**	**1180**

GoI (2006), cited in UNICEF, FAO and SAciWATERs 2013.

Rainwater harvesting and utilization

Rain water harvesting has been adopted in many areas of the world considering its importance. In areas where conventional water supply systems are not available or have failed to meet the needs and expectations of the people water harvesting is meeting the demands (Alam 2006). In India the intensity of rainfall in monsoon season generally accedes, the infiltration rates of land leading to about 20-40% loss of rain water as runoff with sediment. Therefore there is ample scope of runoff harvesting in ponds, community reservoirs, and utilization for productive purposes while recharging the ground water for off season use. Community reserves or tanks are significantly important water reserves and are life supporting water reserves in arid and semi-arid areas where harvested water is being used for drinking and supplemental irrigation to crops. Moreover ample opportunity of rainwater harvesting exists in the urban areas where roof water harvesting can be made mandatory. This collected water can be utilized for households purposes, kitchen garden, car washing, and more importantly it will also recharge the ground water.

Improvement of water use efficiency

India is predominantly an agriculture based economy where irrigation sector has been given high priority in five year plans to increase agricultural production and achieve self sufficiency in food production. However agriculture consumes more than 82% of available water. As per an estimate by the year 2025 and 2050 the population of India at a low growth scenario is expected to be at least 1286 Million and 1346 Million, (MoWR, 2009) with food grain requirements of 308 and 420 Million Tons, respectively with higher annual water requirement for different sectors. Higher requirement in domestic, industries and power sector will lead to reduction in water availability for agriculture with added emphasis on economic and efficient use.

The Government of India laid top priority in developing the irrigation system after independence. As a result irrigated area increased from 21 to 63 Mha (about 30%), which also paid rich dividends by quantum jump in food grain production from 50 Million to 250 Million Tons. The Agriculture was canal driven in first few five year plans after independence. Up to the end of IVth Plan (1974), the irrigation potential created matched with utilized potential, though at a low irrigation efficiency (Planning Commission, 2009). Inherent limitations of canal irrigation lead to a boom on tube welling during 1970 to 1990 due to easy loans, subsidies on power in agriculture sector. Consequently, canal based irrigation was taken over by tube well based agriculture which is one major factor responsible for down ward trend in ground water availability. By 2005-06 wells contributed 58% of surface water irrigation whereas canal only 25%. A spectacular gap between the irrigation potential created and utilized (Fig. 7) warrants improving water use efficiency of canal system thus less dependence on ground water irrigation at least in canal command areas. The water use efficiency of canal command areas is hardly 25 to 30% and that of ground water irrigation up to 60%.

Important steps for sustainable utilization of water resources: -

1. Laser leveling for uniform distribution of water in field
2. Conservation irrigation to economize on water use
3. Use of check basin, border rows in place of flooding
4. Use of micro-irrigation like drips and sprinklers wherever possible
5. Water application in consonance with water requirement of crops
6. Adoption of low water requiring crops and varieties
7. Irrigating at critical stages of crops
8. Adoption of water economic practices like SRI for paddy and sugarcane
9. Integrated water management for higher productivity per unit of water

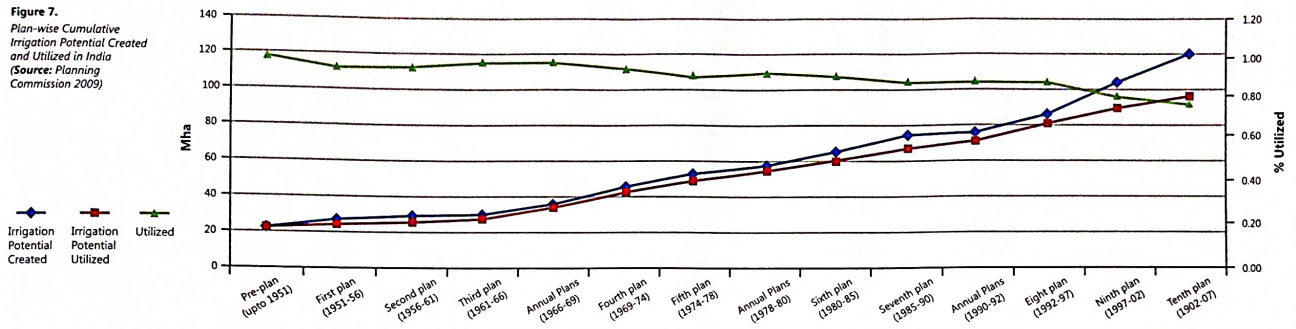


Figure 7.
Plan-wise Cumulative Irrigation Potential Created and Utilized in India (***Source:*** *Planning Commission 2009)*

Measures for the improvement in water use efficiency in Agriculture sector

Agriculture is the major consumer of fresh water and its share in all overall demand of water is about 80%. However, Water Use Efficiency (WUE) in irrigation sector is relatively low providing ample scope for water use efficiency improvements and reducing the risk of causing diffuse pollution through over-irrigating by improving the farm irrigation system. As per Singh et al. (2010) for the comprehensive improvement of water use efficiency it is necessary to raise the following ratios to their maximum: stored soil water content/ water received through rainfall and irrigation, water consumption/ soil water storage, transpiration/ water consumption, biomass yield/ transpiration, and economic benefit/ biomass yield.

The measures which can significantly enhance the field water use efficiency in irrigation agriculture include conducting water irrigation scheduling, reducing water pollution, using of harvested rainwater, checking for water losses in distribution systems, improving water management, and reuse and recycling. In addition, good agricultural practices like managing soil fertility and reducing land degradation are important for increasing water efficiency. These include more reliable and precise distribution and application of irrigation water (such as drip irrigation), supplemental and deficit irrigation, and soil conservation practices. The water use efficiency of some of the major crops is given in Table no. 2.

Table No. 2. Water use efficiency of some major crops (Yadav et al. 2000)

Crops	No. of sites/ observation	WUE range (Kgm^{-3})	Average WUE (Kgm^{-3})
Food grain crops			
Rice	6	0.30-0.54	0.45
Wheat	23	0.58-2.25	1.24
Maize	10	0.49-1.63	0.91
Sorghum	70	0.56-1.43	0.88
Pearl millet	4	0.41-0.70	054
Pulse crops			
Chickpea	8	0.40-4.02	1.60
Lentil	6	0.39-2.43	1.05
Green gram	4	0.37-0.50	0.44
Pigeon pea	3	0.27-0.72	0.46
Black gram	2	0.25-0.31	0.28
Kidney bean	2	0.55-0.79	0.67
Oil seed crops			
Groundnut	7	0.20-1.11	0.50
Mustard	3	0.41-0.98	0.67
Sunflower	8	0.16-0.93	0.59
Sesame	2	0.36-0.36	0.36
Linseed	4	0.15-0.93	0.53
Soybean	3	0.35-1.04	0.60
Vegetable and cash crops			
Sugarcane	9	3.25-7.83	4.68
Cotton	8	0.17-0.40	0.26
Cauliflower	7	13.8-114.9*	59.6*
Tomato	7	2.34-15.34*	6.80*
Brinjal	6	0.26-0.86*	0.50*

**Efficiency of applied water only*

Sustainable utilization of biodiversity and agro-biodiversity conservation

The downward corkscrew trends in biodiversity loss as well as ecosystem services is largely due to unsustainable management of land, exploitation of natural resources beyond their capacity, infestation of invasive species, climate change and pollution. While biodiversity is crucial for the poverty alleviation due to the goods and services it provides, it is also integral to majority of developmental sectors such as agriculture, forestry, and tourism on which more than 1.3 billion people depend for their livelihoods.

Agro-biodiversity conservation for long term sustainability of Indian agriculture

India's rich agro-diversity is the result of thousands of years of farmer's selection, improvement in genetic capabilities and propagation of advantageous traits of desirable species in innumerable ways for their subsistence and cultural requirements. This biodiversity has been eroded due to poor policies and unsustainable agricultural practices such as homogenous cropping of high yielding varieties to meet the need of growing populations. It is well established that the diversity decreases as habitats change from forest to traditional agriculture to modern agriculture (Altieri 1990). In India various traditional practices like intercropping, agro-forestry etc are neglected in the changing world. The agriculture intensification is the major factor responsible for the loss of landraces, which were resilient to climate change and other externalities. For example the flood and salt tolerating varieties of rice grown in frequent flood affected areas of Gangum district of Odisha and elsewhere to sustain livlihood. Hence for the long term conservation of the agro-biodiversity, on-farm cultivation, agricultural innovation and value addition to eroding genetic resources in the form of landraces is important.

The commodity production relies on vital services provided by biodiversity, resilience, or systems capacity to recover from external pressures including climate change is also enhanced through sustainable utilization. The phenomenon of land degradation is not only confined to dry-lands but it has become serious concern in other ecosystems as well. Therefore it is imperative to manage land for the long-term availability of the ecological goods and services and for the well being of present and future generations.

Valuation of biodiversity and ecosystem services

Biodiversity Component	Location	Ecosystem service	Economic value
Provisioning services			
Oak and Pine forests	Himalaya, Uttarakhand	Fuelwood, fodder, minor timber, medicinal plants, wild edible fruits, manure	Oak forests ₹ 5676/person/ annum; pine forests. ₹ 4640/person/annum
Dry deciduous forests	Odisha, eastern India	NTFPs	Coastal area, ₹ 36,584/hectare; inland area, ₹ 48,535/ hectare
Regulating services			
All Indian forests	All of India	Carbon sequestration	₹ 96,203/hectare
All Indian forests	All of India	Prevention of soil erosion	₹ 47072.56 million (in 2003)
All Indian forests	All of India	Augmentation of groundwater	₹ 1238.58 million (in 2003)
Cultural services			
Dry and moist deciduous forest	Corbett Tiger Reserve, Uttarakhand	Recreation	USD 167,619/annum

Source: *Parikh et al. 2012, cited in CBD 2014 India report*

S no.	Category	Number of Cultivated plants	Number of wild relatives
1	Cereals	15	37
2	Millets	13	33
3	Grain-legumes	18	36
4	Vegetables	105	168
5	Fruits and nuts	117	176
6	Oilseeds	19	13
7	Sugar-yielding plants	3	18
8	Fiber-crops	12	23
9	Forage/fodder-crops	96	33
10	Spices-and-condiments	46	123
11	Plantation-crops	20	21
12	Medicinal and aromatic plants	89	58
13	Ornamental-plants	182	90
14	Agro-forestry-species	35	31
15	Other-crops	41	42
	Total	**811**	**902**

Source: *CBD 2014 India report*

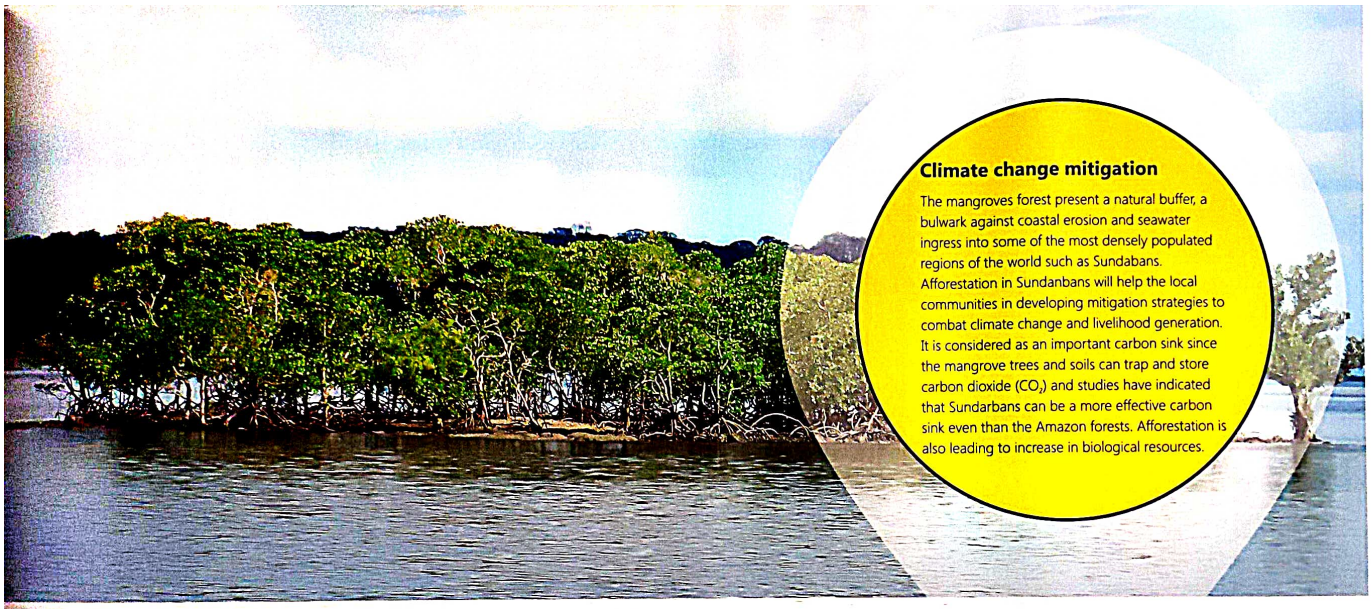
Agro-biodiversity of India

India is classified among the 12 mega-diversity centre's of the world, in relation to crops and it is the region of diversity of many major cultivated plants like Rice, Wheat, Maize, Cotton, Kodo Millet, Mango, Black Pepper, Sugarcane, Brassica, Groundnut, Garlic/Onion, Cassava, Cowpea etc. Moreover it is home to over 811 crop species and 902 wild relatives (India's 5th National report to CBD, 2014). Agro-biodiversity of the country deserves special attention to ensure conservation of valuable germplasm for prosperity, sustainable development, livelihood security and to deal with potential climate change impacts. Appropriate policy and institutional reforms are needed to address the rapid changes which are affecting the agriculture and farming sector.

India due to it is rich animal diversity as well as genetic resources is considered as an important domesticating centre in the world. The vast resources of livestock (485 million) and poultry (489 million) in the country play an important role in livelihood security. India ranks first in buffaloes, second in cattle and goats, third in sheep, fourth in ducks, fifth in chicken and sixth in camels in the world with respect to their population. Fairly large number of indigenous breeds of cattle, buffaloes, goats, sheep, swine, equines, camel and poultry are distributed in different agro-ecological regions of the country. About 140 breeds of livestock and poultry are reported to be present in India, out of which 30 breeds are of cattle, 10 of buffalo, 42 of sheep, 20 of goat, 3 of pig, 6 of horse and pony, 8 of camel and 18 of poultry. In addition the vast habitats of India support significant number of breeds of animal such as Yak, Mithun, Ducks and several nondescript populations. However due to low input production systems the local or indigenous livestock varieties are threatened to extinction. As per an estimate about 50% of indigenous goat, 30% of sheep, 20% of cattle and almost all poultry breeds are threatened.

Climate change adaptation

Climate variability and change is greatly influencing the natural and socio-economic environments throughout the world, though the extent of vulnerability differs across regions, and countries. It is manifested as increased frequency of extreme climatic events like heat wave, floods, droughts, cyclones, recession of glaciers and monsoon rain variability instability in food production, reduced water availability, loss of habitats and displacement. Climate change is also an added risk to arid and semi-arid and coastal regions. Majority of the drylands and a coastal line of about 7500 km in India is highly vulnerable to climate change.



Climate change mitigation

The mangroves forest present a natural buffer, a bulwark against coastal erosion and seawater ingress into some of the most densely populated regions of the world such as Sundabans. Afforestation in Sundanbans will help the local communities in developing mitigation strategies to combat climate change and livelihood generation. It is considered as an important carbon sink since the mangrove trees and soils can trap and store carbon dioxide (CO_2) and studies have indicated that Sundarbans can be a more effective carbon sink even than the Amazon forests. Afforestation is also leading to increase in biological resources.

About 13% of the national GDP is contributed by agriculture and allied activities. Change in both rainfall pattern and temperature by the end of 21st century are likely to cause significant negative impacts on forestry and agriculture sector including livestock, forestry and fisheries that provide employment to about 70% of the work force. About 19% of the area of the country experiences extreme arid conditions of which 15% is in the North India and 4% is in the southern Peninsula. Recent studies reveal a decreasing trend in aridity from the beginning of the 20th century which is mainly attributed to the west ward shift in the monsoon rainfall activities and the change in the land use pattern This emphasizes the need for a better understanding of the impacts of climate change through various regional models which in turn can help evolve sustainable land management practices.

Various climatological studies conducted by India Meteorological Department and Indian Institute of Tropical Meteorology reveal that annual mean temperature for the country as a whole has increased by 0.56°C for the period 1901-2009 and a significant warming trend is reported across most parts of India. As rainfed agriculture covers 63% of the total cultivated land and accounts for about 45% of agricultural production, late onset and breaks observed in south west monsoon poses serious challenges to the livelihood of millions of dependents. Rainfall trends have also indicated change in the timing and intensity. Significantly increasing trend is observed in the frequency and the magnitude of extreme rain events in central India over the past 50 years.

Out of the total geographical area of 329 Mha, more than 40 Mha is flood prone. Sharp rise in the intensity of extreme rainfall has contributed to the rise in flood events in recent years, which is attributed to the global warming condition during 1998-2009.

The impact of climate change on vegetation patterns, species community structure, distribution and ecology is significant. Projections of various regional climate models indicate a shift towards wetter forest types in northeastern region and drier forest types in the northwestern region in the absence of human influence. Climate variability is an important determinant of agricultural land use practices viz., cropping pattern and diversification. Climate change and more significantly its variability is affecting the Indian agriculture especially the production of cereals and horticultural crops. Moreover change in climatic umbrella might affect soil moisture and its characteristics and length of growing period and ultimately the productivity. It could also affect pests, insects and pollinators causing considerable reduction in crop production.

As such, it becomes imperative to develop and identify practices which are climate smart or resilient to climate change. The cultivation of landraces which posses climate adaptability should be supported and the other varieties of crops which are climate resilient (salt tolerant/ flood tolerant) should also be cultivated as a strategy to combat climatic variability or extreme event.

Sustainable livelihood generation and socio-economic improvement

One third of the country's population lives below the poverty line, 70% of which live in rural areas. Of this almost 27% is below the poverty line. High poverty incidence is found in the semi-arid tropical region, where shortages of water and recurrent droughts have reduced land productivity tremendously. There is also a high incidence of poverty in flood-prone areas and in coastal areas which also have high vulnerability to natural disasters. A major cause of rural poverty is poor agricultural growth lack of access to productive assets and financial resources, combined with high levels of illiteracy, inadequate health care and extremely limited access to social services and lack of opportunity.

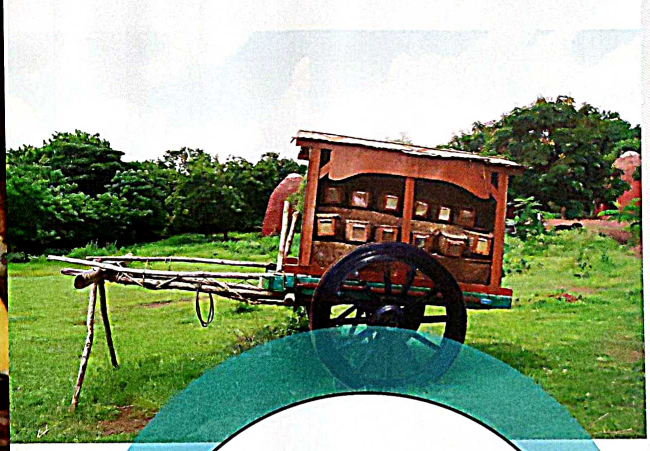
While majority of the rural population is dependent on agriculture, most of them are engaged in the struggle for food security. Therefore, it is necessary to promote suitable rural technologies which can enable the local communities to enhance their efficiency and earnings. With the improvement in agricultural production, various opportunities can emerge in the agri-business and non-farm sectors in the future. Over the years, a large number of activities have been identified both in On-farm and non-farm sectors. On-farm Activities for sustainable livelihoods include interventions like better crop production, horticulture, forestry, sericulture, livestock husbandry, fishery, making agro service centers, food processing and production of agricultural Inputs like biofertilisers, biopesticides, vermicompost, mushroom spawn production, seeds and plants, cattle feed etc. Off-farm activities like textile, incense stick making, weaving etc also contribute towards sustainable livelihoods and a reduction in pressure on land. Training and awareness generation is also an essential prerequisite for encouraging income generation activities using natural resource management like medicinal plants cultivation, organic farming and alternative high value cash crops.

Institutional Innovations for Sustainable resources use

India has traditionally had several village level community based institutions for sustainable resource use and management. There are several examples where local communities have been formally recognized and empowered to govern and manage the forests of their villages, or where they have self-initiated Community Based Forest Governance systems (CBFG). These include several thousand Van Panchayats in Uttarakhand, natural resource management by the community in several North-Eastern states etc. These institutions therefore play an important role in any initiative related to natural resource management.

Several other Government initiatives like the Joint Forest Management (JFM) also ensure the involvement of the community in conservation, management and protection of forests with an in-built benefit sharing mechanism. Currently, more than 118213 JFMCs are managing around 23 million hectares of forest in the country (FRI 2011), with benefit sharing mechanism.

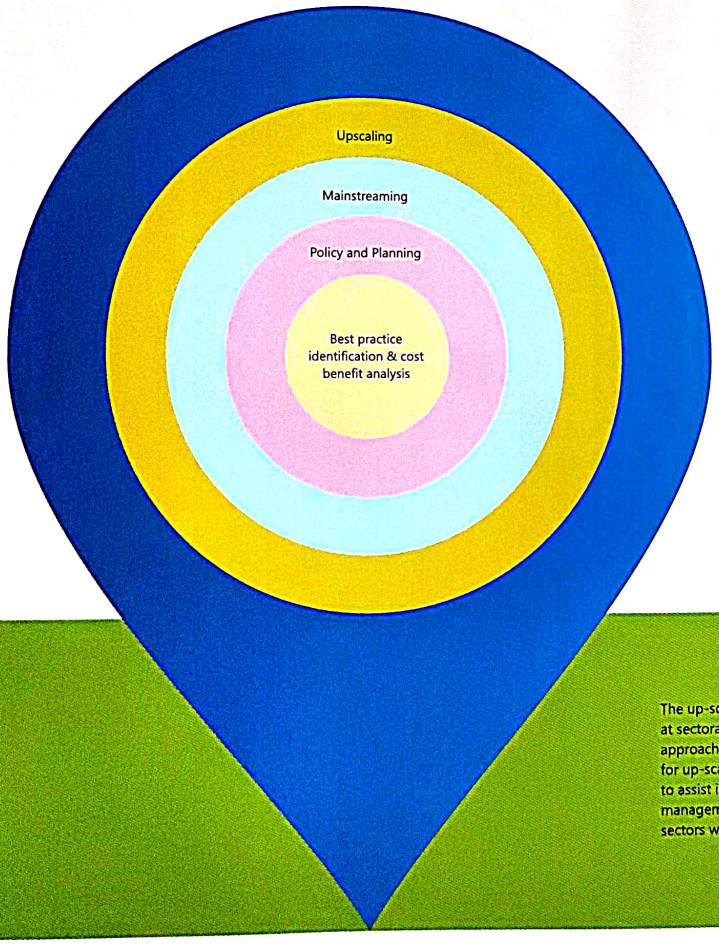
The Van Panchayat (VP) system is a prominent and successful example of participatory management of common natural forest resources in the state of Uttarakhand. This devolution of powers to control and manage forest for subsistence purpose is the earliest example of co-management of natural resources by the state and local communities in India. Van Panchayats or Forest Panchayats have been incorporated under Section 28(2) of the Indian Forest Act, (1927). While all Van Panchayats in the state are governed by the Forest Panchayat Act, at village level, rules and regulations may differ. As per the Van Panchayat Rules, villagers themselves make the rules for day-to-day management. This significant role of the van panchayats in forest management has been tapped by the Government for holistic management of watersheds in the state.



Dissemination and Outreach

The objective of the sustainable land and ecosystem management is to accelerate and up-scale best practices with respect to SLEM in India. The present document highlights experiences of the field in the form of case studies, best practices and intervention models and other knowledge products from which others (non practitioners) can become inspired and can be induced for sustainable land management in India. The present document could be best applied at the community and the local level to identify those who execute Government policies as well as at the State and National level for those who influence and make policy decisions.

UPSCALING AND MAINSTREAMING BEST PRACTICES



The up-scaling of SLEM best practices with respect to land management can be achieved at sectoral, institutional and community level. For this it is important to mainstream SLEM approaches into sectoral policies, making inter-sectoral convergence a critical requirement for up-scaling and mainstreaming. The present document on SLEM best practices intends to assist individuals, communities and institutions to address the issues related to land management in India in general and specific to drylands in a strategic way among all sectors with respect to land management.

CONCLUSIONS AND OPPORTUNITIES FOR MAINSTREAMING BEST PRACTICES

Competing uses of land influence land use patterns, cause land degradation and have adverse impacts on forest resources and biodiversity, ecological and economic sustainability both for the present and for the future generations. Land degradation and climatic change affects about 250 million people in India. Managing land sustainably while also maintaining land productivity has become a challenging task which calls for methodologies, tools and models to assess both land degradation processes and mitigation initiatives for their effectiveness. The strategies to arrest and reverse ecological goods and services depletion would include spatial landscape level resource planning with inter sectoral convergence.

In the Indian socio-economic context enhanced productivity from irrigated as well as dry land ecosystems is critical for food security and reduction in poverty. Appropriate land use and sustainable management of the country's natural resources and agro-ecosystems can help to meet the challenges and sustain environmental services. It is now internationally recognized that scientific findings and technical know-how can play an important role in achieving a land degradation neutral world. It implies that the degradation of productive land can be prevented and land that is already degraded can be restored through sustainable land management policies and practices.

The Indian farming tradition is replete with several examples of conservation of soil and water, rich agro-diversity and community practices for participatory natural resource management. Several of these practices have been neglected or have been forgotten over time. While several of these practices need to revitalized, and mainstreamed, quite a few innovative practices seen across the country need to be up-scaled for improving land productivity and enhancing livelihoods.

The SLEM-CPP approach reinforces the adoption and implementation of sustainable land and ecosystem management in several states of India. One of the important focal areas of this project is dissemination of information and mainstreaming and up scaling SLEM best practices. The SLEM project at ICFRE has captured some of best practices related to land and water management, agro diversity and other innovations for improving land productivity from various parts of the country through frequent field visits to SLEM-CPP project sites as well as similar non SLEM-CPP projects. Whilst this is a small effort in this direction, there are many more such practices from various agro-eco-regions across the country that remain to be identified, documented and disseminated.

The following factors would contribute positively towards this initiative:

Building a knowledge database and dissemination of information

In the present scenario of burgeoning population, poverty and degradation of natural resources, sustainable land and ecosystem management becomes extremely challenging. This would require efficient innovative land and water management practices. Knowledge management and extension services play a vital role in dissemination of good soil and water conservation practices to stakeholders, in capacity building and participatory involvement of village level institutions. As per the 59th round of NSSO farmers do not get sufficient information from the extension worker. While the Krishi Vigyan Kendra are the main source of training for farmers at the district level, there is further scope to make the system broad based, demand driven, and farmer accountable.

Concerted effort is therefore required to standardize documentation of soil and water conservation strategies and approaches, ensuring qualitative collection of scattered knowledge. This will only be possible through the participation of land users, technical experts, community based organizations and other stakeholders. The documented information should be made widely available and accessible to stakeholders at various levels so that they may make informed choices.

Monitoring and Assessing Best practices

A Monitoring and assessment framework for various sustainable land and ecosystem management initiatives is needed to establish clear links between past, present and future initiatives and developments. It has been observed that such monitoring leads to important changes, course correction and modification in approaches and technologies and form the basis for fine-tuning, reorientation and future planning. This also contributes to outreach, creation of knowledge base, mainstreaming and up-scaling of successful policy and management initiatives. Such an exercise would facilitate a timely delivery of outputs and also evaluate the expected ecological benefits in a cost-benefit manner. It could also include a geographic coverage of the sustainable land and ecosystem management practices, monitor the extent of the practices and map the information, leading to awareness generation and guide future decision making.

Developing a mechanism to monitor and evaluate local conservation practices, land management innovations and traditional land use systems will help to assess their conservation effectiveness and facilitate learning from past efforts. This exercise is also an important tool to chronicle developments before they become outdated since land and ecosystem management practices and initiatives evolve constantly, changing in response to situations, demands and opportunities. While this calls for a sound and efficient data collection and data reporting mechanism, training and capacity building for objective and unbiased assessment is an essential prerequisite.

Community participation

For a land and resource management initiative to be successful participation of the local community plays a significant role. Land users are the key actors in any initiative and innovation for improvement of land productivity and its management. Building farmer innovations into national extension programs and into agricultural and natural resource management initiatives is beneficial to the community as a whole since they are site-specific, more often than not readily acceptable to neighboring farmers and can significantly improve the performance of agro-extension and techno-advisory services since the visual impact of demonstrations can be a powerful way to attract potential end users of new "best practices". Related to this up-scaling and mainstreaming of best practices is the vital role of tangible benefits like enhanced agricultural productivity, food security, and income enhancement through market access and getting the requisite price for their produce.

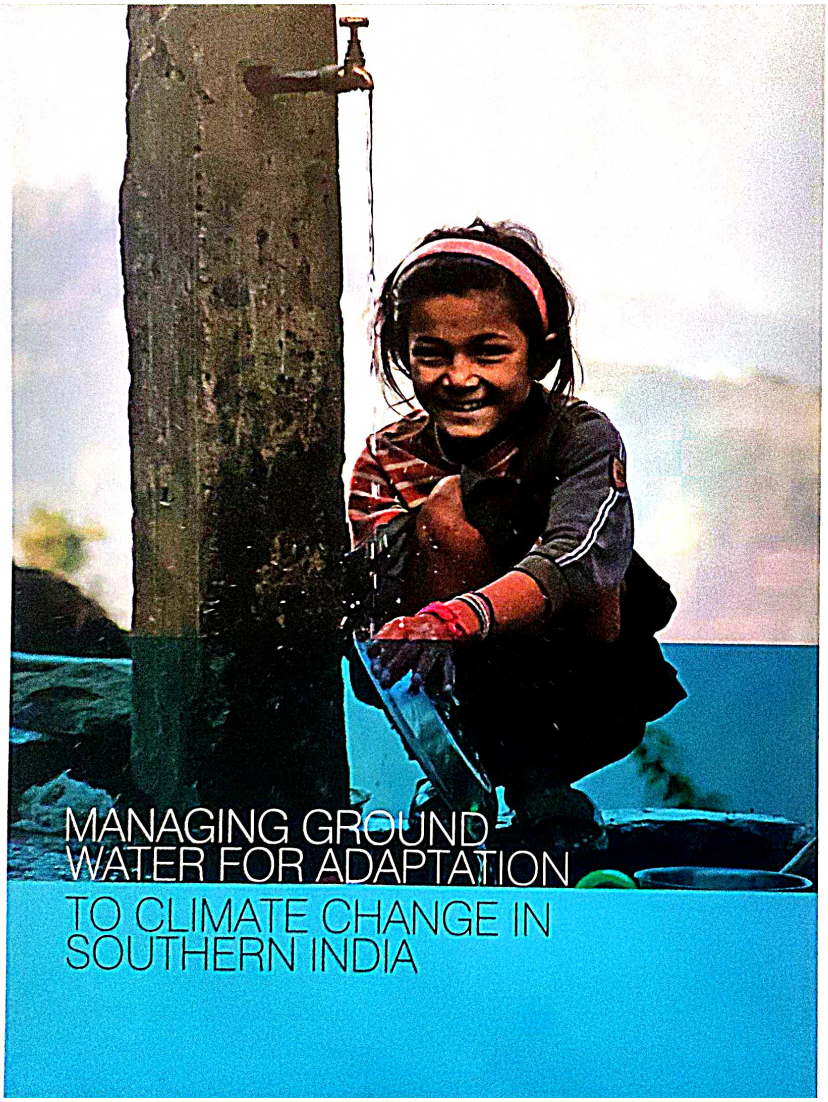
BEST PRACTICES

(As collected from different part of India)

The document is based on the lessons learnt from various case studies which addresses the issues related to land management, biodiversity conservation, climate change adaptation, sustainable livelihood generation and institutional innovation for land management in India. The application and use of the document will depends upon the needs of each user with respect to problems associated with land management in India. However the document has been designed and compiled for audience with diverse background representing different eco-regions of India. A broad range of issues with respect to land management such as land degradation, biodiversity loss, climate change impacts, and livelihoods have been showcased.

As it stands, the present document is an attempt to summarize some of the most important best practices with regard to sustainable land and ecosystem management in India. These best practices present key findings of some traditional practices as well as innovations which can address specific problems with respect to SLEM in India.

While this document does not claim to showcase best practices from all eco-regions, it endeavors to present best practices which have replicability in more than one eco-region and which address crosscutting areas of SLEM in India. However, each eco-region may or may not be adequately addressed by the document due to inherent specific priorities and problems. Validation of the document is needed in such areas by testing it against their needs and in the process will lead to the development of their own version. While there may be many more best practices existing at at the time of compilation of this document, the ones which address crosscutting areas of SLEM in India are the ones presented.

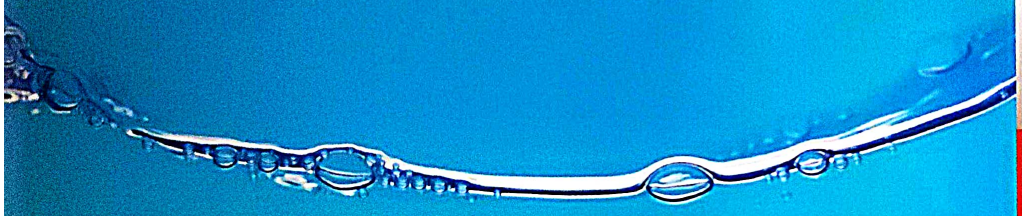


MANAGING GROUND WATER FOR ADAPTATION TO CLIMATE CHANGE IN SOUTHERN INDIA

Outburst of population in India and lopsided development has resulted in fast depletion of ground water and scarcity of water across the country especially in dry regions. Agriculture sector consumes nearly 80 % of water resources. Increasing demands for human consumption and industries by 2030 will pose restriction of water use for agriculture. Therefore, economic and efficient use of water has to be promoted for survival in future. Ground water is the main source of irrigation under rain-fed areas and to some extent in irrigated areas as well. Ground water development has reached 142% in the state of Punjab and 134% in Rajasthan. The semi-arid transitory zone on desert margins in the state of Rajasthan receives double the rainfall (500 mm) annually than the hyper arid western part. However, intensive agriculture, the major culprit, has caused over- exploitation of ground water creating dark zone in 9 districts where ground water decline is more than 10 m, during 1984-2009 (40 cm per year). This is not seen under modest cropping or range management in the arid western region.

Overexploitation of ground water has become serious issue in arid and semi-arid regions of Rajasthan, Andhra Pradesh, Karnataka and Maharashtra and also in irrigated states under intensive cultivation. Projections of Climate Change suggest that water scarce areas of the world will become further drier and hotter. Higher water demand on water intense regions shall affect land productivity and survival in dry regions.

Andhra Pradesh Farmer Managed Ground water Systems (APFAMGS) articulated knowledge of Ground Water Management to the farming community. The project was spread over seven drought prone districts of Andhra Pradesh underlain by hard rock aquifers and over-exploitation of groundwater; covering 638 habitations and 6,500 farm families under 63 hydrological units. The project was executed by a federation of NGO's coordinated by Bharti Integrated Rural Development Society (BIRDS) with technical and financial support of FAO. A very successful model in seven districts of Andhra Pradesh has shown a way for management of ground water in arid and semi arid areas imparting drought proofing in context to climate change.



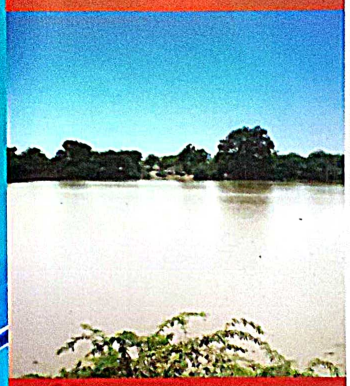


Fig.1
A large village pond for recharging ground water

Imparting Knowledge

The backbone of the program is capacity building of farming community by non formal education through Farmer Water Schools. Regular trainings are held for demystifying the science of ground water which is otherwise invisible. Ground water is an exhaustible resource far away from non-exhaustible myth. Recharge and dynamics of ground water is very slow under repeated abstraction of surface profile through evapo-transpiration. The ground water moves on contour from recharged to depleted zones irrespective of field boundaries. Community participation is necessary in augmenting ground water. Thus, ground water ought to be in public domain and not align with the property rights.

Group Actions

Participatory hydrological monitoring by stakeholders, management committees and Federations at Hydrologic Unit Network (HUN) level recognize the ground water as a community resource dispelling self-centered benefits.

A careful network of farmers is created to monitor daily rainfall, stream-flows, fortnightly water levels, and bore well discharge to provide real time data to develop the water budget, and matching crop plans for judicious use of ground water. Bottom-up approach is the basis of community action on-the-ground. However, top-down measures to create enabling environment and cross-sectoral coordination of ground water related programs in the state strengthened the execution of the program. Government-stakeholder interaction at district level proved indispensable, and mandatory. Best Practices for efficient water management both indigenous and improved were utilized in implementation of the program.

Traditional systems of ground water recharge in arid and semi-arid regions have been Khadins, village ponds, conservation measures like anicuts, recharge pits and trenches juxtaposed with low water requiring grasses, millets and modest mixed cropping (Fig. 1).

Reduction in Ground Water Usage

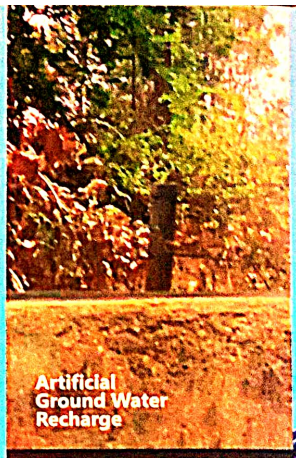
Best Practices helping sustainable use of ground water for cropping are familiarized through regular trainings, simple models and hands-on experience. Ground water pumping to the extent of recharge and its management is maneuvered through innovative approaches. Behavioral change in users is articulated by education that excess irrigation does not necessarily produce best yields. Farmers are convinced to optimize irrigation as per crop needs at critical stages.

The core message is that ground water abstraction over the long term needs to be aligned with its availability. This path-breaking achievement is beginning to emerge in a number of Hydrologic Unit Network under the project, and is likely to result from impact of dissemination of ground water information and farmer decision making. The net effect of natural ground water recharge conditions and demand side management of Ground water is visualized through static water level in the monitoring wells.

Such an approach has helped farmers to reduce risks especially with high input crops, reduce losses, limit ground water extraction to safer limits, improve water use efficiency while generating higher productivity and more wealth.

Changing cropping patterns with low water requiring crops is a crucial issue strengthened by irrigation techniques and methodology that includes need based watering at critical stages of growth and adoption of check basin, sprinklers and drip methods instead of flooding. Soil moisture conservation practices such as leveling, contour cultivation, strip cropping, inter cropping with leguminous cover crops weeding, mulching, intercultural, etc. help in soil moisture conservation from fields considerably.

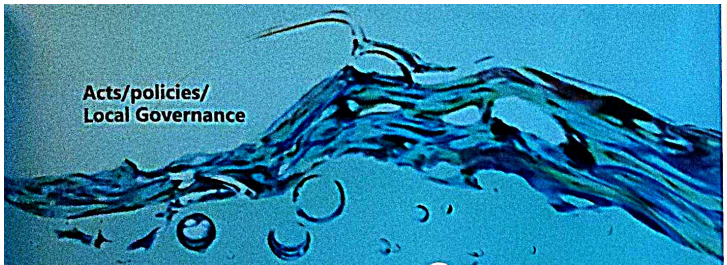
Fig. 2. Abandoned well utilized for Ground Water recharging through rain water



Artificial Ground Water Recharge

Fig.3 Recharge structure behind check-dam

Recharge structures are vital for trapping flash floods in abandoned open wells/bore wells (Fig. 2) or behind check dams (Fig. 3) and percolation ponds in conjunction with soil and water conservation in fields, which helped in water saving and reducing crop water needs.



Acts/policies/ Local Governance

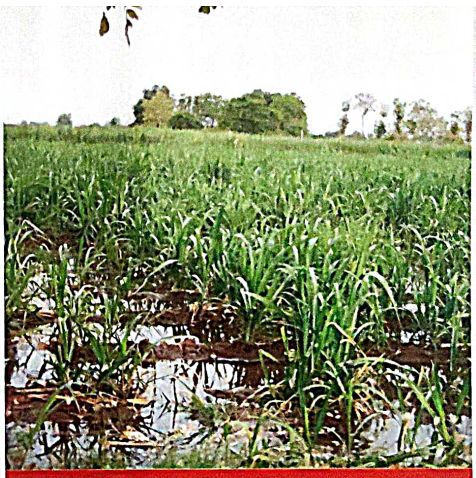
Panchayat Raj Institutions are the best equipped to handle issues related to ground water resources and their management at the village level. Land use plans have to be prepared and judiciously followed for integrated management of resources reducing area under high-water-using crops (requiring more than 800 mm water) and preference for the short duration cultivars needing less water.

- Regulation of subsidies on the power and diesel in order to reduce abstraction of ground water
- Restriction on sanction of unlimited number of tube wells. Permission should be accorded after hydrological survey
- Formation of Ground water User's Group and Coordination amongst water and ground water related departments at the level of individual aquifers is required
- Policies to support community-based ground water management is indispensible. Efforts should be made to convince and mobilize communities to join these groups voluntarily
- Policies and Governance: Ground water should be kept in public domain. Bye-laws should be framed for Ground Water User's Association.
- Metering the water use at farm gate and fixing the water charges as per the use that is based on kind of crop, number of irrigations and, amount of water actually utilized

Specific Models Recommended for Replication

Alternative models for ground water legislation are required which involve entire community, with transparency in dealing with User's Association, equity in distribution of ground water resource, water charges with in-built humanity element. Empowering communities with skills and knowledge to collect, collate, understand implications of their actions and triggering discussions on possible options and initiating safeguard actions at the village level. Ground water Crop Water Budgeting (CWB) at the beginning of Rabi season is crucial in case of ground water

Fig. 4
Flood irrigation of high water requiring sugarcane



CASE STUDY

Ground Water Management

A Project Supported by FAO at Muthyalpadu, Nandyal, Distt. Karnool

The project site falls in the catchment of river Vakkiluru. Historically Nandyal was a typical rain-fed millet growing area receiving 650 to 800 mm rainfall mostly through south-west monsoon. Of 85,594 ha land, 50% having 74 habitats is under agriculture and remaining 50% is under forest, which was not included under project activities. It possessed sizable population of SC, ST and OBC and was also inflicted by factionist on account of poverty. In early 90's considerable amount of subsidies were provided under various rural developmental schemes for tapping good reserves of ground water for irrigation. There was therefore a dramatic shift in cropping pattern in favor of high water requiring crops like paddy, sugarcane (Fig 4), banana, cotton and groundnut under incentives of some industries resulting in over exploitation of ground water. Farmers borrowed loans for digging deep wells from money lenders, which was difficult to repay due to frequent failures of borings. A similar situation also existed in other districts. This led to suicides of farmers in many cases.

Crop Water Budgeting (CWB)

Ground water balance based on total recharge and draft is estimated (Fig.5). Based on these, farmers make informed decisions on the crops to be grown and ways to manage/ use available water efficiently. The following analyses are made in the meetings for each hydrological unit.

- Ground water recharge and draft during Kharif
- Ground water balance of Kharif crops
- Recharge through projected rainfall and secondary sources in Rabi
- Crop plants vs Crop water requirement in Rabi
- Annual ground water balance

Fig. 5
Monitoring discharge and ground water level

Participatory Hyrological Monitoring (PHM)

It created awareness amongst the group of farmers regarding:

a) Ground water availability
b) Rainfall recharge relationship
c) Water use plans matching utilisable ground water
d) Need for conservation of the ground water
e) Ways for augmenting ground water recharge

Farmar's Water School (FWS)

It is a kind of non formal education for probable diagnosis and practical solutions. Group learning aimed at improving skills and knowledge of farmers through hands on experiences. FWS run at 15/20 days interval thru full hydrological year. About 25 to 30 farmers participate in each training, which are conducted in different modules, mainly dealing with water management and other aspects of crop production including integrated water management, vermi-composting, pest control and Farmar's Field School-CWB modules. Field days were also organized for benefit of other villages and farmers of the area.

Impacts of Project

Rainfall and static water levels are measured regularly. In the study ground water draft and cropped area are directly related (Fig. 6). Ground water at the end of May 2010 (Fig. 7) is positive 2007 onwards. These relationships are crucial for understanding of the farming community for planning matching cropping schemes. These impacts of the project on ground water augmentation were remarkably manifested for climate change adaptation.

1. The high water requiring crops such as paddy, sugarcane, groundnut and cotton have been almost replaced by red gram, okhra, green gram and short duration variety (TCA-37) of groundnut.
2. There is a shift from flood irrigation to check basins, conservation furrow method, sprinklers, drips and rain guns for spray of pesticides.
3. A few tractors, bullock drawn seed drills, threshers and rain guns are made available on custom hire basis.
4. Peoples' Institution: Mutually Aided Cooperative Societies (MACS) have been formed, which are acting as ground water monitoring committees (GMC).
5. The project has been rated as highly successful project. The FAO funded project on "Reversing Environmental Degradation and Rural Poverty through Adaptation to Climate Change in Drought Stricken Areas in Southern India" is furtherance to Andhra Pradesh Farmer Managed Ground water Systems with revised focus and objectives in context to climate change.

Fig. 6 Relationship between Ground water draft and cropped area

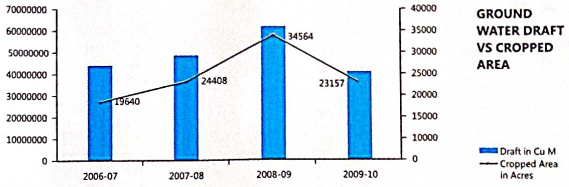
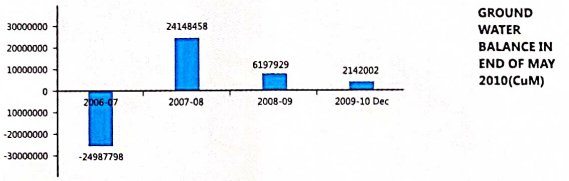
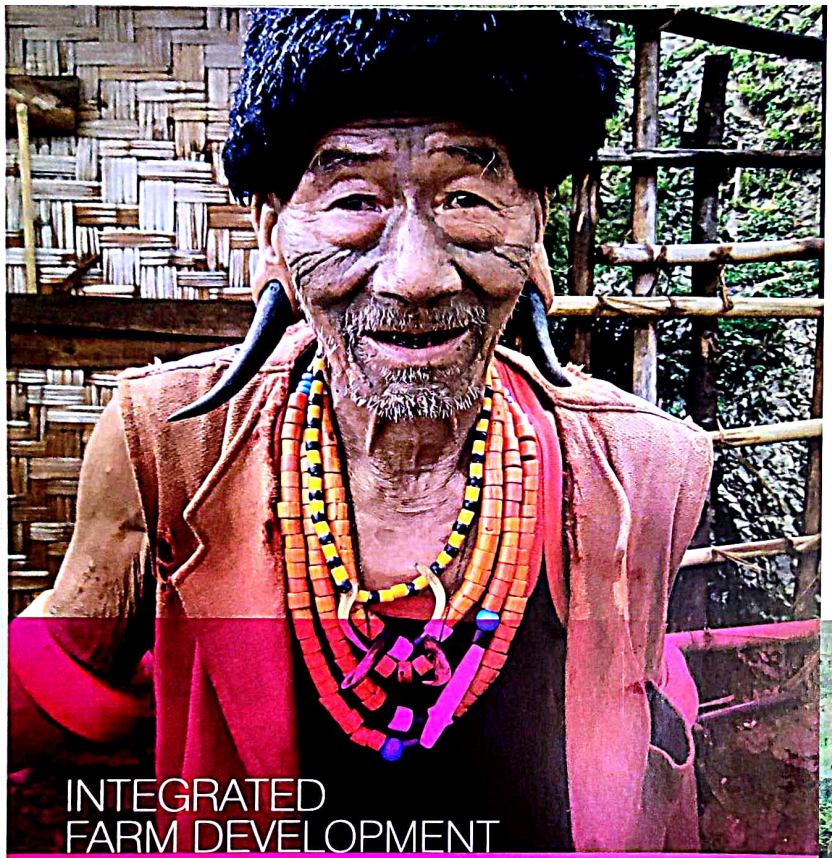


Fig. 7 Ground water Balance at the end of May 2010 Source: BIRDS



Regional Applicability

The technology can be replicated to the hard-rock aquifers, covering about 2/3of Indian aquifers. Target Groups/Stakeholders are farmer community and collaborating network partners are the Farmer's Community, Govt. Department , NGOs wherever involved and financial institutions.



INTEGRATED FARM DEVELOPMENT FOR SUSTAINABLE LAND PRODUCTIVITY IN NAGALAND

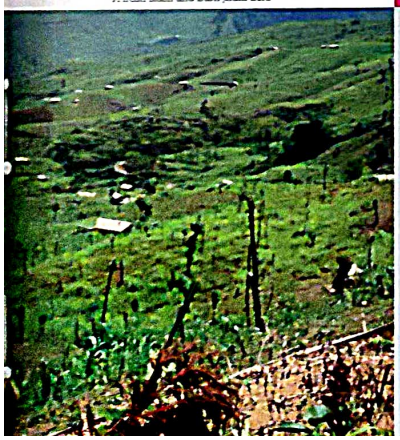
Agriculture has traditionally been and continues to be the mainstay of Naga life-the numerous festivals are centered around agriculture and have their roots in cultivation practices. Since generations there have been close links between nature and people and these linkages and traditional practices have been formalised through experiences and empirical observations, and interwoven into social, religious and traditional values, making, the production system in Nagaland close to proto-agriculture, like most of the world's tribal population. Customary land tenure system exists in Nagaland . Traditionally the tribal land is classified either as agricultural land or as reserved land. The practice of Shifting cultivation covers over 37 % of the total arable area of the State. It is mostly concentrated in the districts of Mokokchung, Tuensang, Wokha, Zunheboto and Mon. In other areas, terraced rice cultivation (TRC) or combined Jhum and TRC are practiced.

The general outlook towards Jhum since the last 50 odd years has been that jhum cultivators are primarily responsible for deforestation of natural forest. Nagaland faces a major challenge in adapting land use and production systems to meet rising populations and changing lifestyles, while also maintaining its ecological sustainability.

- Total area under shifting cultivation in Nagaland: 37% of total arable land
- Plantation activities under IFD: More than 12000 HECTARES
- Jhumia families benefited under IFD: 800-900
- Increase in average income of 4000 families-By 15-20%

The project Sustainable Land and Ecosystem Management (SLEM) in Shifting Cultivation Areas of Nagaland for Livelihood & Ecological Security"focuses on land based activites for livlihood enhancement and ecological restoration

A fresh slash and burn jhum field



Integrated Farm Development

Innovative agricultural techniques like the integrated farm development model (IFD model) have been developed by the SLEM project to address issues of land degradation and livelihood. The IFD model is based on the concept of complementary integration of all the components of agriculture like crop-livestock-fishery-forestry-horticulture-soil and Water conservation and land development works. These provides an environmentally sustainable and economically viable and location specific technology that encompasses rational utilization of available resources and provide supplementary income from non-jhum activities.
The IFD model has helped the small and marginal farmers in reducing the input cost and increasing the yield and improving the farm economy. The soil conservation measures have had a positive impact on soil fertility leading to improved jhum practices, with the same land being cultivated or more than two years, extending the Jhum cycle and simultaneously managing the fallow. The socio-cultural importance of jhum cultivation in the life of the tribal communities is built into the IFD approach and the community as a whole and traditional institutions like the Village Councils are closely involved in decision making. Provisions have also been made for appropriate market linkages.

Customary land use is seen in Nagaland

Impact of the IFD Model

Activities under the IFD include plantations, infrastructure development, alternate livelihoods, and land development works. Horticulture and agroforestry plantations have been introduced in over 11,000 hectares of land. Over 800 jhum-practicing households have benefited from introduction of IFD practices. The model also integrates the animal and human waste into useful and productive components such as for the manufacture of vermicompost, biogas and production of crop pest repellent, thereby reducing input cost for farmers. There has been an increase in average incomes of about 4,000 households by 15-20 %. The interventions have led to strengthened coordination and convergence mechanisms between line departments through better awareness of links between land degradation, forest resources, and rural development and Improved land regeneration. Some of the IFD interventions are:

- **Horticulture:** complementarities of crop-animal-fish-birds-multipurpose trees (horticulture) in the farming system are used. This system benefits the community through supply of essential commodities throughout the year, providing year round employment to the farming family and reducing cost of production and ensuring against the failure of individual crop/enterprise etc.
- **Non Timber Forest Produce (Broom cultivation):** Broom grass cultivation on non-agriculture land has been carried out. Broom cultivation and production has led to 50-80% improvement in beneficiaries livelihood. The cultivation of the broom grass has a multi- pronged impact-as an alternative to farming, need for a low financial input for cultivation and its economic value as a marketable item, and its use in land reclamation
- **Agriculture innovations:** Ginger is cultivated with multiple crops like sugarcane, orange, turmeric, Jatropa, tapioca, Amla, colocassia, rice beans (nitrogen fixing plant) mango, needle tree, etc. in the same plot. Trees like mango, needle tree, Amla provide agade to ginger. The planting of the trees, tapioca and colocassia serve as soil erosion control measure since they are planted in a stripped manner. The department of Agriculture supports by providing ginger rhizome. A beneficiary harvested a total of 1200 kgs of ginger in the first harvest. He sold the produce and earned an income of Rs. 30,000/-. The ginger cultivation has also provided him options for settled cultivation.
- Interventions like integrated fish culture cum paddy cultivation, and growing vegetables on bunds have shown enhanced productivity and reduced soil erosion. For example, pre intervention 15 kgs of rice produced about 500 kgs, whereas with the integration of fish with paddy enhanced the production to 700kgs because of the organic manure provided by the fish excreta. Further from the same field about 50 kg of fish was harvested, and sold at the rate of Rs 120/kg, providing extra income for the farmer.
- **Piggery:** In Nagaland along with agriculture, backyard pig and poultry rearing is integral to the livelihoods of farmers. Pig rearing is also a socio-religious obligation and provides additional income to households while diversifying their risks. Pigs are fed on by-products of paddy, maize, taro, vegetables and gathered forages. Among all meat animals pig keeping is still considered as an excellent source of subsidiary income for poor because the pork consumption in Nagaland is highest among all NER .
- **Marketing linkages:** Marketing sheds are constructed on main roads enabling the farmers and women to sell their produce in a more organized manner . On an average this has led to more than doubled earnings. The marketing sheds which have turned into mini local business centres have been especially useful for the women, who sell produce from their kitchen garden and add to the family income. Farmers from nearby villages bring their products to sell on whole sale basis, and sometimes retailers from nearby town come to purchase produce. Livestock, piglets, poultry birds and even handloom products also find their way to the marketing sheds. Most interestingly the sheds also turn into social hubs where farmers and women meet, exchange information, sell their produce, and simultaneously may engage in local craft like netting baskets, bead making, hand bags etc.
- **Gender aspects:** With the introduction of the Integrated Farm Development (IFD), many women benefit directly or indirectly. Most of the women are involved in organic farming. In one district the women's income increased by 10% from their farm produce sold in the marketing sheds constructed with support from the project. Poultry Units operated by (mostly women) Self Help Group under the project have generated income at the rate of Rs 16,500 and Rs 17,600 per anum.

Land development works

Marketing shed in Mon District

Women SHG

CHAUKA SYSTEM FOR MANAGEMENT OF COMMON PROPERTY RESOURCES FOR SUSTAINABLE LIVELIHOOD AND ADAPTATION TO CLIMATE CHANGE IN DRY REGIONS OF RAJASTHAN

The State of Rajasthan covers an area of about 34.22 Million ha largely under arid and semi-arid climate, receiving 250 to 700 mm annual rainfall in western regions, high temperatures in the months of May and June (40°C to >43°C) often accompany strong winds/ dust storms. Temperatures drop to 13°C with occasional frost during winters. Wind erosion is the prime cause of land degradation followed by water and chemical degradation. Water scarcity and high intensity drought (once in 2-3 years) is a common feature of dry areas threatening livelihood of people in Rajasthan. Vagaries of climate change further accentuate the problem. Agriculture is not a dependable proposition on the fragile dry ecosystems hence live stock based farming has been the dependable basis of survival. Consequently, the population of livestock is about 6-8 times higher in dry regions of Rajasthan as compared to rest of the country. The fodder scarcity, which is normally 30% increases to 100% level of absolute scarcity during the drought years, compelling large scale migration in search of greener pastures and work. Livestock causalities are common feature during drought years, despite provisions of voluminous fodder and water as drought relief. The situation is likely to get worse due to impacts of climate change.

Non conducive climatic conditions allow merely 4.7 percent forest cover of the geographical area and the state faces scarcity of fuel and fodder. Staking of dry fodder and grasses as drought preparedness strategy is a traditional way of life in dry regions Degraded and waste lands occupying nearly 54 per cent of dry lands, of which 50 percent are waste lands having vast potential for fodder and water harvesting. Development water, fodder and fuel as common property resources (CPRs) and their appropriate management is of paramount importance for combating Desertification Land Degradation and Drought (DLDD) in dry regions of Rajasthan.

Status of Common Property Resource

In Indian context CPRs include village ponds, pastures, forests, wastelands and rivers etc., which are accessible to and collectively owned / held / managed by an identifiable community with no exclusive individual property rights. Consequently CPRs are often subjected to abuse, exploitation and encroachment resulting in their decline and degradation. Common property land resources constitute about 15% of geographical area in India (0.31 ha per household and 0.06 hectares per capita; NSS 54th Round 1998). These are the key sources of water, fodder fuel and sustain livelihood of the rural household by supporting livestock population particularly in semi-arid regions. It is reported that contribution from CPRs to household income at the national level is INR 693. About 31.8 % of landless families utilize CPRs to collect fuel-fodder, which may be as high as 50% in tribal areas. The decline and weakening of traditional management systems is leading to degradation of these precious resources. National data show a decline of 19,000ha in the extent of common property land resources, ranging from 26 to 52 percent in several states of India during the last four decades[1] , and Rajasthan is among the more severely affected states.

Rajasthan is predominantly an agricultural state. Western and and semi-arid regions survive on animal based faming system utilizing community grazing lands. Traditional community grazing lands in Rajasthan consist of *Agors* that are areas that served as catchments for water bodies; *Gouchars* that are areas that served as community grazing lands; and *Orans* that are areas that served as community forests. Over the years, area under community managed lands has declined and the level of degradation has intensified mainly due to encroachment, conversion of such lands to agriculture, for settlement, roads, and other purposes. Intensive grazing affects soil quality and impairs native vegetation. Many palatable perennial species are replaced by unpalatable annuals, thus changing the vegetation composition and ecosystem dynamics. Community pastures exist in most villages in western Rajasthan, for which the extent of about 10% land is allocated, ranging from 100 ha to 1000ha. Of the 1.194 mha community land in the state, 40% is barren land. According to an estimate community lands contribute 20% of the annual livelihood of poor in Rajasthan as compared to 2% that of affluent farmers.

Since water is the most critical resource for survival in arid and semi-arid regions of Rajasthan, in-situ rain water conservation, runoff harvesting and storage in village ponds (*Nadi*) and ground water cistern (*Tanka*) are traditional practices for managing water for drinking, recharging ground water agriculture, arid horticulture, plantations and pastures development (Fig.1). A vast potential also exists to utilize more than 30% waste lands for community ponds and pastures. In salt affected semi-arid regions, high intensity rainfall leads to flooding and water logging occasionally as a result of impeded drainage due to presence of impermeable hard pan of *murram* (silt impregnated with calcite). Integration of runoff harvesting, pastures improvement, ground water recharging and agriculture development have been successfully achieved in the Innovative *Chauka* System, described hereunder.

[1]*N.S. Jodha, 2005, Paper presented at the UNDP workshop on "Sustainable land Use in Dry Lands: Global and National Perspectives", 2nd February 2005, New Delhi.*

Status of community land in Rajasthan

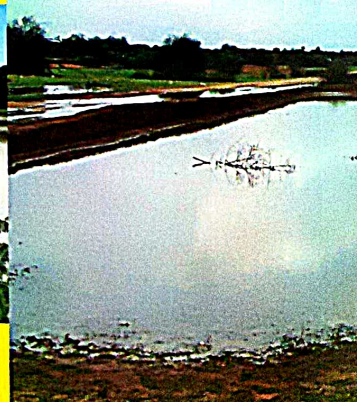
Permanent Common property Resource and other grazing land	Barren un culturable land	Culturable land	Current fallow	Land put under non-agriculture use
1703277 ha	251437 ha	4866381 ha	6688117 ha	1764582 ha
4.98 %	9.73%	14.22%	19.54%	5.16%

Fig. 1 *A multipurpose community pond (Nadi)*

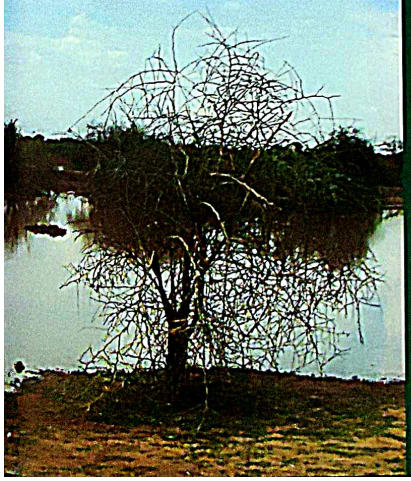
The Innovative Chauka System

The *Chauka* system is generally developed in *Gauchar* or community land having mild 1.5 to 2% slope, good water holding capacity and runoff potential. The *Chauka* is bounded from three sides leaving fourth above the slope open, through which runoff enters this piece of land. The main bund is straightened along the land slope and designed to withstand a pressure of 9 inches standing water. The length of the side bund is such that it makes a 9 inch slope on the main bund and the average height of the side bund should not be less than 50% of the main bund.

- *Chaukas* channelize runoff
- Recharge profile soil moisture
- Improve Pastures
- Recharge community ponds
- Augment ground water
- Enhance land productivity
- Improve Biodiversity



Developing a *Chauka* system requires understanding of land slope, existing water ways, surrounding areas, roads etc so that the runoff is efficiently managed. The grazing land is divided into many *Chaukas*. After 9 inches of water spreads in all the *Chaukas*, excess water finds way to a village pond/Nadi through a drain. The *Chaukas* are designed to have maximum 9 inches of standing water so that the grasses are not adversely affected. The distance between the main bund of the Chauka and the various small compartments *Chaukis* is 3 m so that there is no water stagnation and excess pressure on the bund. Choice of the correct *Chauka* model is extremely important for its success.



Models of Chauka System

A Simple model (at top), is made on land with uni-directional slope not exceeding 1.5% with a shape of long rectangles. The main bund is slightly tilted to enable excess water to move in one direction. All the Chaukis are made similarly and the excess water moves from one to the next Chauki and finally into the Nadi.

Chauka with water way (in middle), is very common and effective for land which has a natural outlet for runoff to drain excess water. Lands having natural drainage by small water ways can be used for this model, however, it cannot be utilized on uneven land.

Staggered model (at bottom), is utilized on land with uneven slope not exceeding 2%. The direction of the Chauka changes according to change in direction of slope. The excess water drains on both the sides of the Chauka and ultimately in to a community Nadi.

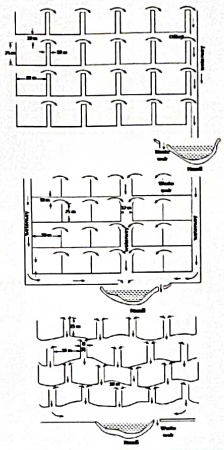


Fig.2 *Models of Chauka System: Simple model (Top); with water way (Middle) and Staggered model (Bottom)*

Advantages of Chauka System

- **Long slopes are broken into many smaller slopes and water erosion is reduced.**
- **The rain water is caught where it falls enabling efficient conservation**
- **Regeneration of local species of grass, bushes and trees takes place. Generally native species like babul, khair, khejri are planted on the sides of the Chauka, are seeded with karad, and dhaman grasses.**
- **Rain water is managed to develop multipurpose water resources Nadis, for drinking water of livestock, improve community pastures, and augment ground water for improved cropping.**
- **Drought proofing through availability of water and fodder**
- **Overall an improvement of biodiversity takes place.**

About 103 bore wells which use to be dried up earlier have plentiful of water and sustain increase pumping duration

CASE STUDY

Gram Vikas Navyuvak Mandal (GVNM), Laporiya:

Laporiya , located at 90 km from Jaipur, is a small village in Duddu block with 250 households and a population of 4060 which use to be 2955 before start of the project (1990-91).The livestock population at the start of the project was 2955 which increased to 4060.The village falls in typical semi-arid region with 350 to 750 mm annual rainfall and 20°C to 45°C mean temperatures. The village has been often affected by varying degree of droughts and acute shortage of fodder despite 400 ha community grazing land. The village is affected by salinity, has a hard impermeable kankar layer impregnated with silt causing loss of large part of heavy rains as runoff and creating water-logging as well. Such lands are very common in semi-arid tracts of, Jaipur, Nagaur, Pali, Jodhpur Jaisalmer, Barmer, Bikaner and Hanumangarh. There is vast potential of runoff conservation, harvesting and storing in community ponds and utilize it for drinking, ground water recharge, agriculture and drought proofing. Shri Laxman Singh is the Secretary and founder of GVNM at Laporiya, pioneering rain water harvesting and pasture improvement.

Systematic runoff harvesting in village ponds and management of water resources for development of community pastures, embracing animal based farming and improving breeds of the cattle are the central issues of the Chauka system adopted by the GVNM, Laporiya. Voluntarily participation and mobilization of society is the key for the success, which has been achieved through well organized Jal Chetana Yatra. GVNM Committee has resolved several disputes and even the legal cases .As a glaring example ,only two legal cases of the village are pending in court. The Model has imparted drought proofing and economic security for the village and has been very successful.

Chauka System for Pasture improvement and Runoff harvesting:

The innovative Chauka sy+stem was developed by GVNM society for conservation of rain water, runoff harvesting which was integrated with improvement over compartmental bunding with provision of drainage. (Fig.3).

Rectangular Chaukas were construction in a row keeping one long arm of Chauka open. Thus, the structure has one long, two short arms and two corners. A broad bund was made by putting earth from nearby small rectangular pits. These Chaukas are kept on slight upward gradient. When the Chaukas are filled to a depth of 9", the runoff overflows to the next compartment and then to next and finally to the drain which ultimately delivers in a pond. In the process adequate infiltration of water, conservation of moisture in pasture occures and the excess is stored in the village pond.

Impact of Chauka on Augmentation of Water Resources & Ground Water:

Geomorphology of Lyporiya offers an ideal situation for runoff harvesting and its storage in community ponds. There are negligible seepage losses due to hard pan in the profile. Laporiya has developed three village ponds namely Dev Sagar (utilized for religious pursuits), Fool Sagar (for drinking purpose of animals) and the Anna Sagar (sea of food grains). The Anna sagar is the biggest pond, having an area of more than 50 Bigha (35 acres), receives most of the runoff from 200 ha Chauka system, is utilized for irrigation and ground water recharge (Fig. 4) of large number of bore wells. Two canals have been constructed from Anna Sagar for irrigation purposes. Sometimes ground water reaches few feet below ground level and pumps have to be lifted to avoid submergence (Fig. 5). The community ensures cleaning and desilting of ponds through Shramdan before onset of rains.

Fig.3 Chauka System for Runoff harvesting and Pasture improvement at Laporiya

Fig. 4 Runoff harvesting pond in Laporiya

Fig. 5 High water level due to Ground water recharging

Fig. 6 Crops irrigated by ponds or recharged bore wells

Fig. 7 Development of improved pastures through Chauka system at Laporiya

Fig. 8 Improvement of local cattle by Gir breed of Gujrat

Improvement in Land Productivity

Crops

About 1400 Bighas (900 acres) of agricultural land is being irrigated in Laporiya through community ponds and bore wells against only 100 acres in pre-project period (Fig 6), which is the major contributory factor for economic security through 2-3 times enhanced yields of irrigated crops in nearly 1400 percent increased in command area.

Pastures and fodder

Pastures have come up as result of adoption of Chauka system. Pastures are seeded with native grasses, Dichanthium annulatum and indigenous trees like kerr (*Capparis decidua Forsk.*), *Acacia nilotica*, Neem (*Azadiricta indica*) and peepal (*Ficus religiosa*) etc. and self fertilized by the excreta of goat and sheep (Meengani). Laporiya has developed excellent pastures and abundant grasses for their cattle (Fig. 7). The GVNM committee regulates management of the pasture, ensuring equitable distribution of water and fodder.

Herders are allowed to graze their cattle and not to cut grasses or trees from the pastures. Voluntary Shramdan is performed by uprooting of *Prosopis juliflora* in lieu of grazing. Small ponds/water holes have been made for drinking water to cattle and RCC resting places for herders. During the drought years when grasses are scarce, the GVNM committee allows lopping of *Acacia nilotica* first, then *Azadiricta indica* and finally *Ficus religiosa* under extreme cases. In addition to pasture development, farmers are also persuaded to grow green fodder of lucern, Berseem or Jowar in small area to supplement feeding to milking animal. The excess fodder and grasses are staked for scarcity period to secure drought proofing. The technique evolved by the experience, is claimed to be an improvement on the compartmental/ contour bunding, provides adequate fodder and has been well acclaimed.

Improvement of livestock

Enthused by the availability of fodder and realizing importance of animal based farming in the dry areas, GVMN took up improvement of the cattle breed, which is the land mark. Poor yielder Nagauri drought breed was improved by providing free service of Gir bulls. An improvement of 70-80% in purity of local breed is a land mark achievement. GVMN aims to achieve 90- 95% purity (Fig. 8).There is quantum jump in the milk production of the village. Now Laporiya is producing about 1600 liters milk daily and earning Rs 30 lakhs per annum by sale of excess milk.

An improvement of **70-80%** in purity of local Nagauri breed is a land mark achievement

Improved Biodiversity Conservation

GVMN realizes the fact that traditionally managed Agor, Oran and Gochar are repositories of biodiversity and the source of multiple products such as grass, fodder, fuel wood, timber and non-timber tree products. GMVN is making praise worthy efforts in conservation of biodiversity through improvement of community pastures, imposing ban on poaching, developing biodiversity exclosures and feeding yard for birds near the Dev Sagar. Surprisingly, in recognition for the service and reverence, GVMN has constructed worship places for the Giri bulls called 'Sand Baba Sthal'. The village demonstrates an exemplary harmony and secularism. There is attitudinal change in Laporiya and wonderful social mobilization beyond imagination.

Development of water resources, community pastures, ground water recharge for drinking and irrigation, improved farming, there is enough water reserve and fodder for droughts. With these strategies, GMVN can proudly say that drought and floods will never visit Laporiya. Herders have stopped migration even temporarily in search of pastures and employment. There has been a shift in the cropping pattern from conventional crops like Bajra, Til, Moth, Barley, Taramira and linseed to cash crops such as Bajra, Jowar for fodder, berseem, Moong, Til, Mustard and gram. Social movement and participatory approach is the crux of the overall success of the program. People are deadly against any encroachment on community land. The Laporiya Model is providing sustainable income from enhanced production from irrigated crops, milk and employment to the entire family (Table 1).

Table 1: Impacts of Chauka system in Laporia village, Dist. Jaipur, Rajasthan

S.N.	Particulars	Before (1990-91)	After (2012-13)
1	Irrigated area (acres)	110	1370
2	No. of village ponds	1	3
3	No. of bore wells	17	123
4	Water availability	July to October	July to April
5	Depth of water below ground(feet)	75	30
6	Milk yield (lit/day)	450	1600
7.	Income from milk (lakh per annum)	5	30
8	Migration of herders	common	nil
9	Migration of youth	50%	<10%

Laporiya model is community driven with low input costs, which can be replicated under similar agro-climatic situations. According to the, Shri Laxman Singh jee the technology has already spread to 84 villages in the region, of which 15 are doing exceedingly well

'WADI' : A TREE BASED FARMING SYSTEM MODEL (TBF) FOR SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT

The word 'Wadi', a Gujrati term means a small orchard. A `Wadi plot' is a piece of family-owned land that is developed for agro-horti-forestry, with soil and water conservation. In this model an acre of land is covered with crops like cashew, mango, amla or any suitable fruit crop with forestry species on the periphery of the land holding bordered by a productive live-hedge. A typical orchard promoted under this scheme involves planting of 40-60 fruit species and 300-400 forestry species along the border per acre of land. The Wadi programme originated in tribal areas of South Gujarat and was initially restricted to development of mango orchards, hence it came to be called Wadi. Subsequently, the scope of the programme was expanded but the original name stuck on. In Wadi, the fruit-tree component is the main source of income, and agricultural crop production is generally limited to the first 4 or 5 years, or till fruit trees reach maturity. Other useful trees are grown along borders.

The Rationale

The rationale for this agro-horti-forestry model is that mature fruit trees can be a source of livelihood for the poor families, year after year, for several years, unlike agricultural crop cultivation, which is highly dependent on monsoons. Orchard plots could be so laid out that some agriculture is also possible in alleys and spaces between trees, to meet part of a family's food requirements, till fruit trees begin to yield. Multipurpose tree species grown along boundaries, to meet the family's fuel, wood or fodder needs can also be a source of additional income. Agro-horti-forestry thus meets a broad range of key needs of poor families.

WADI means orchard in gujrati. The "Wadi" consists of mango or cashew or amla or any fruit crop suitable to the area or a combination of these tree crops, with forestry species on the periphery of the land holding and annual crops in the interspaces of the fruit crops

This model has the essential features for sustainability in species diversity and flexibility in crop selection. All the farmers engaged in this programme may have more than 20 species on their plots at any time. At least three of the crops are grown in large enough areas to yield marketable quantities of produce. There is also flexibility in selection of appropriate crops based on prevailing growth conditions, experience and market demand for produce. These aspects make the model sustainable and influence its replicability positively. A TBF model would thus consist of the following components:

Forestry plants
Forestry species are planted along the field boundaries. Multipurpose species such as Teak, Caurina, A.auriculoformis, Gliricidia, Pongamia Silver Oak, Sesbania, etc are desirable.

Horticulture plantation
Horticulture species like mango (spacing of 7m X 7m) and pomegranate (spacing of 5m X 2m) are planted in pit size of 1m X 1m X 1m.

Pit filling
Along with the topsoil, Farmyard Manure, green manure with neem cake and rock phosphate is filled in the pits.

Grass seeds
Grass seeds (Stylo hemata) is planted along the field bunds. This helps in stabilizing the bunds and provide green fodder perennially.

Intercropping
Intercropping is done between the horticulture plants. This comprise of cereals and pulses such as green gram, bengal gram, castor, redgram, groundnut, cowpea, hybrid jowar, etc This avoids mono cropping practices and enhances the productivity.

Integration of Non Pesticidal Management (NPM)
Non-pesticidal management is encouraged. This help in reducing input cost, and enhancing organic content / biomass in the soil. Promotion of green manuring such as Gliricidia, Sunhemp, Dhaincha, Sesbania sesban, Sesbania grandiflora, pongamia, neem, cassia semia, Erithrina, vermicomposting, Nadep compost, Heap method compost, in-situ compost, liquid manuring such as Jeeva Amrutha, Panchagavya,etc. is encouraged.

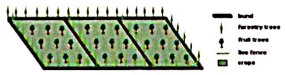
Integration of Small ruminants
Small ruminants (6-8 months old) are introduced to add to the family income and optimize resource use.

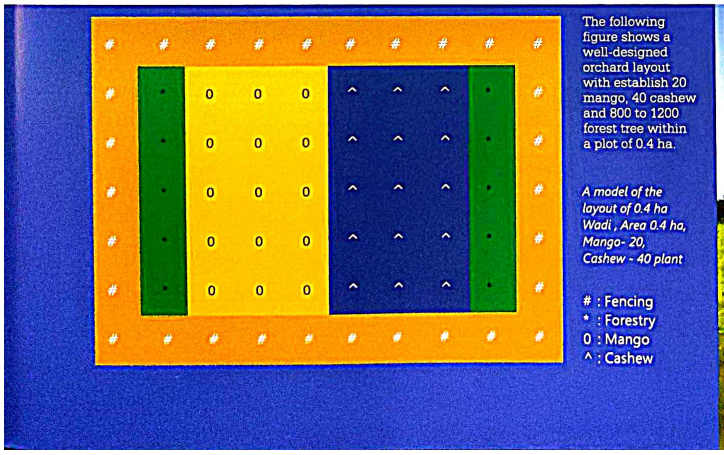
Farm ponds
One farm pond is constructed for every hectare of land. The desirable dimensions for the pond are 10x10x3 meters and it can store upto 1.8 to 2 lakhs litres of water. These farmponds tap the rainwater, enhance ground water through percolation & also provide protective irrigation during dry spells. It also checks the run off and help in insitu conservation of soil and water.

Bunding
Trench cum bund is done under soil and water conservation measures @ 60cmt/acre with site specific sections. This provides additional moisture to the crop and helps in increasing the crop productivity.

Fencing
Fencing is done using the live hedge comprising of thorny plants like Agave and Euphorbia is taken up along the field boundaries.

Tree based farming system model





Water and Soil Management In The Wadi Model

As far as possible water resources are created for joint use by the participants. There may be contiguous patches of upland belonging to small and marginal landholders. Creation of community (Joint) water resources helps farmers to increase their agriculture production and also provide water to the animals and life saving irrigation for horticulture plants. A network of percolation ponds is created in the catchment at the rate of one pond for every 2 to 3 ha of catchment. These ponds help to harvest and percolate maximum rainwater and thereby help in ground water recharge. Since these ponds are scattered all across the watershed they help to maintain the sub soil moisture levels that is essential for crops . These ponds are located in the individual holdings and hence the maintenance of the ponds is the responsibility of the owners. The desilting is also done by the farmers themselves. The water in the ponds in the post monsoon period is utilized to irrigate the horticulture plantations and also to raise small patch of vegetables for home consumption. Mini percolation tanks are constructed at suitable places to trap the run-off water. This helps in ground water recharge and for vegetable cultivation and other short duration crops.

Soil moisture conservation

The work on the project is executed with a "Ridge to Valley" approach, starting from the top and coming downwards. This means that the treatment of the hilltops and hill slopes is completed first and land at the bottom of the valley is treated at the end. Ridge to valley treatment ensures that the soil erosion is reduced and treatment at the lower catchments are protected. This also helps in water conservation and ground water recharge. The treatment is taken up on both public and private lands. Farm bunds, Stone outlets and staggered contour trench are constructed to reduce the water velocity and prevent soil erosion. Locally available stones is be utilized for the purpose. Grass seeds of stylo hamata spp., napier grass, signal grass is sown on the bunds and other wastelands to stabilize them and also provide fodder for livestock.

Gully plug

Construction of gully plug is done using locally available boulders. A dry stone masonry wall of these boulders is constructed across a gully. This wall allows water to flow through it but allows soil to deposit through it. The various stakeholders discuss among themselves to identify the suitable locations for gully plugs.

The gully plug protects soil along the hill slope and the hill top from erosion caused due to flowing water. Once soil degradation is stopped biomass is generated which can be used as fodder and can be used as an organic manure. It also allows more time for water to percolate in the ground due to decrease in the run-off water. It leads to increased income level from waste land. The Silt accumulated can be used for nursery plants or can be used in the fields for increasing organic matter in the fields.

Outcomes of the Wadimodel

- Large tracts of land are covered under this tree based farming system
- Small and marginal farmers are able to diversify their farming operations and successfully venture into integrated farming with mixed cropping, tree based farming and livestock based farming. Marginal and landless families able to successfully establish different livestock activities.
- All the land holding families directly benefit from the natural resources and conservation activities.
- Self help groups in these areas are actively involved in development process and participate in the panchayati raj institutions.
- There is a reduction in migration due to alternative employment created through various farming and non farming activities.
- The families are able to raise their income levels because of increased productivity per unit area of land, less external input, chemicals and pesticides and coupled with adoption of diversified farming system.

Developing A Wadi Plot

Plot Selection

Plot should be on well drained soil, and slopey, not very close to the roads, and ownership should be with a family

Plot Marking and Pit Filling

A measuring rope is used to keep distance between two plants. It should be 10 x 10 meter for mango,Tamarind , 7 x 7 meter for cashew, Amla, Custard apple, lemon etc. The distance from Fencing is 50% of spacing. There should be staggered layout for high slope. The Pit filling should be completed when the pit is dry i.e. by end of May and dusted by pesticides before filling it layer by layer. At bottom there should be 15 cm of dry leaves + layer of top soil, and 10 cm layer of green leaves and small twigs + layer of top soil. The second layer of 25 cm consisting of mixture of soil (excavated from the upper layers of the pit) and farm yard manure or dried dung. This is followed by a layer of 45 cm mixture of soil, bone meal and neem cake. A small heap of 30 cm is made on the top and one wooden peg is inserted at the center. The height of the sticks should be more than grafts, and the top is thatched with Grasses or leaves or Gunny sheet. The Bottom of the sticks are to be painted with tar paint before fixing it into the soil

Live hedge Fencing

The fencing should be done for whole WADI plots instead of individual tree.

Material used for dry fencing Dry branches of Karvand, Ber, sadada, bamboo, nirgudi, karvi and other thorny material available in the area

BAIF Baif Development Research Foundation, Maharashtra has assisted over 1.81 lakh families to establish 68586 ha Wadi, spread over 10 states in India. The economics of 0.4 ha in the project villages as per a techno-economic feasibility study undertaken by BAIF is as follows:

- Generally, development of 0 4 ha of land under agri-horti-forestry requires an investment of Rs. 32000/- over a period of 4-5 years.
- Initial income of Rs. 8,000 to Rs. 10,000 from inter-crops starts form the first year
- Major income of Rs.30,000 to 40,000 per annum comes after 6-7 years, when the orchards started bearing fruit.
- Supplementary income generation through, forestry nurseries, mushroom production, bee keeping, gum and lac production, processing of local fruits and vegetables, establishment of goatry, poultry and dairy etc enhances income by 40-60%.

AGARBATTI PREPARATION FROM DEGRADED BAMBOO FORESTS OF MADHYA PRADESH

Agarbattis (incense sticks or scented battis) are commonly known as "Doopbattis". Agarbattis have been used since long during religious prayers and in the households as a room freshener. The journey of Agarbatti manufacturing began from Thanjavur region of Tamil Nadu in South India and gradually spread to other parts of the neighboring states. Wide spread utilization of herbal based Agarbatti for their pleasing fragrances have also been found in the Middle East, European countries and other parts of the world.

As far as Agarbatti manufacture in India is concerned, the rural Small and Medium Enterprise (SMEs) experts have identified Agarbatti as a consumable good whose demand is increasing constantly. This sector has got tremendous potential and is capable of creating livelihood opportunities in the rural pockets, especially for the women. It is a cottage industry, in which large-scale rural employment can be created to increase standard of living among the rural communities.

Agarbatti production uses traditional skills and renewable resources largely obtained from the forests. While production requires simple technologies and low capital investments, the industry is highly labour intensive. This lays the attractiveness of the sector for rural poverty alleviation since a large number of people can be benefited. Agarbatti is a widely consumed product domestically and internationally. While the unit cost is low, it is produced in large volumes of several billion sticks a year. The production process is manual and Agarbatti produced largely by women in informal home-based work or working in SHGs, often at their own pace. The industry thus creates home-based income generating opportunities for a very large numbers of women.

The production process of Agarbatti essentially entails four stages: (1) production of bamboo sticks for the central core of the Agarbatti; (2) production and preparation of charcoal and Giggat powder; (3) preparation of incense paste (Masala) and its application onto the bamboo stick to produce the batti; and (4) scenting, or application of perfume, to produce a good quality Agarbatti, followed by packaging. The value addition between these stages is nearly exponential.

With the objective of rehabilitation of degraded bamboo forests, the project on Integrated Land and Ecosystem Management to Combat Land Degradation and Deforestation under UNDP was implemented during 2010 in MP Forest Department. Under the project Agarbatti preparation was also proposed in the districts of Betul, Chhindwara, Umaria, Sidhi and Singroli to utilise the discarded bamboo for commercial uses. The Forest Division officials have identified beneficiaries from villages for preparing bamboo sticks for supplying ice cream and incense making small scale industries in the region. In Sidhi more than 150 participants both men and women from 10 SHGs were trained by the department and provided with necessary equipments. These participants after the training become the community resource persons for the Forest Department for others trainings and sensitization initiatives for the local community. A loan of Rs. 3.00 lakhs was also provided for running the Agarbatti manufacturing unit. An amount of Rs.1.00 lakh has already returned to the Forest Department. Similarly the Forest Division of Sidhi also organized another 15 days training programme for women SHGs in Incense stick (Kari) and Incense Agarbatti making as livelihood initiatives. About 750 participants belonging to 12 SHGs participated. Tool kits were also provided by the Forest Department to the SHGs.

Bamboo-based livelihood on Agarbatti promoted by MP Forest Department shows a pathway out of poverty. They use a sustainable natural resource, involve large numbers of rural people in employment (directly proportional to production), generate cash income opportunities for those who never had such opportunities and above all

put a measure of economic power in the hands of tribal women.

In village Kohlueeh in Sidhi Forest Division the beneficiaries are successful running one Agarbatti unit. On an average a beneficiary is earning Rs.70-100 per day for working 4 to 5 hours per day. They are preparing the Agarbatti and packaging in half kg packets, which are being sold @Rs 40-44 per kg. During one and half year's duration the unit has prepared 570 quintals of Agarbatti by the SHGs cluster. About 4200 women from 32 villages benefitted from these initiatives in Sidhi. The packing is also done at the unit itself so far the product has been sold to Rs 24 lakhs to the traders from Kolkata, Shill ong, Nagpur, Jabalpur, Indore etc. Now the center has given it the brand name 'Maa Chandika' which is being distributed to small traders and retailers like Yugal Bihari, Cycle Brand etc.

The unit has recently purchased seven Agarbatti manufacturing machines at the cost of Rs 28,000/- per machine for making good quality finished Agarbatti. The Agarbatti prepared through machine provides one and half time more earning per day in about 4-5hrs a day to the beneficiaries than the handmade Agarbatti.

Gandhi gram unit is another processing unit for Agarbatti preparation. The production here is completely done by the machines. In the unit they have heavy duty slicer machine which can produce about 70kg slices in 8hrs from bamboo sticks. Heavy slicer machine can produce 50kg slices in 8hr, square stick machine produces 20 kg slices in eight hours time and double square stick machine produces 40 kg slices in eight hours time. The Agarbattis prepared by machines are being purchased by Kohludeeh Agarbatti centre. In total 90SHGs women are involved in Agarbatti making. The women are provided Rs.100 per day as wages after deduction of Rs.15/- as maintenance of machines and electricity charges.

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Ms. Sumitra Goshwami a member of SHG known as Maa Chandika has been working on agarbatti preparation for one and half years. She lives in Kohludeeh village of Sidhi District with her husband and two children. She is one of the active women and trained number of other SHG women in Agarbatti making. Earlier her husband used to move to the town for getting job, but for last one year he is not going out she earns Rs.3000/- per month. She had received training in preparing "masala", the mixture that is rolled on to Agarbatti. She is now a master trainer in batti making. After association she has not only developed her capacities in entrepreneurship skills but also improved her family living conditions.

Economics: - Under the livelihood activities of UNDP project in the Sidhi Forest Division, MP, poor households are identified for preparation of bamboo sticks for Agarbatti making. A large area of degraded bamboo forest exists in nearby villages of poor families. These families are involved in rehabilitation of bamboo forest of 640 ha area allotted by the MP Forest Department. 32 poor families were allotted 20 ha area to each family in these villages. The families involved in making sticks for Agarbatti preparation gets bamboo from the forests at a nominal cost and earn an additional income for their livelihood. About 4200 families from 32 villages are involved in making of Agarbatti from the sticks obtained from the rehabilitation of degraded bamboo forests. Discarded bamboo clumps are normally used for making sticks for Agarbatti preparation. The Forest Department has provided trainings, necessary infrastructure and equipments. On an average each beneficiary is earning Rs.100/- for working 5-6 hours per day which was very essential for their livelihood.

Advantages

Degraded areas reclaimed under the development programmes and utilization of discarded bamboo for useful purpose like making sticks for Agarbatti

- The marginal as well as poor tribal groups got opportunities to improve their livelihood
- Restoration of the ecologically degraded bamboo forests
- Sustainable use and management of local resources ensured with community participation
- Bridge the gap between the local communities and Forest Department by ommon objectives of both the stakeholders
- articulating the common objectives of both the stakeholders
- The local communities have developed capacities to train other communities in Agarbatti making, build confidence, marketing knowledge and quality improvement

Cost of making simple Agarbatti

S. No.	Raw materials for making Agarbatti	quantity	Value in Rs
1.	White chips	2 kg	24
2.	Gigatu	1 kg	35
3.	Charcoal	1kg	8
4.	Bamboo sticks	1 kg	28
	Total	5 kg	95

Labor charges for making Agarbatti from 5 kg raw material = Rs.100/-

Cost = Raw material + Labor charges
=Rs 95 +Rs 100 = Rs 195 for 5 Kg or Rs.39/Kg.

Selling Price of 5Kg of Agarbatti is Rs 220 i.e. Rs 44 per kg

Hence, net profit= Rs 5/kg

Cost of making scented Agarbatti

S. No.	Description	quantity	Value in Rs
1.	Oil	1 liter equivalent to 1 kg	145
2.	Scent	200gms	480
	Total	1200gms	625

Dipping in the solution consisting of above mentioned materials (1200gms) is sufficient for 3.50 kg of Agarbatti. For 1kg of Agarbatti, we require 350gms (1200/3.50) scented material

Cost price for dipping 1 kg Agarbatti = Rs. 625/3.5= Rs. 180 (Approx.)

Agarbatti cost = Rs. 44/-

Scented material (350 gms) for making 1 kg Agarbatti is Rs.180/-

Labor charges to women for packaging = Rs. 22.50

Cost of 45 packets = Rs. 56/-

Total cost of 1.350 kg scented Agarbatti
= Agarbatti cost + Scent cost + Labor charge + Packet cost
= Rs. 41 + Rs. 180 +Rs. 22.5 + Rs. 56 = Rs. 303

For preparation of 1 packet of Agarbatti 30 gms material is consumed

Hence from 1.350gm of material having 30 gm material per packet, 45 packets are prepared

Selling price for 1 scented packet=Rs.10/-

Thus selling price for 45 packets = 45x 10 = Rs. 450

Thus net profit: = Selling price -Input cost = Rs. 450- Rs. 303 = Rs. 147

For preparing scented Agarbatti the beneficiary is able to earn more profit.

REHABILITATION OF DEGRADED BAMBOO FORESTS IN MADHYA PRADESH

Bamboo is a very important product for forest dependent people in India. It is one of the most productive and fast growing plants and this unique capacity makes bamboo a valuable sink for carbon storage.

Bamboo, which is an important forest produce, has high significance in socio-economic life of the rural Madhya Pradesh. It is utilized for house construction, bamboo ply, agricultural implements, handicrafts, Agabatti sticks, irrigation, brooms, food, fuel, fodder, paper pulps, medicine etc and has a good economic value. The average rate of bamboo is about Rs 7000/ton and the productivity is nearly 1.6 tons/ha. One bamboo Culm retails between Rs. 20 to 30. About 1.80 lacs ha of bamboo forest area is degraded in M.P. and needs rehabilitation. The reasons for degradation of bamboo forests are over exploitation, pressure of human population, lack of protection against fire, damage by wild animals and the new Forest Ownership Act of M.P.

Project Initiative

To overcome the problem of degradation of bamboo forests, the government of Madhya Pradesh has taken up a project "Integrated Land and Ecosystem Management to Combat Land Degradation and Deforestation" financed by UNDP, covering an area of 15,000 ha of degraded bamboo forests in the districts of Betul, Chhindwara, Umaria, Sidhi and Singroli. This would help in improving the socio-economic condition of the tribal poor families', biodiversity conservation as well as in improving the overall environment. About 80% population is below poverty line including 2/3rd of the tribal population. Main source of their income is from brick making and agriculture. The area is facing the problem of serious erosion and low moisture retention. The climate is generally dry except rains during June to September. The cold season is from December to February followed by hot season from March to mid-June. Soils of the area is red loamy to rocky. The area has undulating topography of Satpura range.

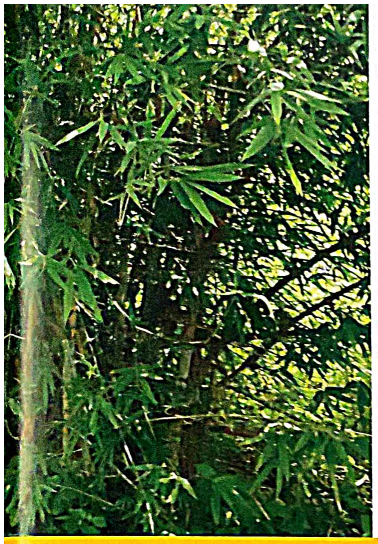
A massive programme was undertaken by the MP Forest Department during 2010 to treat these degraded bamboo forest by allotting 20 ha area for four years (5 ha/year) to the poor tribal families residing nearby these forest. Each poor family is to treat 5 ha every year and during four years period 20 ha will be treated under the project. Monthly remuneration of Rs. 2500/- in lieu of the work done as participatory co-management rehabilitation of degraded bamboo for the last two years has been provided. The families who are allocated these degraded bamboo forests carried out weeding, cleaning of congested bamboo clumps, soil work and protection etc. The yearlong management by the families and protection help the bamboo forest to revive the areas. Accounts of each family have been opened in a Nationalized Bank and their monthly remuneration of Rs.2500/- is deposited regularly in their accounts. This additional household income (Rs. 30,000/- per year) has provided these for addressing the issues of health, education, loan payment and additional savings.

casestudy

Churhat Forest Range in Sidhi District, covering 5 villages namely Maldeva, Padarkhuri, Pawai, Padarkhurikodar, Kudia, Ghadokar, has been selected and 32 poor families are involved for bamboo treatment. During 2010-11 and 2011-12, a total of 320 ha area (10ha per family) has been treated. It is planned that each family will treat another 10ha of degraded bamboo forests in the next two years. During the initial survey there were 32664 degraded bamboo clumps in existence in 320 ha area (average clumps about 102/ha).Similarly, in Chitrangi Forest Range in Singrauli district an area of 800 ha degraded bamboo forests was treated (10 ha per family) involving 80 poor families of 6 villages namely Kekrou, Shivpurva, Duera, Amarapan, Bagdewa, Garai. The total number of clumps at the time of initial survey was counted as 1, 11665 (140 clumps/ha).The average clumps/ha in these two Forest Ranges works out to be 120 clumps/ha. The new bamboo rhizomes were also planted in the fallow areas. The degraded bamboo forest areas under treatment have assisted the regeneration process and in addition, the villagers has also observed a positive change in local biodiversity enrichment. Regeneration of bamboo would promote healthy growth of foliage. It is estimated that through regeneration the project could delivered 3-4 tons of biomass per ha per year for meeting the fodder needs of the livestock. This is especially important in the lean season when dependency on forests for uncontrolled grazing increases immensely. Due to treatment of degraded bamboo forests very successful results have been achieved. The growth of new bamboo culms has improved maney folds due to treatment and protection by the beneficiaries under the support of the local forest officials. In the successful association of villagers towards the core activity, the families are also involved in making Kadi (bamboo sticks) from discarded bamboo and growing seasonal vegetables for their own consumption as well as for selling out in the nearby local market.

Economics

The input cost in the first year on treatment of degraded bamboo forests to an area of 5 hectares is Rs. 30000 incurred in the form of wages to the beneficiary @ Rs 2500 per month for 12 months. Rs. 30000 in the second year for another area of 5 ha for treatment and another Rs. 30000 in third year and also in fourth year will be spent on treatment. A maintenance cost of Rs. 5000/year from 5th to 7th year has also been provided. During the initial four years the beneficiary would able to earn a revenue of Rs.2000 per year in the form of 500 discarded bamboo culms in 5 ha area to be sold @ Rs. 4/ Culm or utilized by them in preparing Kadi (bamboo sticks).It



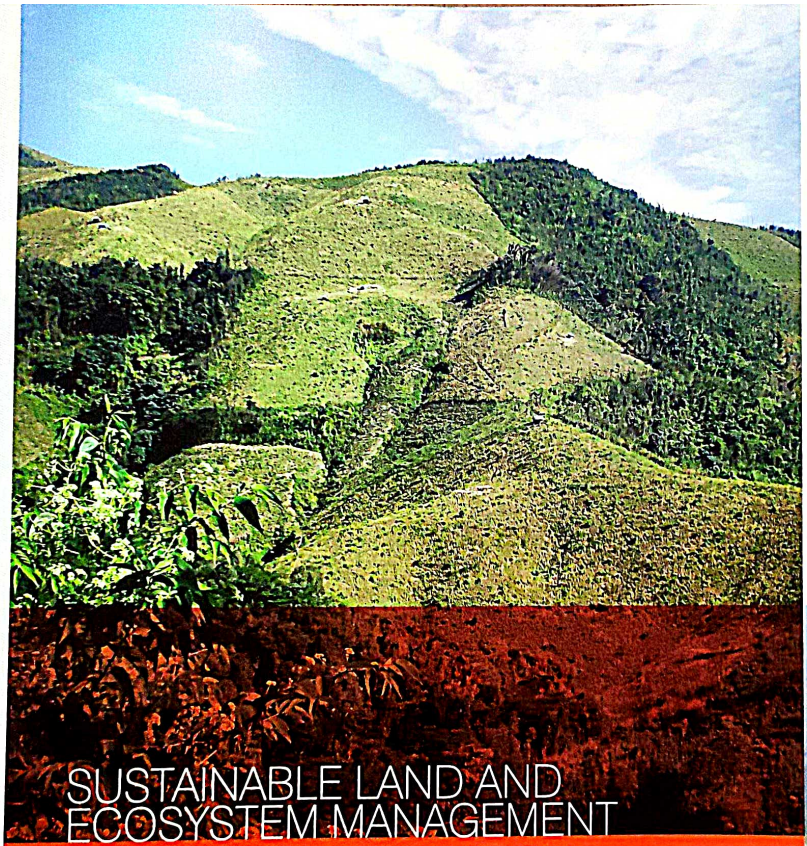
is expected that clumps would improve from 15-20 culms (baseline scenario) to 25-35 culms through sustainable management of degraded bamboo areas. Beginning from 5th year, the harvest of matured bamboo is expected to be 1200 culms/ha (120 clumps and in each clump, 10 culms expected) per year. With each Culm selling at a nominal rate of Rs. 10, the total revenue per hectare per year from bamboo alone worked out to be Rs. 12000. From an area of 5 ha the revenue of Rs. 60000 is expected (Table).Sales proceeds rise each year as the number of culms increases every year (12-15 culms to a bamboo per year growth), hence marginal increase in revenue.

Year	1	2	3	4	5	6	7
Input **Wages @ 2500 Per Month**	30,000	30,000	30,000	30,000	5,000	5,000	5,000
Revenue **Discarded bamboo** **Sell of bamboo clumps** **bamboo biomass**	2000	2000	2000	2000	 60,000 15,000	 65,000 15,000	 70,000 15,000
Total Revenue	2000	2000	2000	2000	75,000	80,000	85,000
Earnings / Benefits	-28,000	-28,000	-28,000	-28,000	+70,000	+75,000	+80,000
Accumulated Earning / Loss	-28,000	-56,000	-84,000	-1,12,000	-42,000	+33,000	+1,13,000

Regeneration of bamboo would promote healthy growth of foliage. About 3-5 tons of biomass/ha is expected through regeneration of the project to meet the fodder needs of the livestock. With conservative estimate, 3 tons/ha of biomass would yield a revenue of Rs. 3000/ha. From 5 ha area, the biomass production would generate a revenue of Rs. 15000.The total revenue in the 5th year is worked out to be Rs.75000 from 5 ha area (Rs 60000 from sale of bamboo and Rs.15000 from biomass production).From the table it is clear that break even will be achieved in the sixth year when a profit of Rs.33,000 and in seventh year a substantial profit of Rs.1,13,000 from 5 ha area (Rs. 22600/ha/ year) can be expected to the Forest Department/ beneficiaries due to rehabilitation of degraded bamboo forest areas. The project is financially viable. The economic analysis based on 7 years project life and 12% discount rate was also carried out which gave a Net Present Value(NPV) of Rs. 28820 having Benefit Cost Ratio (B:C) of 1.28:1 and Internal Rate of Return (IRR) of 21.4%.The cost can be recovered within a period of 6 years.

Apart from rehabilitation of bamboo forests, employment generation and poverty reduction of poor tribal families, there are other benefits like increase in socio-economic conditions of the poor tribal families, control in degraded bamboo forests, control in land degradation, improvement in bio-diversity, ecological revival associated with immediate and long term livelihood opportunities and overall improvement in environment.

The technology can be applied in the similar topography, soils and climate conditions in Madhya Pradesh and other parts of India.



SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT IN SHIFTING CULTIVATION AREAS OF NAGALAND

Introduction

Shifting cultivation or Jhum cultivation in Nagaland is a complex phenomenon and there are variations from district to district and tribe to tribe. Jhum agriculture involves an intricate combination of land and labour management (or gainful employment) intertwined with strong cultural linkages. Land tenurial systems that differ across tribes and villages further intensify this complex set-up.

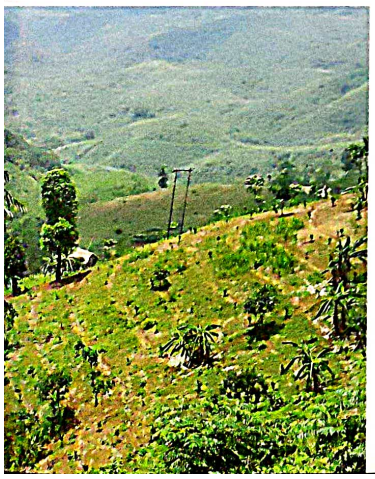
Jhuming may be considered to be one of the earliest attempts for cultivation. The system is not static and has continuously evolved in response to rising population and changes in land use practices. It includes land use strategies, devised and adopted by communities in response to specific ecological conditions, size and number of family members willing and able to work on the field as well as combination of cash and no-cash required or consumed. As per customary law of the state land ownership is rested on the Nagas and it cannot be sold/transferred to non-Nagas.

Households adopt varied land use strategies and the project has attempted to contribute to these land use strategies through an increasing set of options - individual households select specific interventions based on specific requirements of families.

As confirmed by the local people and many research studies, jhum cultivation is no longer productive and most agricultural lands have already reached their carrying capacity. Moreover, in most parts of Nagaland, members of a household working in jhum fields have reduced, unlike a few years earlier when families with large number of children added to the agricultural labour force. This is largely due to the increasing income options and other opportunities, such as

education, non-farm occupations, government services and other activities that require out-migration.

Traditionally, before the onset of the second year cropping, the villagers enter into the new jhum cycle for fresh slash and burn of the secondary forest for cultivation. Two jhum fields are managed at the same time by a farmer/household. The distant location of the second jhum land, intensive labour required to clear forests for new jhum cultivation, decline in soil fertility and lesser number of family members engaged in jhum, have dissuaded farmers from working in two different jhum lands. Traditionally, each household cultivates in the same jhum field for two years prior to leaving it fallow.The first year cropping is paddy combined with other agricultural crops, whereas the second year cropping is purely for paddy.The main crops grown in jhumfields range from 10-50 and most of these are mainly for household consumption. The surplus, if any, is sold in the local market. There are cases where jhum fields are abandoned after the first year, mainly due to labour constraints or decline in soil fertility.



SLEM in Nagaland

The SLEM project in Nagaland intends to bring out lessons for land use strategy which enables households to find gainful employment for their members and provide for cash and non-cash needs. Independent surveys have clearly established cash needs of rural households in independent India as a significant and growing consumption of the overall basket, in particular, spending on education, health care and travel.

The SLEM project attempts to achieve sustainable land management principles in 70 villages in three districts of Nagaland by addressing the complex mosaic of challenges posed by jhum agriculture. The project emphasizes the need for increased land productivity through soil fertility measures for higher yields, both in cultivated and fallow lands, to meet the demands of the rapidly growing population and to reduce pressure on natural and community forests.

The project goal aims to encourage a mix of land use through an integrated approach combining improved soil and water conservation measures as well as intensive organic farming in jhum lands through traditional and scientific methods. Livestock breeding is also carried out to diversify incomes under the sustainable agro-forestry concept.

In the integrated farming model most project beneficiaries manage one jhum land while engaging in the integrated farm development. Improved soil fertility and moisture retention has helped farmers to cultivate in the same plot of land for three years and the beneficiaries are hopeful of cultivating for a few more years, till the soil fertility declines. This improved jhum system has enriched soil moisture with qualitative improvement of crops grown in the contour bunds where top soil collects.

Currently the jhum cycle has reduced from 15-30 years to 7-9 years in the past few decades. More recently, the intensive energy and labour inputs to manage the jhum lands do not correspond with the yields that are now insufficient to meet a household's subsistence needs.

Sl. No.	Jhum Locality Name	Appx. Area (Ha)	Year 2004	Year 2005	Year 2006	Year 2007	Year 2008	Year 2009	Year 2010	Year 2011
1	Rhojong	120	C1	C2	F	F	F	F	F	F
2	Ngakhong	100	F	C1	C2	F	F	F	F	F
3	Nyaga	110	F	F	C1	C2	F	F	F	F
4	Okam	100	F	F	F	C1	C2	F	F	F
5	Longshom	100	F	F	F	F	C1	C2	F	F
6	Pongjhong	100	F	F	F	F	F	C1	C2	C3
7	Rapnyin	90	F		RESERVED			FOREST		
8	Chingin	100	F	F	F	F	F	F	F	C1

C1-First year cropping,C2-second year cropping,C3-third year cropping,F-fallow.

Case study of SheanghahTangten village in Mon district

SLEM is demonstrated in the case study of SheanghahTangten village in Mon district. This is applicable in most of the project villages that have adopted integrated farming concept.

In Sheanghatangten village, there are 7 Jhum cycles where the farmers cultivate in rotation. The demarcation of these Jhumcycles was done by the forefathers, and is an integral part of the village land-use plan. The Jhum cycle demarcation in the village shows that not even a single cycle could be encroached even if there is a shortage of land for cultivation in the allotted Jhum cycle. Each Jhum cycle is assigned different names depending on the topography and location as Pongjhong, Chingon, Rhojong, Ngakhong, Nyaga, Okam and Longshom. Till 2005 the village had 8 Jhum cycles. One Jhum cycle at Rhojong location has been set aside as Reserved Forest in 2005 by the Village Authority, reducing the jhum cycle to seven.

In all the Jhum cycles, the villagers do not cultivate the entire area earmarked for Jhum. About 20% of the total area remains intact during the jhum cycle cultivation. This is because all the households in the village have terrace fields. Moreover, some farmers do not cultivate because of non-cultivable land in the given Jhum cycle and others for shortage of labours. In the process, the uncultivated area has ample time for natural regeneration, 14 years in this case.

One Jhum field meant to be cultivated in 2010 has been set aside for Reserved Forest in 2005 by the village authority and the villagers have not slashed and burnt the secondary forest for cultivation in 2010 but continued for the third consecutive year in 2009 jhum cycle. The GEF-UNDP, SLEM project intervened in this Jhum in early 2011 where soil and water conservation measures and organic manures were given due importance. Cultivating the same Jhum field for three consecutive years is a new positive trend in the Jhum system practiced in this village.

The farmers are of the view that if this trend continues and the system of farming is well maintained, the Jhumcycle, which at present is 7 years, will eventually increase to 14 years. This will also give the soil sufficient time to regenerate, improving the productivity of the jhum lands and minimizing land degradation thus meeting the objectives of the project.

Azolla cultivation

Crop diversity in a Jhum plot

CLIMATE CHANGE ADAPTATION STRATEGIES

SRI: THE SYSTEM OF RICE INTENSIFICATION

Rice or paddy one of the most important staple food crops of India accounts for nearly 42.5% of the total food production on almost one quarter of the total cropped area. Of the total irrigated area, almost 23% is under paddy. The paddy production has consistently increased in India, especially over the last few decades. The upward trends started with the green revolution and the introduction of the high yielding varieties which are highly responsive to key inputs like fertilizers, agro-chemicals and most importantly irrigation water. However this has made the Indian agriculture especially the Rice cultivation highly dependent on large quantities of surface and ground water. It is estimated that under the modern methods of rice cultivation, the typical water requirement to produce one kilogram of rice is 3000-5000 litres (WWF/ICRISAT 2007).

Climate change is expected to aggravate stresses on natural systems, including hydrological systems and groundwater resources. In semi-arid regions in the country, rainfall is projected to be more erratic, with heavier precipitation events after longer periods of dry spells, resulting in reduced groundwater recharge and higher surface run-off. All of this is likely to pose new pressures on the already over-exploited resources like the groundwater and land. These challenges call for new technologies which help to increase water use efficiency in rice cultivation.

The system of rice intensification (SRI) offers a valuable option in this context. The practice essentially reduces water requirements in rice cultivation while at the same time increasing yields and reducing the need for input of seeds, chemical fertilizers and pesticides. These gains are due to the fact that biological process that is beneficial for the development of the plants and production of gains area stimulated and applied through improved management of plants, soil, water and nutrients. SRI therefore capitalizes in potentials for optimized symbiotic processes in plant roots and leaves. The main advantage of the practice is:

- Considerable ecological benefits
- Does not require large investments
- "Pro-poor technological innovation
- "Easy to implement of small and marginal land -holdings

Table: Comparison of SRI against conventional method practices

	Conventional Method	SRI method
Seed input	50-60 kg/ha	5 kg/ha
Transplanting of seedlings	After 25-35 days	After 8-12 days
Number of hills/m2	About 30-40 hills	About 16 hills (with 25 cm spacing)
Fertilization	Require application of chemical fertilizers, pesticides, herbicides and insecticides	Preferred application of organic fertilization, non-chemical weed management, pesticide & insecticides usually not required
Water management	Continuous Flooding	Moist conditions, no submergence requiredSource: WWF/ICRISAT, 2007

Source: *WWF/ICRISAT, 2007*

Methodology

SRI is not a fixed package of technical specifications, but a system of continuously evolving combinations of locally customized practices. They may include changes in nursery management, time of transplanting, change in planting, water and soil fertility management and weed control. A list of key cultural practices, combination of which can help achieve optimum results is recommended (WWF/ICRISAT 2007) as follows:

Land preparation

SRI requires careful leveling and raking of the land, so that the required moisture level is uniformly maintained. In order to facilitate drainage about 30 sm wide channels are made at two-meter intervals across the field.

Preparation of land for the SRI

Nurseries

As in the conventional rice plantation seeds are sown into the nutrient-rich nursery beds for transplantation. Nurseries are to be established as close as possible to the main field to minimize time and transportation cost of the seedlings.

Technique of transplantation:

The seedlings are to be transplanted singly with their roots intact, and the seed sac attached, and are to be place at a depth of 102 cms from the surface. In the conventional system, three or more seedlings are planted per hill.

Timing of transplantation

Under the SRI practice transplantation takes place when the seedlings are just 8-12 days old, ie soon after they have two leaves, and at least before the 15th day after the sowing. Under the conventional system the seedlings are kept in the nurseries for 25-35 days.

Prepaprtion of Seedlings in the nursery

Precise and wider spacing helps in better growth

Spacing between seedlings

The seedlings are place at precise spacing, usually 25X25 cms (optimum spacing depands on soil fertility and for very fertile soil it can be 50x50 cms). Spacing is important since rice plants roots and canopies grow better if spaced widely due to better exposure to sunlight, air and nutrients. Accurate spacing also enables the application of mechanical weeder.

Accurate spacing enables the application of mechanical weeder.

Table: Input costs, proceeds and profit from SRI and conventional rice cultivation (per ha)

		SRI Practice	Conventional practice
Input costs	Land preparation	Rs. 5,113	Rs. 5153
	seeds	Rs. 126	Rs. 1,291
	Organic fertlizers	Rs. 6,000	Rs. 3,863
	Chemical fertilizers	Rs. 3,764	Rs. 4,117
	Pest and disease management	Rs. 671	Rs. 914
	Weed management (including hired labour)	Rs. 2,582	Rs. 2,418
	Harvesting	Rs, 4, 382	Rs. 3,826
	TOTAL COST	**Rs. 22,637**	**Rs. 21,538**
yield	5.241 tons	4.25 tons	
Sale proceeds (Rs 5850 per ton of rice)		Rs. 30,660	Rs. 24,863
Profit		Rs. 8,023	Rs. 3,325

Source: *Adapted from Climate change Vulnerability and adaptation experiences from Rajasthan and Andhra Pradesh, SRI Case study, AFPRO (Based on Primary data collected by AFPRO, Hyderabad for Kothus, Sriranagapur and Mehbubnagar districts of Andhra Pradesh)*

Soil Nutrients

Under the SRI system it is preferable to apply compost or farmyard manure instead of synthetic fertilizers.

Watering

SRI requires the root zone to be kept moist, not submerged. Water applications can be intermittent, leaving plant roots with sufficiency rather than surfeit of water. This encourages extensive healthy root systems which support water and nutrient uptake and avoid root degeneration.

Weed Management

In the conventional rice cultivation method, continuous submergence of rice plants prevents emergence of weeds. Therefore under the SRI careful and frequent weeding is required. Precise spacing facilitates application of the mahual weeder in both directions between hills within 10-12 days of transplantation and after every 10-12 days thereafter. This not only prevents weeds, but also churns the soil for better growth.

A comparison of Input costs, proceeds and profit from SRI and conventional rice cultivation shows an improvement in returns under the SRI system.

Bumper Crop under the SRI practice

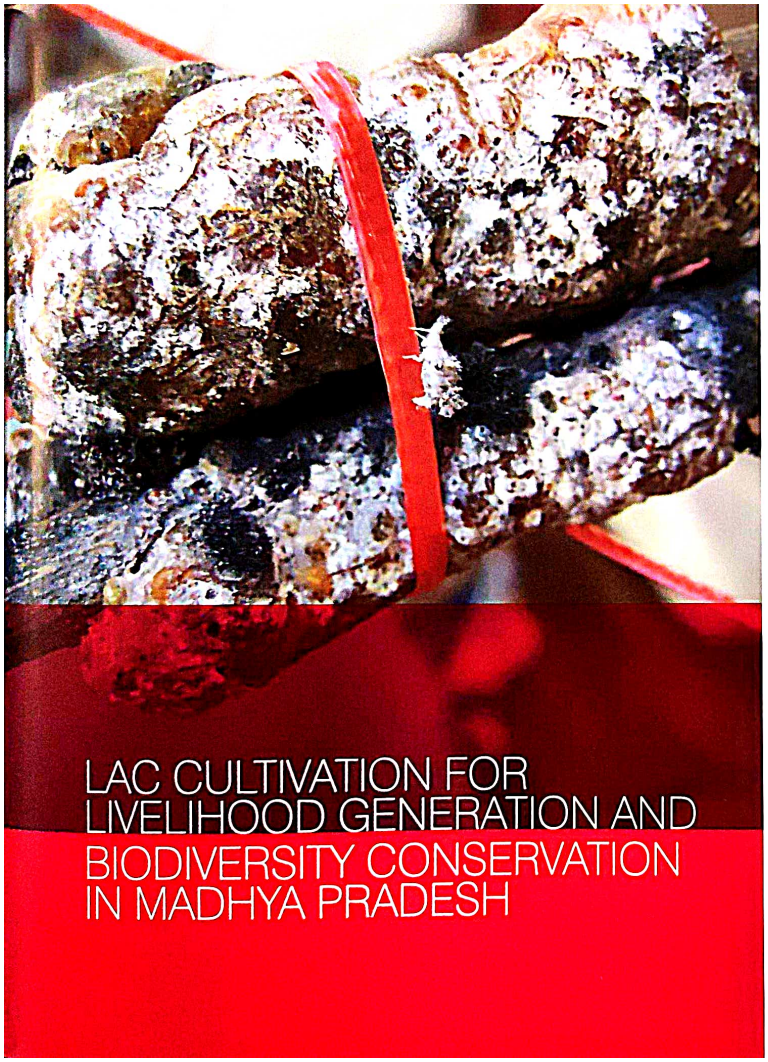
Application of the SRI practice across the country:

Over the past 15 years the SRI practice as been systematically documented under various projects and programmes in various states of India. The following table provides an overview of the results measures under various pilot projects and field trials all over the country. Results show an overall significant yield advantage of SRI as compared to the conventional rice cultivation methods, reduced water requirements and seeds inputs.

Table: Results of SRI compared to conventional methods from different States in India

Study area	Seed input	Water requirement	Yield increase	Source
Andhra Pradesh	90% reduction in input	50% reduction in water requirement	2 t/ha, 1e 20% yield increase as compared to conventional method	WWF- Dialogue Bulletion, Issue No15, 2005
Tamil Nadu	53% reduction in water		3.9 t/ha, 1e 28% yield increase as compared to conventional method	India Development Gateway
West Bengal	90% reduction in input		6.282 kg/ha 1e 20% yield increase as compared to conventional method	S Kumar Sinha and J Talati, 2007
Gujrat		46% reduction in water requirement	No yield increase	
Tripura		90% reduction in input	For high- yielding varieties : SRI yields ranging from 4.6-8.5 t/ha, as opposed to 2.5-5.2 t/ha under the conventional method	WWF-ICRISAT Project, 2007
Punjab	60% reduction in input and treatment expenditure	14 times irrigation under SRI compared to 26 times under conventional methods	2.1 t/ha, 1e 27% yield increase as compared to conventional method	WWF-ICRISAT Project, 2007
HimachalPradesh			2.4 t/ha, 1e 82% yield increase as compared to conventional method	WWF-ICRISAT Project, 2007
Uttrakhand			2.7 t/ha, 1e 96% yield increase as compared to conventional method	WWF-ICRISAT Project, 2007

Source: *Adapted from Climate change Vulnerability and adaptation experiences from Rajasthan and Andhra Pradesh, SRI Case study, AFPRO*



LAC CULTIVATION FOR LIVELIHOOD GENERATION AND BIODIVERSITY CONSERVATION IN MADHYA PRADESH

Beneficial insects like lac secreting ones (*Kerria lacca*) are important components of forest ecosystem since they thrives on the tender twigs of specific host tress viz., Palash (*Butera monosperma*), Ber (*Zizyphus mauritiana*), Kusum (*Scheichera oleosa*), *Flemingia semialata*, *Ficus* spp. etc. Raw lac is the source of three valuable, natural and renewable products i.e. resin, dye and wax. Lac cultivation is an important source of livelihood for forest dependent communities in different states of India. Largely lac cultivation is practiced in states including Jharkhand, Chhattisgarh, Madhya Pradesh, West Bengal, Uttar Pradesh, Orissa, Maharashtra, Gujarat and NEH region. It is a highly remunerative crop that pays good economic returns to the farmers and also generates foreign exchange for the country though exports. As per an estimate by Indian Lac Research Institute (2009) the total stick lac production in India is approximately 20-22 thousand tonnes which form the raw material for lac based industries, which includes handicraft and other small scale industries providing livelihood for local communities of India. During 2009-10 above 6 thousand tonnes with a value of INR 110 crores was exported to different countries from India. Because of degradation of forests and indiscriminate cutting of lac host trees for social and industrial activities the area under lac cultivation is gradually shrinking. To overcome this situation and to support the local livelihoods in the SLEM project areas of Madhya Pradesh, the Forest Department has supported the lac cultivation activity by planting more lac host trees and by encouraging the locals to choose lac cultivation as livelihood option which can fetch fairly good amount of income. The lac is produced by an insect, which gets its nourishment from host plants.

Cultivation of lac not only provides livelihood to the communities, but also aids to the conservation of forests and biodiversity associated with lac insect complex. The lac insect falls under complex multi-trophic web of flora and fauna. There are 87 species representing nine genera distributed globally. India is represented by 19 species belonging to Kerria and Paratachardina. In India two stains of lac insects are recognised, the Rangeeni and Kusumi. Lac insects are dependent on over 300 economically and medicinally plant species usually occurring in forest areas. Twenty two species of lac predators, 30 species of primary and 45 species of secondary parasites, besides several fungal pathogens have been reported to represent a rich diversity (Sharma et al 2006). The insect fauna associated with lac insects are species-specific and therefore, loss of even one species of lac insect poses a danger of losing many other related species. From the point of view of biodiversity, several lac insects and associated fauna have become threatened with extinction where lac cultivation has been abandoned or habitat lost. lac cultivation in the state of Madhya Pradesh does not only check degradation of forest and land but also conserve associated flora and fauna.

Lac cultivation in the West Chhindwara Forest Division in district Chhindwara of Madhya Pradesh is being done in 30 ha area of Pagara in Parasia range of the forest division. The cultivation is carried out by the Vasundhara Self Help Group (SHG). The SHG has 12 members with Mr. Rata Lal Yadav as President and Mrs. Indra Bai as Vice President. In July 2010, 1.0 Quintal and in November 2010, 75 kg of brood lac was raised on as many as 425 and 325 trees of Palash (*Butea monosperma*). There was an income of Rs 6545 to the society from the sale of 77 kg of brood lac to the village committees (Van Samitis) of adjoining Sanwari Forest Range. Palash trees are lopped during the months of February- March. The brood lac is implanted on fresh coppice shoot during July and October. The lac is produced and spreads widely within seven days of the emergence of the insect. The SHG earned Rs 13000 through the sale of lac to the Obedullaganj forest range.

Reintroduction of Lac Cultivation And Steps Merit Immediate Actions for Long Term Sustainability

Reintroduction of lac cultivation in lac abandoned forest areas is difficult due to the fact that the broodlac cannot be stored for over a week and have low multiplication rate of production, (one kilogram of broodlac yields between 3-7 kilogram of lac), lack of open/organized market for the lac growers, no control measures against the damage by diseases and pests, lacunae in the knowledge of characterization, documentation and conservation of lac insects.

From the point of view of biodiversity studies on lac fauna, following actions are immediately required:

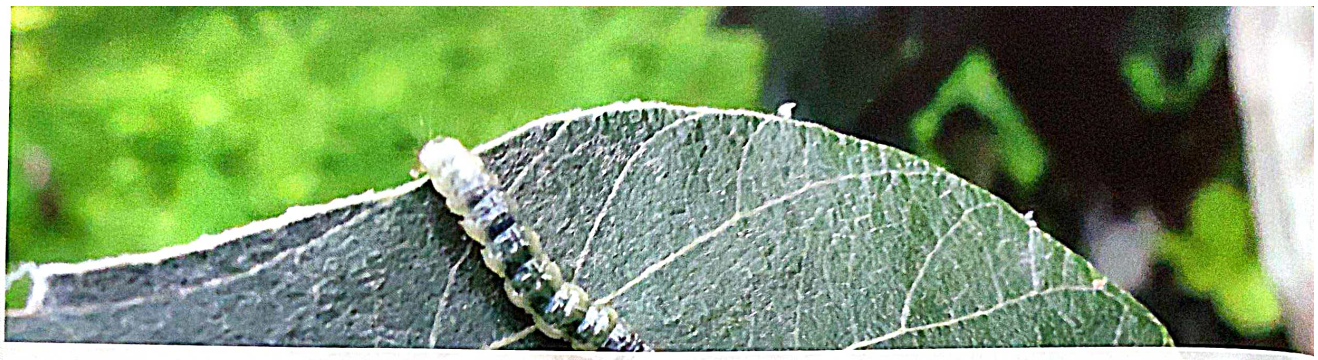
1. Field surveys for present status of the lac insects and their plant hosts.
2. Need to address the gap in the knowledge of the infra-specific genetic diversity of economic value;
3. Need for in situ and ex situ conservation of lac insects
4. Building an infrastructure to develop field repository/germplasm bank representing the lac insects and host plants in the state.

These activities aim at promoting the community-driven sustainable land and ecosystem management at the landscape level through integration of watershed management, joint forest management, and sustainable livelihoods development, so as to balance ecological and livelihood needs. The practices on the components of lac can be duly standardized, monitored and evaluated, validated and documented and fed into SLEM Coordination and Management Mechanism established at national level.

Importance of Lac Cultivation

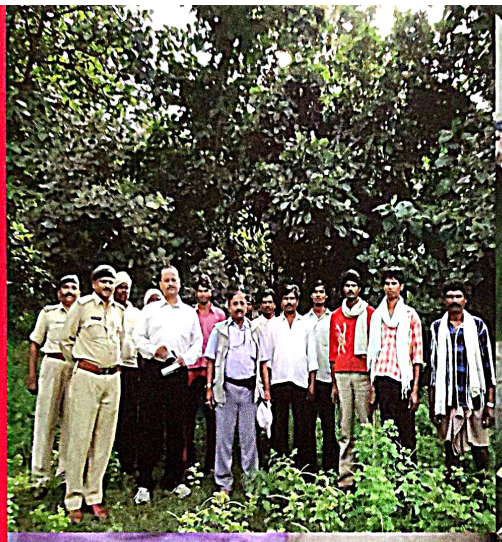
Lac cultivation has some unique advantages, especially for rural communities inhabiting in forest fringe, some of the major benefits related to the lac cultivation are as:

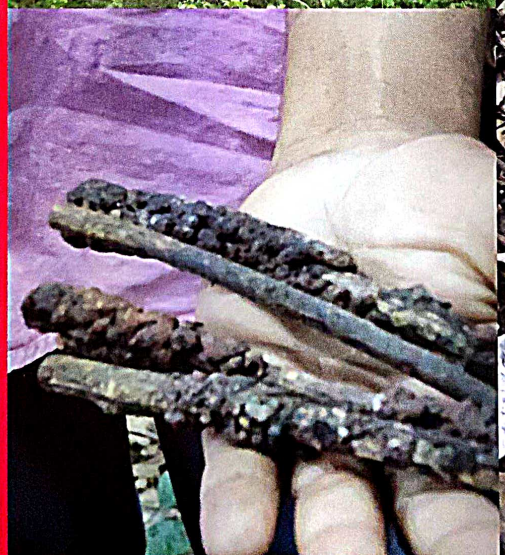
- Lac cultivation is a good source of livelihood of resource poor farmers, tribals inhabiting forest fringe area with meagre investment.
- It is good crop for marginal and degraded lands where cultivation of agricultural or horticultural crops is difficult.
- Highly remunerative cultivation.
- It provides livelihood generation opportunity for growers during drought years when other crops don't survive due to water scarcity.
- Lac cultivation involves significant women participation providing and helps ecosystem development.
- Due to its commercial application lac has high export potential. About 75% of the total lac production in India is exported.
- Lac based diversified farming system can increase productivity and profitability.



Potential of up Scaling Lac Cultivation In India

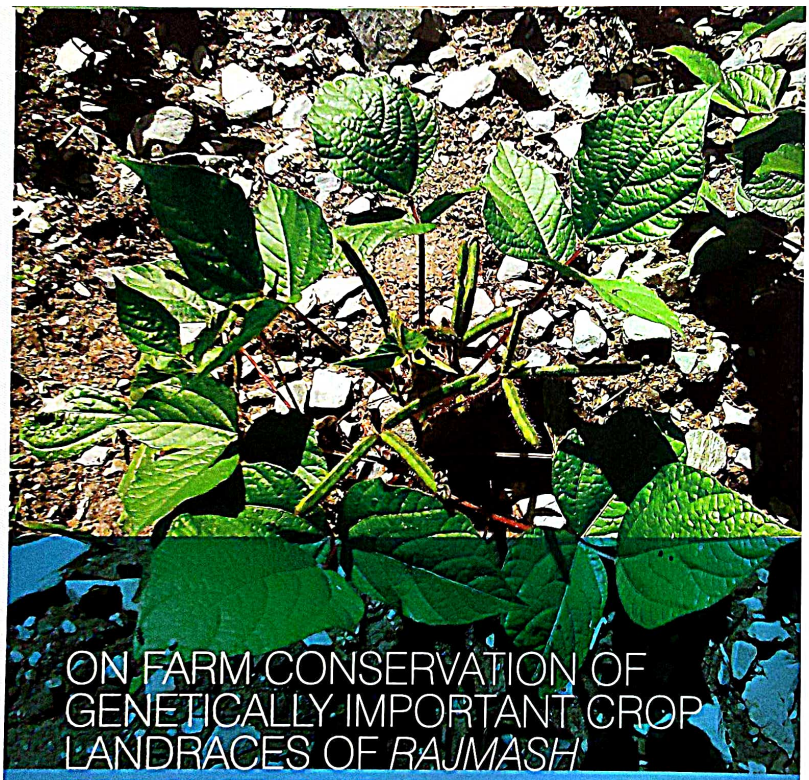
India has great potential for lac cultivation and is the principal lac producing country of the world. There are regular lac cultivation areas in India which are using around 20-25% of the total available lac host trees for production on the other hand there are many areas where lac host trees are present but not used for lac cultivation because of the lack of knowledge and awareness. There are vast unexploited areas for lac cultivation, which are ecologically favorable for lac production where scientifically robust lac cultivation practices can be taken up for up-scaling, livelihood generation and to cater the growing demand of raw lac. These areas are located in different states of the country such as Madhya Pradesh, Chhattisgarh, Jharkhand, Orissa, Maharashtra, Gujarat, and NEH region etc and these states are the part of hot semi-arid ecoregion, hot sub-humid ecoregion, hot sub-humid (moist), warm per-humid ecoregion.





Lac cultivation in West & South Chhindwara Forest Divisions (Pagara and Aambara- Borpani), Madhya Pradesh, 2010-2011

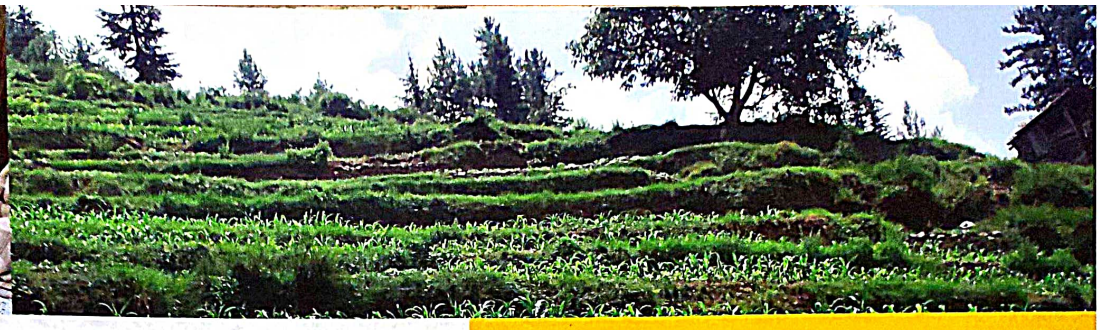
- Brood Lac in inset picture with communities involved amidst natural stands of Palash (*Butea monosperma*) trees
- Twigs of tree with fresh growth of Lac
- Colour indication of matured Lac for harvesting
- Implements used for Lac cultivation, rearing and care



ON FARM CONSERVATION OF GENETICALLY IMPORTANT CROP LANDRACES OF *RAJMASH* FOR SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT IN CHAMBA DISTRICT OF HIMACHAL PRADESH

People living in the rural areas of the Himalayas utilize variety of natural resources for their livelihood. The majority of them are largely dependent on animal husbandry and marginal agriculture for income generation. The importance of crop germplasm found in landraces is well established, and a comprehensive international program exists to conserve this resource ex-situ in gene banks and botanical gardens. Landraces are still cultivated in regions of crop domestication and diversity. In-situ maintenance has been neglected by genetic resource conservation programs in part because of misconceptions about farming systems that produce landraces.

In India crop diversity is well represented in the form of cultivars, landraces or as folk varieties which are distributed in different phyto-geographical regions of our country among diverse crops/ crop-groups. The western Himalayan landscape is known to hold rich diversity in and among the crops such as wheat, sesamum, maize, amaranth, field peas, rice, kindney beans, medicinal and aromatic plants. The Agro climatic zone (National Agriculture Research Project) of Chamba valley is Mid hills sub-humid (HP-2) having mild temperate climate with extreme cold in winter with heavy precipitation in the form of snow. The Chamba district lies in the warm subhumid (to humid with inclusion of prehumid) eco-region (14.2) and the dominant soil types of the region are brown hill (brown forest shallow to moderately deep gravelly sandy loam to sandy clay loam soils), humus and iron podzols and alpine humus mountain skeletal soils.



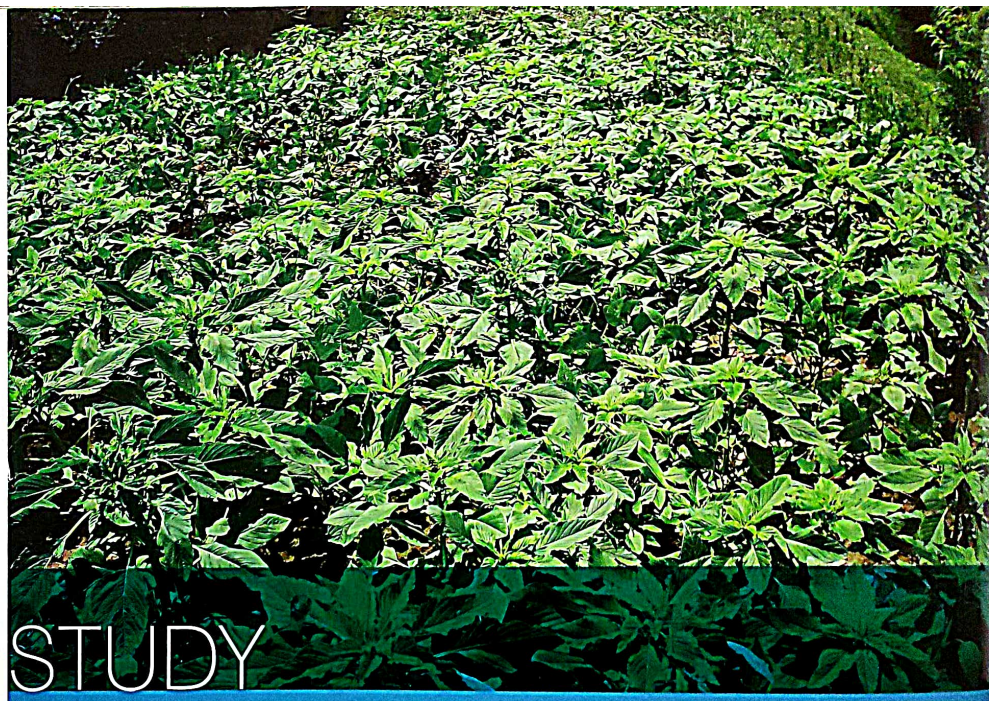
Importance of Landraces

Landraces have originated together with agriculture and horticulture, during the past 10000 years or so. Hence, landraces of many crops have probably been grown for several millennia. Although landraces are commonly considered as endemic to a particular region, they have always been moved over short or even long distance, and thus brought into competition with autochthonous landraces if present. They may disappear, or they may replace these autochthonous landraces or more likely, they may together form a new landrace. These adaptations have taken place by changing the frequencies of phenotypes and hence genotypes for self-fertilizing and vegetative propagated crops, and by absorbing new genotypes either introduced from elsewhere or else which have originated by mutation or by a low degree of interplant hybridization.

Depending on the economic importance of a crop, the degree of the national and local breeding efforts and the introduction of exotic cultivars, landraces will disappear sooner or later. The yield stability of landraces under traditional low input agricultural systems is due to the fact that whatever the varying biotic and abiotic stress for each plant, one or more genotypes within the landrace population will yield satisfactorily. Landraces were and still are grown by farmers all over the world for this reason.

On farm cultivation of important landrace of *Rajmash* in Chamba district

In order to check the over exploitation of useful plant species, the locals worship many ethnobotanically important plant species and their immediate environment. The geographic isolation has preserved the indigenous practices and traditional knowledge of people living in Himalayan region. The indigenous agricultural systems of Himalayan region sustain a large number of landraces, their crop diversity and cultivars. Historically the locals were using such plant resources sustainably for food and agriculture sustenance. However, today the use of such plant crops or landraces has been reduced considerably, which is leading to disappearance of important genetic resource and consequently leading to improvisation in diets of local peoples.



CASE STUDY

The kidney bean (*Phaseolous vlugaris*) locally known as *Rajmash* in Bharmaour, Salooni and Bhaderwah track of Chamba - Doda region is known for its cooking quality, taste, and attractive red colour and nutritional contents (Table 1). Keeping in view the speciality of Chamba *Rajmash*, *Rajmash* Growers Association has been formed and data is being complied to file application with PPV & FRA and also with Geographical Indications. The production and productivity of this speciality crop is low due to traditional farm particles such as sowing through broad casting method, no staking in the sole crops, intercropping with maize, use of mature and immature seeds for sowing etc. Keeping in view the importance of *Rajmash* to the tribal people and region of Chamba, the crop was selected for improvement of yield and to increase economic viability of the crop under the project tilted, ***"Harmonizing biodiversity conservation and agricultural intensification through integration of plant, animal and fish genetic resources for livelihood security"***

Table 1. Nutrition contents of *Rajmash* landraces collected from Chamba and Kangra

Location	Iron (mg/g)	Zn (mg/g)	Na (meq/l)	K (meq/l)
Sanghnee (Chamba)	0.081	0.029	20	127
Bir (Kangra)	0.030	0.012	15	73
Kugti (Chamba)	0.092	0.029	23	134
Bharmour (Chamba)	0.105	0.025	23	133

Fig. 2 a, b
Traditional way of Amaranth and Rajmash Cultivation in the landscape

Traditional farm practices used by the farmers

The targeted landraces were both bush and pole type, which need proper isolation and staking of plants grown in pure/ sole crop. Therefore, majonty of the farmers were growing it as an inter crop primarily with maize. Some farmers were growing it as pure crops without any staking, thus resulting into heavy yield losses and also poor quality seed (Fig.2a,b).

The seed for sowing was usually selected from the missed lot, generally kept for consumption as sale. This bulk seed lot has many immature seeds harvested due to asynchronous maturity of the crop resulting in to poor germination and were therefore sown in double the required quantity.

Line sowing, proper spacing, weeding etc, were almost absent from the practices used by the farmers.

The seeds were harvested in bulk and stored as such in gunny bags without proper seed grading and packaging.

Fig.3
a. *Rajmash Grown with maize damaged by black bear*

b. *Ramjash crop grown with Amaranth not damaged by black bear*

Fig.4
a. *Staking of Rajmash enhances yield and quality*

b. *Intercropping of Rajmash with Amaranth*

Use of inter cropping and stakes for Pole type varieties

The Pole type varieties were demonstrated to the farmers of the regions. The grain amaranth + *Rajmash* were demonstrated at Bharmour and maize + *Rajmash* were demonstrated at Salooni and also a pure crop where wooden stakes were used was also demonstrated to Salooni farm. In total five and 11 number of trials were conducted for such varieties at Salooni and Bharmour, respectively. The yield gain of 20-25% in case of *Rajmash*, 15-20% in maize and more than 100% was obtained in grain amaranth. The average yield of sole crops of *Rajmash* in farm trials at Salooni and Shimla was 17 and 19 q/ha, (against 9 to 10 q/ha in normal varieties) respectively, indicating the potential of best practices.

We found that the maize grown with Rajmash is attracting black bear which is causing damage to *Rajmash* by breaking plants (Fig.3.a). To stop crop damage by black bear, grain amaranth which is not eaten by black bear and also given better economic returns, was used for intercropping with *Rajmash* (Fig.3b). Three varieties of grain amaranth viz. Annapurna, Durga and VL 44 along with local germplasm were tried (Fig.4a,b). Further staking avoided the losses occurring due to rooting of those pods and seeds touching the soil, and also improved the quality of seed both in terms of size and colour.

Fig.5 *Field tails and comparative performance of Rajmash crop trails*

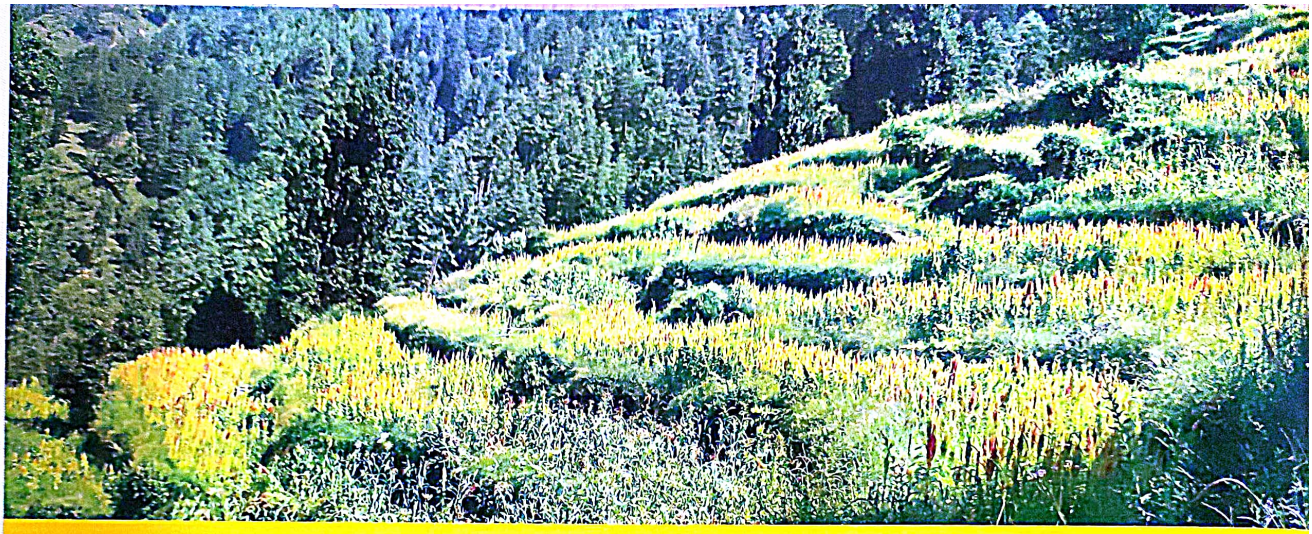
Demonstration through field trails

Comparative field trials were carried out in the farmers' fields to give the feel of best practices adopted (Fig. 5). Demonstration was given for raising pure crop of *Rajmash* using line sowing, making use of healthy seeds and timely time weeding and other operations. The data were recorded on yield and other related traits. There was significant increase in the seed yield / ha (Table 2) and also quality of seed.

Table.2. Impact of interventions on economic status of farmers (2012)

	Rajmash +Amaranth intercropping
Area (ha) under cultivation	3.2
Farmers (No)	27
Productivity (q/ha) Before interventions	9 q/ha
After interventions	11 q/ha
Total production (q) after interventions	35.2
Income generated before interventions	58500 @ Rs 65/Kg
Increase (Rs/ha) after interventions	71500@ Rs 65/ kg
Net economic gain	Rs 13000 / ha
The cost of *Rajmash* also increased from Re Rs 65/Kg to Rs 80/kg due to grandling ad packaging	88000 @ Rs 80/kg 29500 / ha (Gain)

(Source: Seed technology division, HPKVV, Palampur)



A view of Rajmash crop on the hill slopes of Bharmour, Chamba.

Local communities participating in farmers integration meeting at Bharmour, Chamba

Value Addiction Through Grading And Packaging

Farmers were selling their produce as general harvest to local traders, fetching meager rates. Farmers were trained to clean their produce properly, grade for uniform size and pack in attractive packaging (Fig.6). It has resulted in 30-40% increase in price i.e. from Rs. 50-55 to Rs. 80-90/kg at farmer's field and even more when sold in the down town market of Chamba or elsewhere in cities like Pathankot, Chandigarh and Delhi.

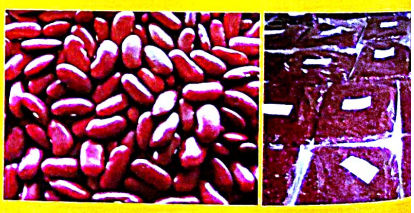


Fig.6. *Color and Size of the seeds obtained using the best practice*

AGRO-BIODIVERSITY INNOVATIONS FOR SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT IN ORISSA

The state of Orissa occupies 4.7 % of India's total geographical area. Nearly 4.8% of country's livestock and 3.58 % of human population inhabits the State. The State enjoys 1451 mm annual rainfall and the climate is congenial for the cultivation of diverse array of crops. The state spread over 10 agro-climatic zones contains two hot spots (Koraput and Mayurbhanj) and three Biosphere Reserves (Bhitarakanika, Semilipal and Chilika). The state has varied and wide spread forests harbouring dry deciduous, moist deciduous forests as well as mangroves with several unique, endemic, rare and endangered floral and faunal species. Approximately 37% of the State's area is classified as forest and Protected Area (PA) network that comprises two national parks and 18 sanctuaries. Orissa is one of the richest biodiversity regions in Southeast Asia. Many threatened taxas of wildlife (Appendix-I) as per IUCN Red Data Book/Schedule-I of Wildlife Act, (1972) are reported to be distributed in the diverse forested habitats of the state. The faunal diversity of the state is represented by 19 species of amphibians, 110 species of reptiles, 475 of birds, and 22 of mammals. Orissa has the distinction of possessing about 10,000 to 15,000 traditional rice varieties out of 45,000 to 50,000 found in the world. The non-domesticated rice species found in Orissa are Oryza officinalis, Oryza granulala, Oryza rufipogon, Oryza nivara and Oryza sativa f. spontanea. The biodiversity of the state is under huge threat from a plethora of largely inter-related pressures that are likely to continue to increase because current levels of resource use and disturbance are unsustainable.

The state has suffered from frequent natural calamities (35 times in 45 years). The soils of Orissa are mainly formed by the parent material, relief and climate and are classified unto eight broad groups. Mostly the soils are red lateritic and acidic in nature. The problem soils of Orissa are grouped into three classes, viz., 1). Upland, less fertile and less water retentive acidic soils; 2). Low-land soils posing iron toxicity problems; and 3). Coastal salt affected soils. The problem soils in Orissa (lakh hectare area) are as following:

The information of this study is based on the review of published literature and the field visits carried out during 2012 under the SLEM- CPP selected state of Orissa for studying different activities in the district of Ganjam, under World Bank- GEF funded NAIP (National Agriculture Innovation Project), Comp. III - Sustainable Rural Livelihood Security (SRLS), sub-project (Strategies to enhance adaptive capacity to climate change in vulnerable regions).

Problem soils of Orrisa (in lakh ha.)	
Soil acidity	40.0
Soil erosion	26.0
Soil salinity	4.0
Water logging	3.0

Picture showing primates in crop land a type of man-animal conflict

Climate change adaptation and traditional knowledge

The climate change adaptation project of Indian Council of Agricultural Research (ICAR) on Sustainable Rural Livelihood Security (SRLS) funded by World Bank- GEF focuses on "Strategies to enhance adaptive capacity to climate change in vulnerable regions". The activities of the project cover identification of indigenous traditional knowledge systems (ITKs) for mitigating the recent and future risks to livelihood and to develop community based flood preparedness plan and implementation of livelihood based designed intervention.

Indigenous and traditional agricultural communities depend on, and are custodians of, agro-biodiversity maintained within agricultural landscapes. The local communities are coping with an increasing number of interlinked stresses related to different aspects of climate change, rapidly increasing population, insecure and changing land ownership, land degradation, and inappropriate policy interventions. The climate change is a major concern and demands dynamic adaptation and coping strategies, since it presents new challenges for the management of the land and agro-ecosystems.

Indigenous and traditional agricultural communities are adapting to change and are developing ways of strengthening the resilience of agricultural landscapes through various local strategies based on the protection of traditional knowledge and agro-biodiversity. The approaches being adopted include the use of centuries' old traditional practices and their adaptation to changing conditions, as well as the development and adoption of new approaches.

Indigenous traditional knowledge systems (ITKs) identified under the projected activities are:

- Use of flood resistant local rice varieties. namely Maipala, Ratanchudi, Baimundi etc. The varities of Varsadhan typically growing taller with the inundated flood water sustains submergence over 20 % compared to other varieties.
- Spraying cow dung slurry and applying karada leaves against diseases and pests in rice after flood. Pyra raised crop in certain localities are adversely affected by the invasion of Black capped langoor and Monkeys leading to the detriment of the agricultural innovation.
- Pyra cropping of pulses and crop diversification with pulses and oilseeds.

The ability of the humans to influence the resilience of the system is referred to as their adaptive capacity (or adaptability). The material within the agro-ecosystem, including species complexes, soil biota and traditional varieties, which can also possess greater adaptability and capacity to evolve and change in the face of changes in temperature, rainfall or other environmental changes. There are several traditional varieties of rice which can be grown in the drought, flood-hit area and other degraded areas to ensure food security.

- The most common flood tolerant varieties of rice are Dhullaputia and Varsha dhaan. Other varieties like Koraput or kalimoori have irritating spikes to keep off the cattle. Traditional rice variety of Bihar, Besariya is reported to survive inundated waters by growing 24 cm per day.
- The Goda variety of rice in the state of Jharkhand survives drought like condition. The short ripening duration of two months make it adaptive for the areas with heavy water run-off, whereas well-known varieties take nearly 90 days.

Spikes and Stakes of Varsha variety of rice grown in flood-submerged land of Ganjam District

The study depicted climate change vulnerability in Ganjam and Rangeilunda blocks of Ganjam district in Orissa which was experienced in four clusters:

- **Cluster I (Poirasi) :** Barapali, Bhuanbuin, Kanthiapali & B. Kainhapur.
- **Cluster II (Khandadeuli) :** Karthikadhi, Santoshpur, K. Ramachandrapur & Udspur.
- **Cluster III (Ganju) :** Burikudi, Phulta, Kulthigaon & Lodigaon.
- **Cluster IV (Beranda) :** Tulu, Belakudi, Chhelia, Panapalli & Indrakhi

The clusters no. 1 and 2 have flash flood which occurs 4-5 times a year, 4-10 days duration with 1-1.5 m depth of water. The turbid water with high current spreads over the kharif season. This submergence remains 1.5-2 m depth from August to October. In cluster no.3 and 4 the submergence of 1.5 to 2 m is reported. The period of deep water rice in some of the sites remains between 150- 160 days. The pyra pulse is rainfed at the onset of summer with chilli, pulses and irrigated vegetables.

The areas visited in Ganjam district have recurring drought, floods, and other natural calamity making the communities extremely vulnerable. The following points are suggested to mitigate the impact of calamities:

1. Late sowing of crop and use of resistant varieties duly supported by research and development (development of new crop calendar)
2. Traditional methods of water harvesting should be given importance.
3. The feed requirement for livestock and seed for farming community needs attention.

Flood tolerant rice diversity of Orissa

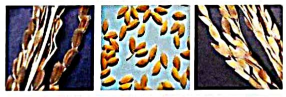
Among the four major categories of rice worldwide, namely indica, glutinous, aromatic and japonica, indica rice varieties have ability to survive submergence in flood water. Coastal Orissa has floods as regular feature with network of rivers inundating large parts of its catchment areas, disrupting livelihoods and shelter. Such recurrent floods also results into the problems of sediment deposition.

Variety/Accessions	Maturity period
Jamainadu	150 days
Kalameghi	150 days
Panidubi	150 days
Panirohi	150 days
Rabana	150 days
Seulapuni	150 days

(As per the accession of PPBSA-Navdanya, Ratanpura, Orissa)

Salt Tolerant Rice Diversity of Orissa

Salt tolerance among the rice variety cultivated in saline affected coastal belt of Orissa has developed over a long period after introduction in Orissa. The salt tolerant land races of the rice produce 34 to 54 tillers by the System of Rice Intensification (SRI) method of rice cultivation.



Variety/Accessions	Maturity period
Bhaliki	145 days
Bhundi	135 days
Dudheswar	130 days
Kalambank	135 days
Lunabakada	150 days
Sankarchin (Aromatic)	150 days

***(Source :** Prakruti Paramparik Bihana Sangharakshana Abhijan (PPBSA)*

National Agriculture Innovation Project (NAIP) Interventions

The intervention under National Agriculture Innovation Project (NAIP) results into following features of significance: -

- Ten varieties of paddy, namely Varshdhan, Swarna Sub 1, Swarna, durga, CR1014, Lunishree, Savitri, Reeta, Kanchan and Lalat were supplied to the farmers during Kharif season of the year 2011.
- Central Rice Research Institute (CRRI), Cuttack supplies improved strains of poultry, Vanaraj to 21 farmers in 5 villages (marginal and landless laborers) for enhancing income to reduce migration and today, the locals are generating INR 1500 per farmer from these poultry birds.
- The introduction of rice hybrids such as Ajay and Rajalaxmi in fallow lands was useful and leading to additional production of 4.5 to 6.7 tons of rice per hectare, to the rabi season which is significant.
- Introduction of improved varieties of tomato, (Utkal Kumari) and chilli (Utakal Rasmi) show an increase in production by 31.5 and 46.1 percent respectively.
- With a view to manage risk through crop diversification in rabi season and to reduce migration of drought/ flood stricken farmers, CRRI is aiming at the short duration and temperature tolerant rice varieties and hybrid maize in dry season introduced short duration rice variety Satabdi, Naveen and moisture stress tolerant varieties. Apo and Sabhagi dhan with a production of 3.65 tons in Apo to 5.5 tons per hectare in Naveen. Introduction of improved hybrid maize (SMH 36) produced on an average 5 tons per hectare.
- Tissue culture banana saplings provided to the farmers were introduced to the bund periphery of the fish ponds along with inter-planting of Citrus, Neem and Marigold for flowers. Among the promising varieties in order to develop strategies to enhance adaptive capacity to climate change in vulnerable regions of Orissa cv. TMV2 of Groundnut, cv. TARM 1, Meha, Durga, cv. PU 31, TU 94-2, Ujala, Prasad, cv. Adarsha of Field Pea, cv. Anuradaha of Mustard, cv. Urmi of Horsegram, cv. Bhairabi of Fingermillet and Paddy cv. Khandagiri were supplied during the rabi season 2011-2012.
- The varietal substitution of rice by as many as 11 varieties shown significant increase in the production as well as quality:-
  1. Varsadhan sustained better submergence by 21% higher
  2. Swarna Sub 1 performed better than Swarna proper by 16 % higher
  3. CR 1014 is preferred by farmers for quality
- Rice in fallow land the performance of rabi crops against the interventions was noted as below:
  1. Cultivar (cv) Samrat of Greengram showed 36% higher yield (3.4 quintal/ha) against 5.6 quintal of seeds provided to 140 farmers
  2. Cultivar (cv) TMV2 of Groundnut yielded 58% higher (19 quintal/ha) against 12 quintals of seeds supplied to 40 farmers
  3. Cultivar (cv) Hyb. MSFH 8 of Sunflower yielded 12 quintal/ha against the supply of 10 kg of seeds to 5 farmers

Ancillary enterprises in Ganjam block of Ganjam district

Among the ancillary enterprises, mushroom (dingri and oyster types), Kiya flower collection and scent extraction, apiary, and pisciculture are most preferred by the communities in flood and drought stricken lands.

Following ancillary enterprises were observed as prominent in Ganjam district:

Mushroom Growing

Under Sustainable Rural Livelihood Security (SRLS) project the demonstration units of 100 bed capacity (0.5 kg per bed) showing mushroom production were developed. As many as 80 farmers were provided 220 paddy straw mushroom spawn bottles. The mushroom cultivation mainly aims at popularization of technology on paddy straw and oyster mushroom cultivation during different seasons, utilization of agro-waste like paddy straw and use of SMS (Spent Mushroom Substrate) for vermi-compost.

Pisciculture

Today under the project implementation areas, 6 community ponds covering 8.4 ha area are producing a harvest of 2 tons fishes per hectare after the release of 1.32 lakh fish/fingerlings which are providing livelihood to the local communities.

A study conducted by Orissa University of Agriculture and Technology revealed that the incorporation of 2% Aqua Mos with fish feed results in maximum growth of Catla, while at 4% the growth is maximum in Rohu and Mrigal. The survival rate at 2% Aqua Mos incorporation reported was 98.33 % for Catla and Mrigal, and 96.66% for Rohu fish.

Apiary (Bee Keeping)

It involves introduction of Apis cerana indica, installation of beehives in different clusters of farming families, seasonal management of bee and other products, besides creating awareness about the importance of honey bee in enhancing crop production among the farmers of rainfed areas of Orissa.

Backyard Poultry

Orissa state is considered first to declare poultry as agriculture. Backyard poultry is taken as subsidiary occupation by the communities. The low input technology birds available in poultry doing well under semi intensive system of management. The poultry birds are phenotypically similar to local or deshi ones except that the poultry birds are high eggs yielding and grow at a much faster rate. The activity aims at sale proceeds earned by the communities to be invested further.

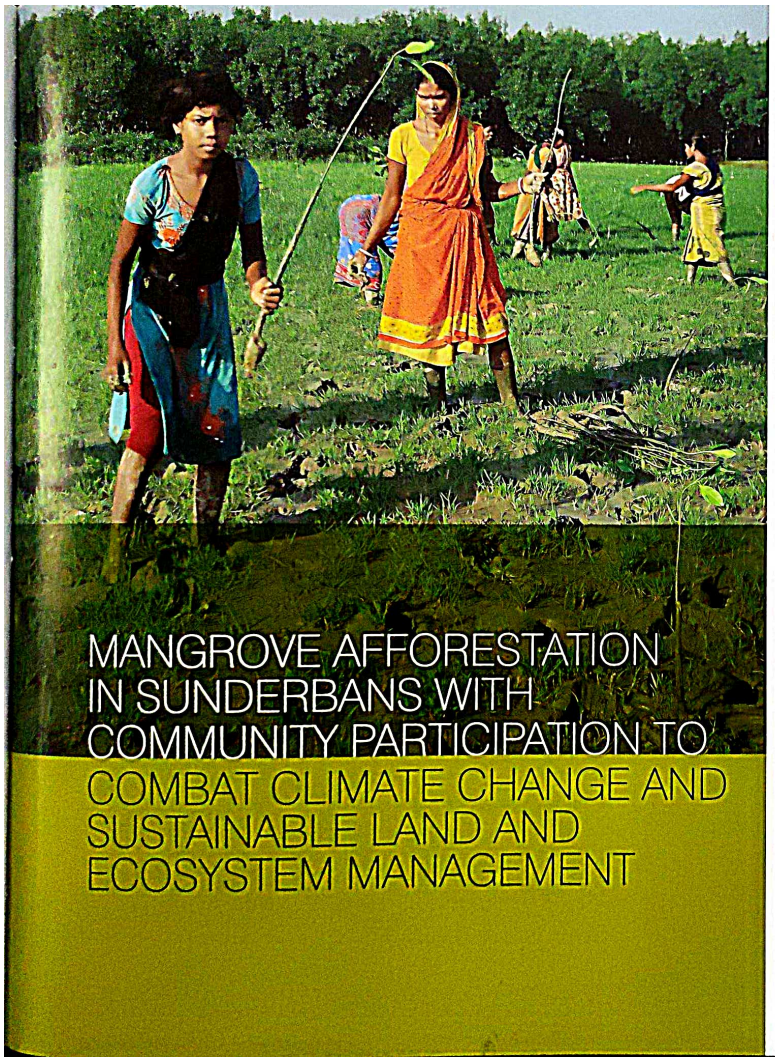
Innovation in Pisciculture and freshwater aquaculture

Central Institute of Freshwater Aquaculture (CIFA) under ICAR in its many activities for the sustainable development is also helping the local communities to combat climatic extreme events which are resulting into land degradation. The CIFA has a fish (Carp) hatchery with a production capacity of 50 million spawn, giant freshwater prawn, breeding and seed production of freshwater prawns (Macrobrachium rosenbergii, M. malcolmsonii and M. gangeticum) hatchery, paddy-cum-fish culture, sewage-fed fish culture, Azolla and its biofertilization for use of biogas slurry, algal culture, integrated fish farming, yard facilities, and feed mill etc

People's Participation

Rural and forest communities of the state are widely aware about the grassroot innovation, knowledge and the experiences being imparted on different aspects of agriculture and forestry. Scientific and educational institutions are involved in the development and delivery of awareness materials to the target audiences.

Public meetings were held at-site of the on-going activities of different organizations in different parts of the project implementation areas. It is imperative to mention that the participation of large number of women and the youth in the interactive meetings held at certain sites which indicates the level of motivation and awareness and most importantly gender sensitization about the sustainable land and ecosystem management.



MANGROVE AFFORESTATION IN SUNDERBANS WITH COMMUNITY PARTICIPATION TO COMBAT CLIMATE CHANGE AND SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT

The Sundarbans is one of the unique ecosystems and also the largest mangrove forest in the world, it is located in the West Bengal state of India and South-Western part of Bangladesh. The total area of Sundarban ecosystem including Bangladesh is 26,000 sq km out of which Indian Sundarbans accounts of 9,600 sq km, which is composed of 4,263 sq km of reserved forest, 2.585 sq km of Project Tiger area and other. Administratively it is divided into two districts: 13 blocks in South 24 Parganas and six in North 24 Parganas. The major rivers that traverse thought the Sundarbans from west to east are Saptamukhani, Thakuran, Matla, Bidhadhari, Guasaba, Raimongol, Ichamati, Jhilla, Jamuna, Bhairab, Kapotaksha, Madhumati, Sibsa, Pasar, Bhola and Meghna. The Sundarbans has 84 species of mangrove plants, the highest recorded among the mangroves of the world, and the Sundari tree (Heritiera fomes) is the most common species.

It accounts for 19.19% of total forest area of West Bengal (FSI 2011) and supports variety of biodiversity includes the threatened population of Royal Bengal Tiger. The mangrove forest and the mud flats of the Sundarbans provide large number of ecological goods and services which are vital for the survival of communities inhabiting in the ecosystem.

In Sundarbans large amount of forest area falls in high tide level where major part goes under water during the rising tide. Every day the tidal water sweeps fairly large amount of such forest twice. The mangrove forest in Sundarbans is basically a salt-tolerant forest ecosystem like other coastal mangroves of India, but uniquely these mangrove forests are exposed to freshwater and seawater mix. The mangroves present a natural buffer, a bulwark against coastal erosion and seawater ingress into one of the most densely populated regions of the world. It is a fragile ecosystem due to its rich ecological diversity, unique biota which comprises of above 100 species out of which 36 species are mangroves, 31 species of mammals, 165 species of fishes, 300 species of birds, 59 species of reptiles and 7 amphibian species and numerous species of invertebrates, phytoplankton's, fungi, bacteria, zooplanktons, benthic invertebrates, mollusks.

The Indian Sunderbans comprises Sundarbans is also an abode for nearly 3.7 million people (Census 2001) and out of 102 islands in the Indian Sundarbans about 54 are inhabited and the rest are notified as reserved forest. These islanders are mostly migrants from other parts of West Bengal or Bangladesh. The frontier islands lying south and closer to the Bangladesh border are most vulnerable to sea water insurge and being constantly configured and reconfigured by tidal movements in the rivers and are more instable deltas.

The irrevocable climatic changes largely in the form of rise in temperature, change in precipitation pattern is affecting the life's of poor and improvised who depend on natural resources for their livelihoods.

A Key Carbon Sink

Scientific studies have proved the relevance of the forests of Sundarbans as an important carbon sink since the trees and soils of this ecosystem can trap and store considerable amount of carbon dioxide (CO2) and it has been envisaged that Sundarbans can be a more effective carbon sink than the Amazon forests. Many other studies have indicated that deforestation lead to release of the stored carbon, for example the tropical deforestation is responsible for about 20% of the world's annual CO2 emissions. Ray et. al. (2011) the overall carbon storage in these islands is estimated to be 21.13 million tonne, with 5.49 million tonne sequestered in the soil (up to a depth of 30 cm). The region stores 0.41% of the total carbon stored in Indian forests (6,621 MT). It uptakes 2.79 million tonne annually, which is 0.55 per cent of the annual fossil fuel emissions (504.6 million tonne carbon per annum) of India (Ray et. al. 2011). In the Sundarbans, carbon capture and storage in live biomass is greater than in the Amazon forest by 35-48%. In Amazon, the carbon intake rate stands at 2.59-3.24 kilotonne per hectare (ha) per annum, whereas in the Sundarbans it is close to 6.54 kilotonne per ha per annum and the carbon accrual in the Sundarbans is faster than in the Amazon. The Amazon will need about 50 years to sequester the same amount of carbon that Sundarbans can sequester in just 10 years (Ibid). At the current global price of forest carbon, which is about Euro 5 (or about Rs 350) per tonne, the carbon value of the Sundarbans can be estimated to be in the range of Rs 737.4 crore, while the annual uptake of carbon can be valued at Rs 97.3 crore which is without pricing the other ecosystem services and livelihood opportunities that the Sundarbans provides to over four million people.

The project was initiated to support the rural communities of Sundarbans to live in sustainable ecosystems which will serve as the foundation for their food security, long term resources availability and also provide resilience to increasing extreme events in the form of storms, tidal insurge due to climate change.

The livelihoods project in Sunderbans aims to develop strategies to combat climate change by at capturing greenhouse gas through the restoration of mangroves in 6000 ha over a period of three years in Sunderbans, India, in line with the provisions of the Kyoto Protocol, under the Clean Development Mechanism (CDM) and according to Voluntary Carbon Standards (VCS). As per the design of the project it is committed to engage local people who are mainly dependent on goods and services provided by climate change vulnerable Sundarbans ecosystem in alternative and sustainable lifestyles, and also to enhance their participation in the conservation and ecosystem management.

The interventions under the project were initiated with Danone Fund for Nature, Paris Afforestation and Reforestation (A/R) of mangroves in the Sunderbans and livelihood which is a unique investment fund whose objective is to restore carbon credits with high societal value to its partner investors. The mechanism of the project can be summed up as follows: through the carbon economy, the fund contributes to ecosystem restoration and development of the local economy and thus to the fight against poverty in Sundarban ecosytem.

Objectives

- To regenerate the degraded biodiversity resources of the wetland ecosystem in the Sunderbans for acting as a biological defense against the natural calamities and protecting the age-old earthen embankments.
- To ensure continued existence of the community in this vulnerable ecosystem through increased access to wetland resources and reduced exposure of local populace to the hazards of tidal surges.
- To involve the village women folk in the plantation programme for enhancing their financial status as well as social security.
- To reduce carbon footprints and get carbon credits in the process of restoration of green belts.

Project Methodology

The unique features of the project is the community initiative, where the community of the adjacent villages are directly involved in collecting seedlings, raising saplings in nurseries, making jute bags to be used in nurseries (instead of the usual practice of polybags), planting, protecting and monitoring over a long period of time. Panchayat members, prodhans, Sabhadhipati's along with the Member of Land and Forest protection Committees are also involved in the project model.

The model also works with utilizing the carbon economy to the best interest of preservation of ecosystem thereby increasing more livelihood opportunity for the community and also to build resilience against climate change. It may also be noted that sustenance of the planted mangroves has always been an issue in Sunderbans which mostly tend to degrade even after exhaustive plantation programme in the past.

Project goals and aspects of implementation

Goal-1
Biodiversity Conservation

Goal-2
Community resilience toward tidal insuge

Goal-3
Reduce carbon footprints

The issuance of Certified Emission Reductions (CER) or Voluntary Emission Reductions (VER) by UNFCCC and validated by the Designated National Authority in India gives the mandate to keep the carbon stock growing for over twenty years. Hence In this case an over-all monitoring programme is taken to keep the carbon stock well maintained over twenty years of time and we are hopeful that this criticality of the project is the key to sustenance of the afforestation/reforestation programme.

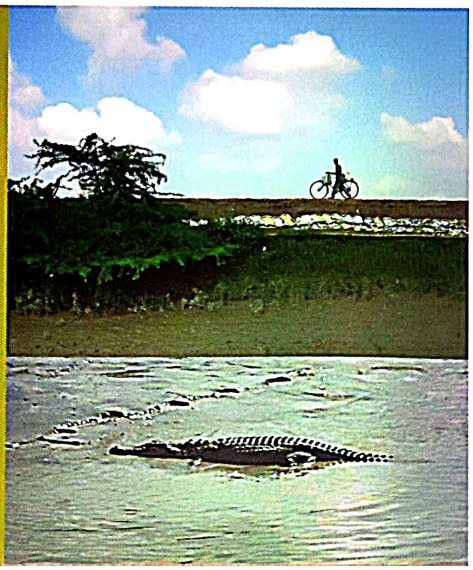
The large-scale CDM A/R project is part of 5 separate community initiatives aiming to provide a new financing mechanism to overcome the current barriers to contribute positively to wetland restoration through mangrove afforestation in a multi-species environment and to allow communities to benefit from the CDM. A key ecosystem restoration objective of the project is to re-establish the ecosystem functions relating to wave and wind erosion control to protect embankments, and to re-establish functioning ecosystems that can also enhance biodiversity. The socio-economic rationale for the project is to provide an economic stimulus in a depressed area, and to protect important livelihood functions for local communities. The A/R activity will provide greenhouse gas mitigation benefits and also important adaptation benefits in addressing climate change impacts. Such impacts include ongoing sea level rise and a probable increase in storm intensity.Thus, there are three aspects to the project implementation.

The afforestation programme is done in a multi species environment, after proper assessment of accresion-erosion, hydrology, bathymetry, salinity and important value indices of the area. As per the tidal inundation, the species are selected and seeds collected by the community esp women. They are given training to raise saplings in nurseries and the Society buys the saplings from them. The women are engaged in the plantation and forest guards from the community given charge to maintain and monitor the plantation.

Wetland Aspects

Goals
Revive the biodiversity of the wetland ecosystem and implement wise and sustainable practices of the ecosystem resources and services

Objectives
Provide biological defence against storms, cyclones, tidal surges, regenerate the degraded biodiversity resources & protect the age-old earthen embankments which is the lifeline for the people of the Sunderbans



Afforestation along the mudflats strengthen the embankments (3600km long) that form the lifeline for people of Sundarbans

Projected Outcome
Increased biodiversity resources and resilience against storms/cyclones. Village community, in absence of mangrove belts, are totally vulnerable to tidal surges. Besides the mangroves act as breeding nursery of shell and finfishes, molluscs, crustaceans, as a bio-shield against storms, cyclones, against soil erosion, as a potential natural way to adapt to sea level rise owing to accretion of land trapped in the lateral branching system in a prograding delta, recreational value and immense economic value by providing services through fishing, tourism, medicine etc.

Community Aspects

Goals
Ensure the continued existence of the community in this vulnerable ecosystem.

Objectives
Increased access to wetland resources & reduced exposure of local populace to the hazards of tidal surges.

Projected Outcomes

Empowered villagers especially women that results in gross community happiness and social commitments of the community. The involvement of the community especially women in the process of mangrove rebuilding from nursery building to raising, planting and maintaining, as if owned by them is emphasized and practiced. Earlier it was and remained the duty of protection and conservation managers only but today the community guards under the project are protection the plantations from grazing and other anthropogenic pressures. Training of the women groups imparting the knowledge and practice of preparation of mangrove saplings in nursery and their role in a socially valuable programme of rebuilding 'green', also empowers them.

Involvement and participation of villagers especially women is a major target of the plantation programme, which not only helps them financially but also inculcates a sense of pride and security among them to be able to take part in a socially relevant question, as if owned by them.

Carbon Related Aspects

Goals
Reduce carbon footprints.

Objectives
Get carbon credits

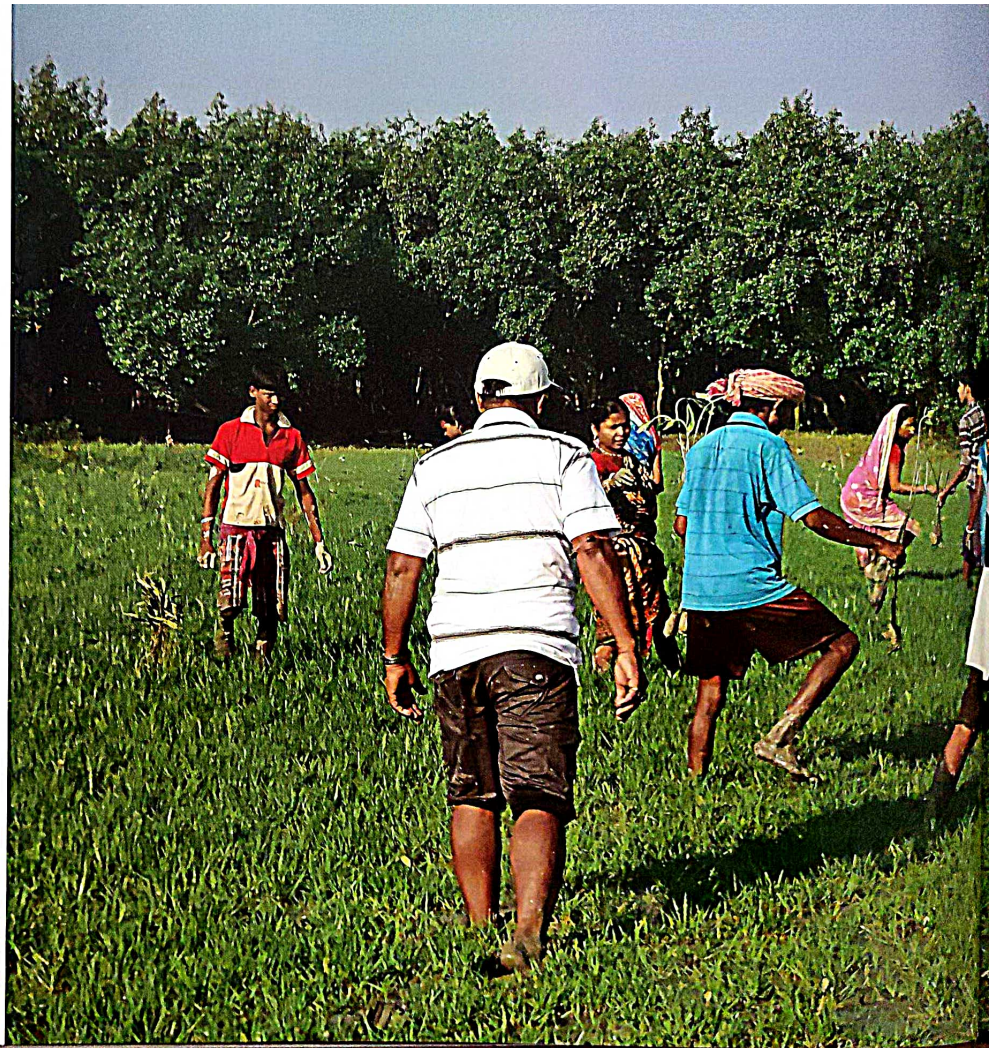
Preparation Activities

The due diligence review of Potential Wet Carbon Project in India was done by H.J. RUITENBEEK RESOURCE CONSULTING LIMITED , France and Canada represented by H Jack RUITENBEEK , who has been working with the Govt of West Bengal on CRZ management issues in World Bank projects in Sunderbans for last four years, in consultation with the Chief Economist, International Union for the Conservation of Nature (IUCN), Gland and with the scientific experts in mangroves and hydrology of Sunderbans from West Bengal. The review report produced a management summary that contained information relating to methodology, general findings, technical project design and implementation, and long-term risk mitigation. The scope of the assessment encompasses wetland impacts, community benefits and impact, and potential for developing a carbon asset that in due course may be registered via the Clean Development Mechanism (CDM) or Voluntary Carbon Standard (VCS). The due diligence review commenced on April 2010 and was substantially completed in May 2010. At various phases, the

management of NEWS takes advise from the subject experts from different institutes of national and international importance.

Letter of Approval from CDM Cell, MoEF, Govt of India has been obtained and the project has been submitted to UNFCCC. The first validation on their part has been completed. The learning's of the project also helped in developing methodology for mangrove afforestation under UNFCCC. A joint awareness program was carriedout in project implementation areas in collaboration with District Administration, and Sundarban Biosphere Reserve, Deptt of Forests on mangrove protection. The law enforcing agencies such as Forest department and Police department are also involved in local campaigns and to ensured complete embargo on illegal felling. The geo-spatial mapping of all plantations was also carried out for the measurements of area under plantation and to maintain transparency.

In total 2266 ha already completed with a target of 3000 ha for 2011-2012 campaign involving twelve villages, 576 women were directly involved in raising 12 lakhs of saplings in nurseries and around 56 lakhs of seedlings were planted to obtain the standard density of plants per hectare. In the second phase of plantation the target was of 2125 ha, out of which 1237 hectare of plantation was completed and about 630 women were directly involved in raising 19 lakhs saplings in nurseries and around 79 lakhs of seedlings were planted to obtain the standard density of plants per hectare. For the monitoring third party audit of the plantation activity has been completed for the first phase. The project area has been divided into 5 zones - Raimongol, Bidya, Matla, Saptamukhani-Thakuran and Sagar for management. Plantation was carried out in 4500 ha land belonging to 95 Villages in 16 blocks (total 19 blocks) of Sundarbans, more than fifty thousand people are directly involved.



Project Implementation target

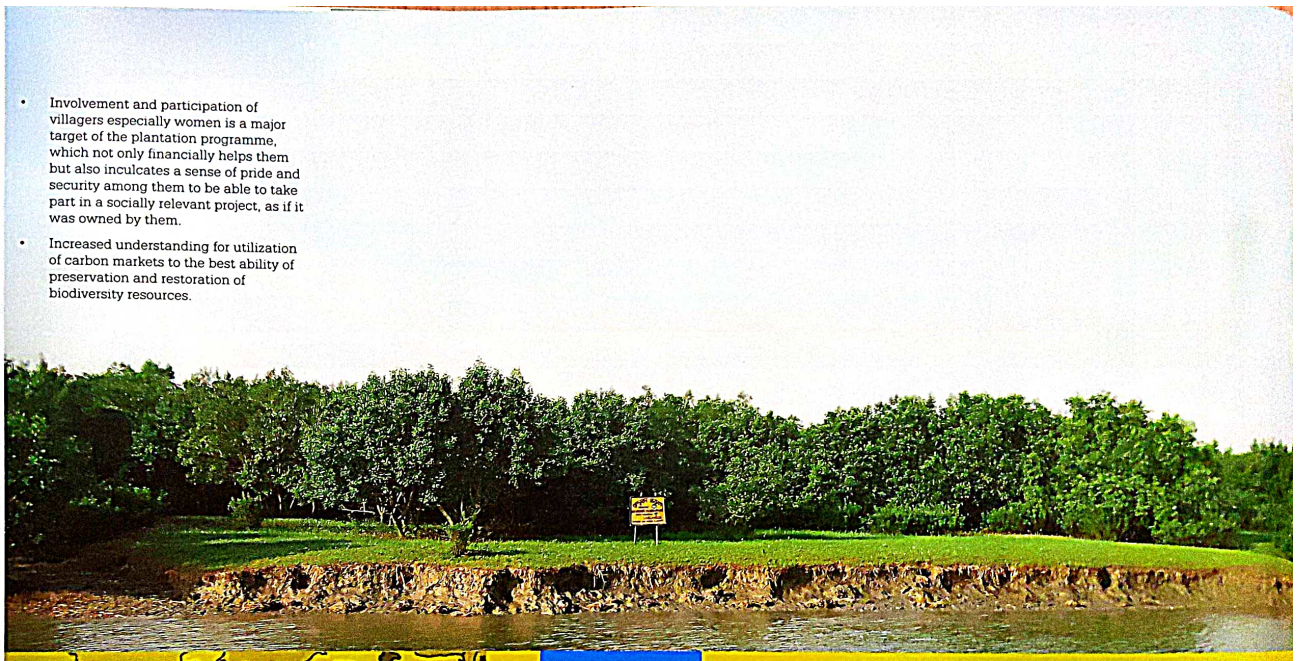
Year	Plantation target	Area (ha)
2010-11	1000 ha	766 ha
2011-12	2000 ha	1500ha
2012-13	3000 ha	1237
2013-14	2000 ha	On going

ZONES	Area planted (ha)
Bidya	577.8
Matla	1236.2
Saptamukhani	870.9
Sagar	1035
Raimnogol	788.7

Overall Project Outcomes

- Increased biodiversity resources and resilience against storms/cyclones.
- Village community, in absence of mangrove belts, are totally vulnerable to tidal surges. Besides the mangroves act as breeding nursery of shell and finfishes, molluscs, crustaceans, as a bio-shield against storms,cyclones, against soil erosion, as a potential natural way to adapt to sea level rise owing to accretion of land trapped in the lateral branching system in a prograding delta, recreational value and immense economic value by providing services through fishing, tourism, medicine etc.
- Empowered villagers especially women that results in gross community happiness and social commitments of the community.
- The involvement of the community especially women in the process of mangrove rebuilding from nursery building to raising, planting and maintaining, as if owned by them, was hitherto not emphasized and practiced. (NEWS had practiced in small scale last year in some villages and was very successful). It was and remained the duty of protection and conservation managers only. Training of the women groups imparting the knowledge and practice of preparation of mangrove saplings in nursery and their role in a socially valuable programme of rebuilding 'green', also empowers them.

- Involvement and participation of villagers especially women is a major target of the plantation programme, which not only financially helps them but also inculcates a sense of pride and security among them to be able to take part in a socially relevant project, as if it was owned by them.
- Increased understanding for utilization of carbon markets to the best ability of preservation and restoration of biodiversity resources.



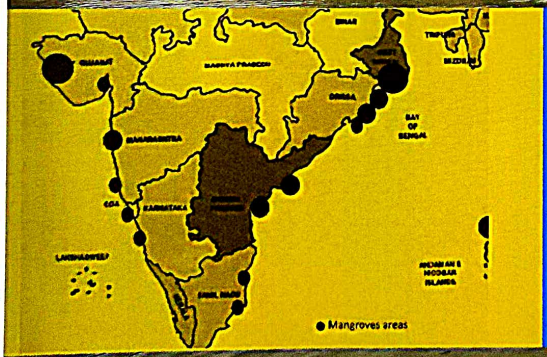


Figure 1. Distribution of Mangrove forest in India and where the present practice can be undertaken

Potential of the best practice for up-scaling

In India, the states like West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Andaman and Nicobar Islands, Kerala, Goa, Maharashtra, and Gujarat occupy vast area of Mangroves. The area under mangroves in Gujarat is the second largest along the Indian coast, after Sunderbans. Gujarat has about 23 percent of India's estimated mangrove cover of 4.88 lakh ha. Of the total mangrove cover in the state, the coastal district of Kachchh covers almost 90%. Mangroves in India account for about 3% of the global mangroves and 8% of Asian mangroves (SFR, 2009; FAO, 2007). About 60% of the mangroves occur on the east coast along the Bay of Bengal, 27% on the west coast bordering the Arabian Sea, and 13% on Andaman & Nicobar Islands. Mangroves are spread over an area of 4,661.56 km2 along the coastal areas of the country.

AONLA BASED AGRO-FORESTRY AS SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT PRACTICE IN SEMI-ARID DRY REGIONS

Indian Gooseberry known as Aonla (*Emblica officinalis*), occupying an area of more than 80,000 ha, is an indigenous fruit plant grown in semi-arid regions throughout the country. Uses of aonla are mentioned in ancient scripts and the nature health practiceners often include the dry fruits in many formulations as it has diuretic, laxative and antibiotic properties. Aonla is one of the richest sources of Vitamin 'C' containing 700 mg ascorbic acid per kg of dry powder. The fruit improves the nutrition of the poor people at low cost. It is a hardy, low water requiring plant, which can also be grown on marginal and salt affected saline/sodic lands. Aonla can be grown successfully as a sole crop but more profitably in agro-forestry system in the States of Rajasthan, Maharashtra, Gujarat, Madhya Pradesh, Uttar Pradesh and Tamil Nadu.

The study area, Achrol Village in Amer Block falls in semi-arid region of Jaipur district,Rajasthan. It receives an average annual rainfall of 480 mm and temperature varies from 2° to 46° C. Bajra –Mustard is the conventional cropping system in the region, which is being replaced by Aonla based agro-forestry with bajra, guar, mustard and wheat as inter crops. The Aonla plantation has come up very well in this area which has now improved ground water status due to adoption of soil and water conservation, field bunding and leveling.

Agro-techniques of Aonla Cultivation

Grafted or budded Aonla plants are planted at a spacing of 10m × 10m (100-110 plants per hectare) during the months of July-August. Pits of 1m × 1m × 1 m size are dug two months prior to planting. In each pit, 3-4 baskets of farmyard manure and 1 kg neem cake or 500 gm bone meal are mixed with soil before filling the pits. To control termite 100 gm endo-sulphan is also mixed. In sodic soils, 5-8 kg gypsum with 20 kg sand is also mixed. Pits are watered if there is no rain.

Chakaiya, Banarasi, NA6, NA7 and NA5 are suitable for the region. Two varieties are planted in alternate rows to safeguard self incompatibility amongst aonla cultivars. Water spouts below the bud union are removed periodically and 4-6 well spaced branches per tree are allowed to develop. A dose of 10 kg farm yard manure, 100 gm nitrogen, and 100 gm phosphorus are given to one year old plants, which is increased yearly up to 10 years of age, there after a constant dose is given. Full dose of farmyard manure and phosphorus and nitrogen is given in tree basin during the months of January- February and the remaining half is applied in August. In sodic soils, 100-500 gm of Boron and Zinc sulphate is also added with fertilizers (Fig. 2).

Though Aonla is hardy and low water needing plant however young plants need watering at 15-20 days interval during winter and at 8-10 days interval during the peak summer. Established aonla orchards, in general do not require irrigation particularly in normal soils. In beanng plantation, first irrigation should be given after manure and fertilizer application in January/ February Irrigation should be avoided during flowering period (March-April). Later on watering is done as per need for optimizing productivity. In salt affected soils, irrigation at 10-15 days interval is recommended. Mulching with organic wastes, paddy straw, sugarcane trash and farmyard manure is very effective to establish Aonla orchard and reduce watering. Farmers are also growing aonla as mixed plantation with pulses and vegetable crops (Fig. 3).

A grafted/budded plant starts bearing at the age of 3-4 years after planting and commercial yield is obtained after 8-10 years, which continues up to 25-30 years with good management. A grown up 8-10 years old aonla tree may produce 100-120 kg (10 to 12 tonnes/ha/year). Fruits are graded in large size for preservation and candy, small size for Chavanprash and Trifla and blemished fruits are utilized for powder and shampoo making.

Traditional Bajra-mustard Cropping

Bajra- Pearl millet (Fig. 1) has been the traditional rain-fed crop in the region. Under irrigated agriculture Bajra is followed by the mustard. For this purpose sprinkler set was purchased at the cost of Rs. 100000, which was subsidized up to 50% by the Department of Agriculture, Govt. of Rajasthan. Bajra –mustard was grown using recommended fertilizer dose and normal cultivation practices. Generally two irrigations are given to the mustard through sprinkler for good yields of crop.

Fig. 2 *Fertilization of Aonla after harvest of Kharif Bajara*

Fig.3 *Mixed plantation of Aonla in agroforestry*

Economics

Table 1: Cost of establishing an Aonla orchard at 10m × 10m or 20m × 5m

S.No.	Items/works	Cost (Rs.)
1.	Cost of 100 plants @ Rs. 80/plant	8000
2.	Cost of digging of 100 plants @ Rs. 80/plant	8000
3.	Cost of FYM @ Rs. 1000/100 cft for 400 cft and 100 kg of neem cake	6000
4.	Filling of pits with soil, FYM, neem cake and mixing with pesticides (Rs. 25/pit)	2500
5.	Planting and watering	2000
6.	Application of pesticides	1500
7.	Gap filling (30% mortality, 30 plants)	2400
8.	Weeding/ hoeing , 3 times/year @ Rs. 20/Plant	6000
9.	Removal of sprouts and staking of plants	1600
10.	Plant protection measures	2500
11.	Watering, 4-5 irrigations till June	3500
12.	Miscellaneous	5000
	Total	**49,000**

The cost of cultivation of Bajra -Mustard, benefit and net benefits from bajra-mustard is given in Table 2. The cost was higher in initial year (Rs. 72,736/-) due to investment of Rs. 50,000 on sprinkler set. The establishment cost of aonla on various items works out to be Rs. 49000 (Table 1).The cost is relatively higher during the first two years due to supplementary irrigation to aonla which stabilizes gradually to around Rs. 4000/- by the fourth year, when plant starts fruiting. However, high yields are obtained by 8th or 9th year onwards (Table 2).The cumulative expenditure of aonla establishment and after care up to 10th year works out to be Rs. 97000/-. The selling price of aonla fruit at the field site varies from Rs. 5 to 7 per kg. The income (return) became positive in the 8th year of cultivation, which is though profitable but not very attractive. Under the agroforestry system the inter-spaces between the aonla plants is utilized for growing bajra-mustard rotation. Income obtained from aonla fruits as well as the inter-crops (Table 2) remarkably improved the economics of aonla based agro-forestry system rendering the system very attractive.

The economic analysis based on 10 years project life and 10% discount rate reveals (Table 3) that net present value (NPV) of traditional Bajra-Mustard cropping workout to be Rs. 34395 with a benefit: cost ratio (B:C ratio)of 1.13:1 having internal rate of return (IRR) of 30.3%.The payback period of the cropping system is 6 years at low level of benefits. In case of aonla as planted as a sole crop, the NPV increased to Rs. 48305 yielding B:C ratio of 1.52:1 with IRR of 17.7%. The investment can be recovered within a period of 8 years and appears to be economically viable. with better returns. However, when aonla is planted with inter-crops, the NPV jumped to be Rs. 97789 raising B: C ratio to 2.04:1 and IRR of 37.64% with a pay pack period of 5 years making the aonla based agro-forestry system highly remunerative.

Potential for Up-scaling The Practice:

Aonla cultivation has wide scope of applicability in the semi arid region, salt affected soils and ravines, where crops are unlikely to give sustainable production. In aonla based agro-forestry with cereals and pulses can be grown as inter crops up to 5-6 years successfully, which is an attractive preposition for up-scaling the Aonla cultivation in semi-arid regions of Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Aravali hills of Haryana and Kandi areas of Panjab, UP and Karnataka (Fig. 2). This will also help in generating more employment opportunity for the local persons specially women/youth in the region.

Table 2: Cost and income from aonla based agro-forestry system in one ha area (Source: Varghese et. al. 2009)

Years	Cost of Bajra-mustard (Rs.)	Cost of Aonla (Rs.)	Fruit yield (kg/ha)	Benefit of Bajra-mustard (Rs.)	Benefit from Aonla based system (Rs.)			Net benefit (Rs.)	Net benefit (Rs.) of Bajra- mustard
					Aonla	Inter crops	Total		Aonla + Inter-crops
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)=(5-2)	(10)=(8-3)
0	72736	49000	-	34928	-	12000	12000	-37808	-37000
1	20082	8000	-	34497	-	12000	12000	14415	+4000
2	19931	6000	-	30113	-	10000	10000	10182	4000
3	21486	6000	-	32282	-	10000	10000	10796	4000
4	22645	4000	700	35230	3500	10000	13500	12585	9500
5	22645	4000	2000	35230	12000	8000	20000	12585	16000
6	22645	4000	4000	35230	28000	8000	36000	12585	32000
7	22645	4000	6000	35230	42000	8000	50000	12585	46000
8	22645	4000	7500	35230	52500	6000	58500	12585	54500
9	22645	4000	8000	35230	56000	6000	62000	12585	58000
10	22645	4000	10000	35230	70000	6000	76000	12585	72000

Table 3: Economics of Aonla based agro-forestry system (Discount rate- 10%, Project life-10 years)

Details	NPV (Rs)	B:C Ratio	IRR (%)	Payback period (years)
Crops (Bajra- Mustard rotation)	34395	1.13:1	30.3	6
Aonla as sole crop	48305	1.52:1	17.7	8
Aonla based agro-forestry system	97789	2.04:1	37.6	5

LAND SHAPING FOR CLIMATE CHANGE ADAPTATION AND SUSTAINABLE LIVELIHOODS IN SUNDARBANS

Sundarbans is a Complex Diverse Risk (CDR) prone agro-ecosystem situated between 20°02' to 22°06' North latitude and 88°25' to 89° East longitudes. Agriculture is the mainstay occupation for majority of people. About 68% of total cultivable land is low lying and mono-cropped. The crop yield in this area is usually very poor due to soil, water and climatic constraints. The major constraints are salinity build up and lack of irrigation of water during dry months (rabi season), deep water logging of fields (in kharif), drainage congestion etc. In Sundarbans, due to heavy rainfall (1700-1800 mm/year) during monsoon season, most of the water goes to the seas as runoff. On the other hand, there is a dry spell of six months with huge scarcity of sweet water. In low lying land situation where water stagnation is relatively high (2-3ft) during rainy season, only traditional variety of paddy is grown. Second crop is not possible in rabi season due to late release of land as well as for scarcity of irrigation water. Attempts have been taken to alleviate the problems of salinity and water logging in this region under one of the NAIP subproject on Sustainable Rural Livelihood Security Through Innovation in Land And Ecosystem Management is being implemented in Sundarbans and Andaman & Nicobar island with the objective of sustainable management of degraded land and water resources for enhancing livelihood security of farming communities.

Land shaping is an effective agro-technology which helps to harvest rain water for cultivation of vegetable crops after kharif paddy. This method is a multi-faceted method by which HYV paddy replaces low yielding traditional deep water paddy varieties in the kharif season and helps growing of high value vegetable crops during winter season. At the same time pisci culture as well as duck rearing in the same pond and growing of fruit crop/vine vegetables along-side the pond and land embankment are also possible.

Principle of Land Shaping

- Excavation of 1/5th area of the low land upto a depth of 8-9 feet
- Adjoining low land raised up to 1.5 feet
- Pond embankment: 5 feet wide and 4 feet height
- Land embankment around the area 3 feet wide and 3 feet height
- 6-9 acre inch of rain water can be harvested and stored in the pond

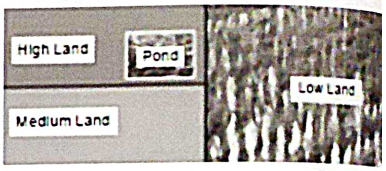


Fig. 1. Farm pond (FP) technique for rain-water harvesting for growing fish and multiple crops in different seasons
Source: Bandyopadhyay et al. (2009)

Three land shaping techniques are followed by the farmers depending upon the land size and their interest in the types of vegetation. Some farmers are interested in Fishing-cum-vegetables- cum-paddy cultivation some in Fish-cum-paddy, and some are interested in vegetables and fishing only. To alleviate soil salinity and water logging problems as well as for creation of irrigation resources different land shaping techniques are practiced by the farmers like Farm pond (Fig.1), Deep furrow with high ridge (Fig.2) and Shallow furrow with medium ridge (Fig.3).

To a large extent good results have been reflected under this project in terms of increased productivity and income. Also, there has been a visible positive impact of women participation. It is interesting to note that now the community has realized the real importance of conservation and re-strategize the activities on the basis of the best practices and the experiences and learning from others communities.

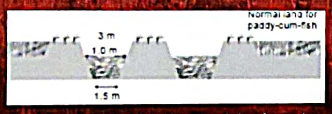


Fig. 2. Deep furrow and high ridge (DF) technique for growing fish and multiple crops in different seasons (side view).

Fig. 3. *Shallow furrow and medium ridge (SF) technique for growing fish and multiple crops in different seasons (side view). Source: Bandyapodhyay et.al. (2009)*

Improved Practice after the Intervention Including Income in Farm Pond

With the introduction of land shaping, the degraded saline lands are converted into cultivable ones thereby increasing the crop bio-mass with diversified cropping patterns. The Ground water recharging has also become possible by creation of a number of water harvesting structures, which in turn has reduced the ground water exploitation. Salinity (Ece) has been reduced from 3-5 mmhos/cm to 0.05 - 1.0 mmhos/cm over a period of two years specially with land shaping. With farm women's' involvement in agricultural land, their tendency to catch prawn seed from riversides has reduce which is helping to conserve the water bio-diversity. The impact of land shaping is felt on improvement of economic conditions also. As this technology creates man days of more than three times of traditional practice, the farmers are now engaged in their own fields throughout the year, which checks the seasonal migration rate of the farm family. In areas of 0.266ha, 472 people are employed which is nearly three and half times more than the traditional practice (135 man days). Social security is also established through this technology by ensuring income security.

Land Shaping New Initiatives for Economic Upliftment for the Farming Communities

The farmer's income has increased three times after the intervention of land shaping techniques. Some farmers shared their experiences about income earned by selling of vegetables;

- By investing Rs.10, 000 in cultivation of tomatoes, bitter gourd and brinjal in 0.07 ha. the farmer earned Rs. 24,000/-
- Mr. Tapan Halder of Dakshin Durgapur Village earned Rs.20, 000/- by selling tomatoes. A total of 600 kg tomatoes are produced in 0.07 ha of land.
- Mrs. Parvati Halder by practicing Paddy-cum-fish cultivation, in 0.07 ha. of land she earned more than Rs. 30,000/- by selling different vegetables like brinjal, cabbage and tomato.
- By investing Rs.12, 000/- in cultivation of bitter gourd in 0.07ha an amount of Rs.33, 000/- was earned by Mr. Halder. An additional income of Rs.7000-8000/- is earned by cultivating chandani (spices) by Mr. Halder.

Comparative Data in Tabular form on Unit Area of Land: 0.266 HA

Parameters	Traditional Practice		Improved Practice		
	Kharif	Rabi	Kharif	Rabi	Year round
Productivity (Per ha)	Productivity Paddy: 19.5 qt/ha Production Paddy: 5.18 qt in 0.266 ha	Fallow	Productivity HYV paddy: 28 qt/ha Bitter gourd : 350 qt/ ha Okra: 285 qt/ha Bottle gourds: 4895 q/ha Production HYV paddy: 4.76 qt in 0.17 ha (Raised land) Bitter gourds: 3.85 qt in 0.011 ha (Land embankment) Bottle gourd: 7.42 q in 0.015 ha (5 ft wide vacant land around the pond) Okra in 4.84 qt in 0.017 ha (Pond embrkment)	Productivity Sunflower: 18.5 qt/ha Okra: 250 qt/ha Production Sunflower: 1.85 qt in 0.1 ha (Raised land) Okra: 17.5 qt in 0.07ha (Raised land) Tomato: 7.63 q in 0.011 ha (Land embankment)	Productivity Fish: 25 qt/ ha Production Fish - 1.4 q in 0.053 ha (Pond area)
Gross Income (Rs.)	4662.00		Paddy: 4284.00 Bitter Gourd: 2310.00 Okra: 2420.00 Bottle gourd: 2968.00 Total: 11982.00	Sunflower: 1850.00 Okra: 10500.00 Tomato: 3815.00 Total: 16165.00	Fish: 1400.00 Total: 1400.00
Total Income (Rs.)	4662.00		29547.00		
Labour Employed (man-days)	135		472		

(Source: KVK, Nimpith)

Meeting with the villagers in Dhakhin Durgapur village

Sustainability of the Project

At present more than 1000 farmers have undertaken land shaping through this sub-project in various areas of Sundarbans and Andamans. In the project about Rs. 15 lakhs have already been collected from the beneficiaries as the sustainability fund. The purpose of raising this fund is to continue the project activities after the project is over. It shall be used for integrated farming, multi-cropping on the coastal lands with improved crop varieties for enhancement of productivity and livelihood security of poor farmers, as well as for rainwater harvesting for improving soil environment and irrigation opportunities. After the end of the project period, the fund will be managed and utilized in the village by a committee of villagers formed for this purpose.

Land shaping intervention has empowered women-folk in the region. Women are now taking interest in other development programme like health and nutrition education implemented in their villages

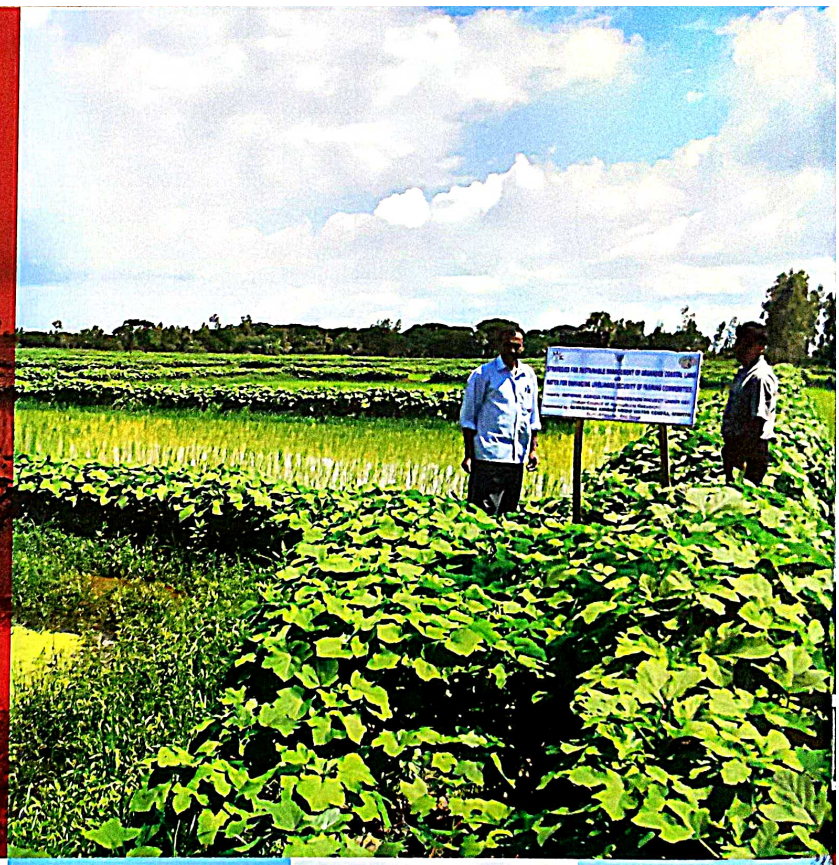
The technology is economically viable and environment friendly and more output in terms of income for the farming communities more and more people in the nearby villages are adopting it and approaching the centre for their capacity building in land shaping. Some of the farmers of Domkal and Dhakhin Durgapur villages have participated in the trainings as resource person.

Inclusion of Land Shaping Techniques in Government Programmes

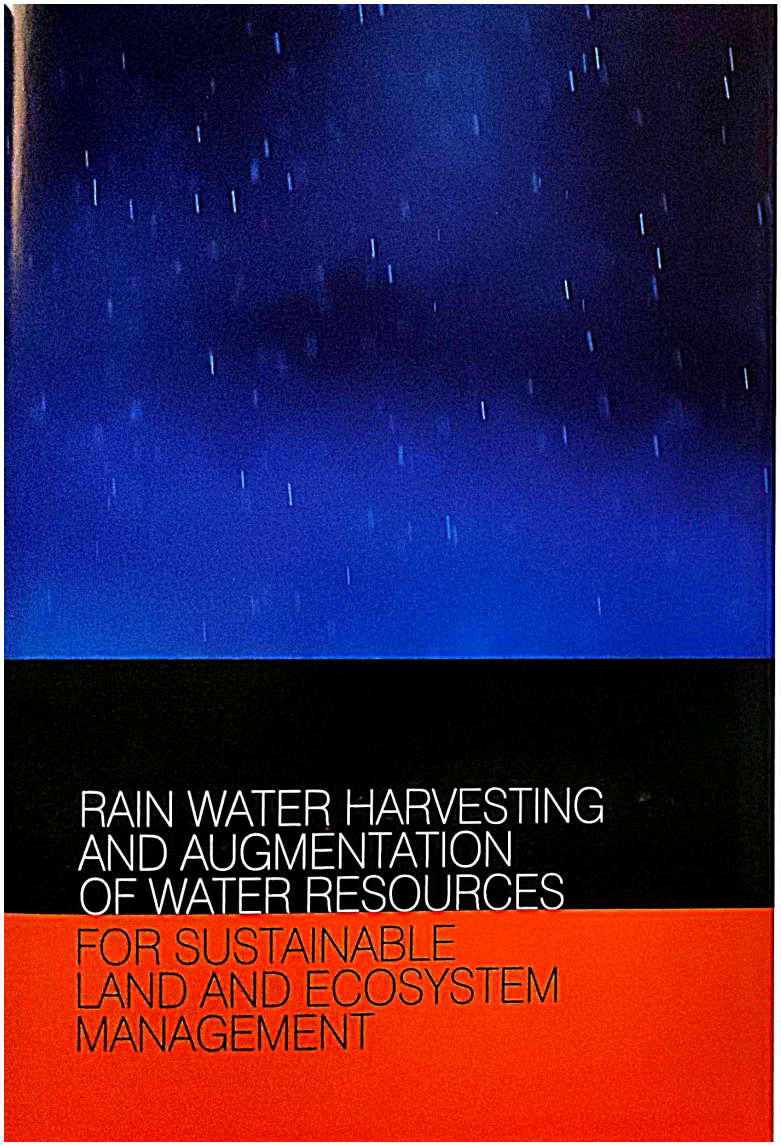
After the successful intervention of land shaping techniques by the team of Ramkrishna Ashram, KVK, Nimpith, different visits and meetings were carried out by the State level officers in the project site. The meetings and visits were also followed by interactions with the farmers who adopted the land shaping techniques in their respective field. The good impact of the land shaping techniques brought to the farming communities have resulted in inclusion of this activity in various government schemes and programmes. The MGNREGS Cell has sanctioned Rs.10 lakh for Land Shapings in the region of 24 Parganas and a similar order has been proposed by the Bringing Green Revolution in Eastern India (BGREI) for Rs.10 Crores for construction. At the panchayat level too, this technology have been appreciated and implemented in different villages. Most of the blocks like Jaynagar-2, Pathorpatima, Kakdeep, Namkhana and Kultali in South 24 Parganas, apart from the project proposed areas the Land Shaping techniques have already been implemented.

CASESTUDY

Achievements of Mr. Nimai Halder, farmer in Paddy-cum-fish cultivation in Dhamkol Village: Mr. Nimai Halder and his family have been involved in Paddy-cum-fish cultivation in 0.2 ha of land. He was associated with the project as a beneficiary for last three years. He was earning Rs. 2175 per annum. Low income from his land compelled him to migrate to Kolkata in search of job during nonfarm activity (post monsoon period). Mr. Halder used to pull rickshaw in Kolkata. But now with the land shaping technological intervention (Farm pond model) from the project to reshape his land to farm pond model, he is now earning a net income of 30, 000/- per annum. Some portion of his low lying area has been raised with excavated soil for growing vegetables round the year. This raised land is now free from water logging during kharif and there are less amount of soil salinity due to reduced effect of brackish ground water at shallow depth. Now he is practicing integrated farming in his farm land round the year. He is earning almost daily by selling vegetables in local market. Mr. Halder is now able to spend on other activities like education for children, health and nutrition for the family etc. The female members in the family are also involved in cultivation.



Photographs of Land shaping from the Field site



RAIN WATER HARVESTING AND AUGMENTATION OF WATER RESOURCES FOR SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT

Water is becoming one of the scarcest commodities the world over. Rainfall, snow and glaciers are the source of its augmentation, particularly in dry rain-fed areas. In situ conservation of rain water in soil profile and ground water; ex-situ harvesting of runoff, its collection in reservoirs and utilization are traditional ways of recycling and augmentation of water resources and drought proofing strategy in the dry rain fed areas. About 44% of net cultivated area in the country is irrigated, where productivity is somewhat declining on account of secondary land degradation issues. Agriculture consumes more than 80% of available water, which may be shared in future by increasing demand from other sectors. Ground water is the mainstay for drinking purpose as well as for irrigation in dry rain-fed regions: However, a shift towards ground water irrigation in canal command is a matter of concern. The rain-fed agriculture covers nearly 56% of net cultivated area in India contributing to about 45% of food grains. A vast potential of rain water harvesting exists in the development of rain fed ecosystems especially in hilly regions.

Hilly regions by and large are blessed with adequate rainfall but lose about half of it as runoff along with rich surface soils due to topographical reasons. About 26% of Degraded lands in hills of Uttarakhand are reeling under drought like situations making agricultural nonviable, which results in large scale out migration. This paper covers rain water harvesting for augmentation of water resources in the States of Uttarakhand, Shivalik Hills and the North Eastern Region.

Fig. 1 *Traditional Kachha Water harvesting system on Hill slopes (Courtesy: Directorate, UDWDP, U.K.)*

Uttarakhand Decentralized Watershed Development (udwdp) Project

The State of Uttarakhand occupies 53,484 km² geographical areas which includes 86% hilly terrain. With 20.5% total cropped area and 13% net cultivated area, the Sate sustains 80% rural population. Although, the State receives 1016-2540 mm annual rainfall (average 1240 mm) but a decline in base flow and drying of springs is causing drinking water problems. Crop yields are very low and sometimes crops fail during the Rabi season on rain fed terrains due to water scarcity. Only 14% of cropped area in hills is irrigated by minor irrigation through Guhls, for which springs are the main source of water supply. Traditional water harvesting systems have been in vogue on flatter part of upper reaches as well as on slopes for animals, watering saplings, irrigation and ground water recharge (Fig 1). There is plenty of potential of runoff harvesting in ponds, augmenting springs for drinking water and recharging ground water and improving land productivity.

The SLEM-GEF UDWDP project covers 20 Gram *panchayats* of Nainital, Bagheswar and Rudraprayag forest Divisions. The project envisages need based participatory planning and execution of micro-watersheds through *Grampanchayats*. The major project activities include construction of *Kachha* water harvesting ponds, augmentation of ground water/ rejuvenation of springs, reutilization of runoff for drinking/ irrigation through *Guhls*, improving livelihood and stocking in degraded forest.

Soil and water conservation is fundamental to watershed management, which is achieved through, vegetative check dams, anicuts to control gully erosion, staggered contour trenching, and contour bunding and, bench terracing on precipitous slopes. Contour cultivation, agro-forestry and silvi-pastures on community lands are developed

Fig. 2
Ground water augmentation pond at Selalekh, Dist. Nainital (Courtesy: Directorate, UDWDP, U.K.)

in conjunction with conservation measures. Improved varieties of crops, fruits, vegetables and medicinal/ aromatic plants are grown adopting integrated nutrient and water management. Afforestation of degraded forest, aided natural regeneration (ANR) of native forest and improved planting material is prepared through forests nurseries, while fodder and energy plantation is performed on community land. The pressure on forests is further reduced through alternative sources of fodder and fuel from pine briquettes, biogas and use of solar lanterns. Value addition of fruits and vegetables, grading, processing and marketing is performed through Self Help Groups of beneficianes at *grampanchayat* level. These initiatives also help in reducing drudgery of women by curtailing number of hours spent to collect drinking water, fuel and fodder from distant places.

Ground Water Recharge (Augmnetation of Naula)

Percolation tanks are small storage structures or big ponds commonly used for artificial recharge on a highly permeable landscape having unconfined aquifers. These are constructed by earthen embankment across natural streams and *Nallas* to impound surface runoff which facilitate its lateral spread and vertical infiltration and percolation into the sub soil for augmenting ground water, downstream springs, locally called *Naulas*. At *Grampanchayat* Selalekh, distt Nainital, two recharge ponds of (22.5mx27mx1m and 25mx22.5x1m) having a catchment area of 7 ha and water storage of 7.5 lakh liter are constructed near the ridge line (Fig. 2). The stored water not only controlled expansion of *Nallah* locally called (*Gadera*) downstream but recharged ground water and rejuvenated spring (*Naula*) for drinking purpose

Water harvesting and utilization for vegetables at Kontha

At Konta revenue village, *Grampanchayat* Tewadisem, district Nainital has decided to enhance water availability of an old spring/ *Naula*, which was at the verge of drying. It provided water at a discharge rate of 7 litre per minute. Nearly 300 trenches were dug in hilly upper region and planted with trees and grasses. Besides some check dams were constructed in the drainage channel. As a result, discharge rate of Naula increased to nearly 11 litre per minute. The steam started flowing for longer duration due to land treatments and surplus water was collected in an irrigation tank utilized for supplemental irrigation of nearly 3 ha vegetables, being exported to plains by Self Help Groups.

Himalayan Foothills (siwalik Region)

Shiwaliks are the range of low lying hills which join plains with foot hills of Himalayas, extending from Jammu and Kashmir to Uttarakhand. Siwalik covers an area of about 2 Million ha in the States of Punjab, Haryana, Himachal Pradesh and Uttarakhand. The average annual rainfall of the region is 1100 mm, of which 82% is received during June to September. The Siwalik Hills with steep slopes and sparse vegetation give rise to a magnitude of ever widening flash torrents, eating into fertile land and carrying heavy load of sediments, chocking the downstream reservoirs. The occurrence of torrents (*Choes*) is quite common as the primary form of drainage. The region is characterized by slope wash, loose sediment deposits underlain by boulders and pebbles having moderate to high percolation laid over an impermeable thick Kankar intermixed silt horizon providing excellent water retention. Narrow gorges and horse shoe type formations in Shiwaliks provide numerous good sites for constructing small water harvesting dams. After a well known case of Sukhomajri, near Chandigarh in 1980-81, a large number of water harvesting structures/small earthen dams were constructed in the State of Punjab and Haryana (Fig. 3) for harvesting runoff and recycling it for farm uses by gravity, ground water recharge and flood moderation. Earthen dams are constructed at the horse shoe shape site of the foot hill with provision of spill way. Irrigation system is designed down streams using steel pipes. Invoking social fencing, the e responsibility of the protection of the catchment and the community structure rests with community, who share benefits regardless to land holdings. These earthen dams have improved productivity of rain-fed areas several fold, recharged ground water.

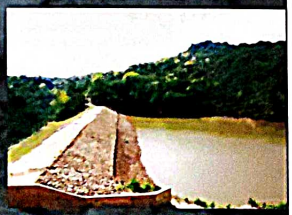


Fig. 3 *Rain water harvesting by earthen dams at Nada (Haryana)* (Courtesy: CSWCRTI, Dehradun)

Water Resource Development in Nagaland in Context to Integrated Farm Development (ifd)

The Northeastern state of Nagaland has 89% tribal population with density of 120 persons per km^2. Land based resources such as agriculture; and rich floral and faunal biodiversity are the main stay of the people. Forests occupy 56% of geographical area with 80% cover, owned largely by the community. Shifting cultivation (*Jhum*) covering about 37% of geographical area, is a destructive practice as it involves conversion of forest in to agriculture resulting in colossal soil and water losses. Though *Jhuming* is a traditional way of life, but its viability is being questioned due to drastic reduction of *Jhum* cycle from 20 - 25 years to about 8.4 years due to high population pressure. The State is not self-sufficient in food grains due to low productivity (average grain yield 1300 kg per ha) despite 2000-25,000 mm annual rainfall, well drained fertile soils suitable for best quality agriculture, horticulture and floriculture. The cropped area is about 23%, which suffers from soil acidity, reduced availability of phosphorus and toxicity of iron and alumina.

Elements of IFD and their Integration

Integration of agriculture-fishery-forestry-horticulture on watershed basis is highly productive, economically viable and environmentally sound sustainable land management system having potential to replace "Jhuming" by settled farming. IFD provides a viable farming alternative with optimum utilization of resources, inbuilt soil and water conservation, synergistic

high productivity through animal based farming systems (crop-animal-fish-birds-MPTs-horticulture), providing the year round employment to minimize movement of tribals from one to other places for Jhum cultivation. So far 21 IFDs have been initiated in Mokokchung, Mon and Wokha districts of Nagaland and over 800 jhum households have been benefited.

Soil and water conservation is fundamental to IFD, which is achieved on lands cleared for *Jhum* cultivation. Contour bunding with provision of drainage and contur farming in inter bunded area and cropping on bench terraces on steeper slopes with grass water ways is crucial. The bunds and risers are strengthened through fodder grasses, shrubs and nitrogen fixing fodder trees such as Aldar and Leucaena. As the mechnical measures are expensive and locals are reluctant to adopt, these are subsidised by the project in conjunction with vegetative measures.

Contour trenching is extremely important on hilly slopes for conservation of rain water. The plantation of trees or fruit plants on half moon terraces is done and saucer shaped pits are mulched with trash to prevent evepotranspiration. Horticulture and agroforestry with MPTs like nitrogen fixing Alder providing shade to climbers and source of fuel wood have become very popular with the tribals.

Water harvesting

Although water resource is plentiful in the State of Nagaland, but not harnessed efficiently/profitably resulting in acute shortage of drinking water in many pockets. Water is the centre point of IFD concept and utilized for multiple water productivity. Mulipurpose ponds have been constructed in the middle of the slopes for water harvesting. These ponds are planted with banana on the embakments, and horti-pastoral system on the slopes. The ponds are utilized for fisheries and watering fruits and also irrigating paddy on the lower reaches through gravity. These ponds also act as a source of ground water recharge and help solve drinking water problems (Fig. 4). These activites envisaging multiple water harvesting systems are far more productive than agriculture and also prefered by the tribals.

Fish farming

Fish farming is one of the novel approaches for increasing the land productivity per unit area. *Kachcha* ponds are more economical and have become popular with the tribals for fisheries (Fig. 5). Farmers earn good income through distribution of good quality fishlings to neighboring villages. For this purpose, IFD project has started fish breeding program in Mon district (Fig. 6). Tribal have innovative idea to enhance capacity of the Kachcha pond by raising the heights by use of bamboo (Fig.7). Back yard poultry and piggery have also become very popular under IFD as they meet daily needs and support livelihoods.

Roof water harvesting

Roof water harvesting is the most convenient and efficient system for water procurement. The water from slopy roof tops is collected through a gutter in to the plastic tanks, kept in court yard in a series (Fig. 8). These tanks are connected with a Pakka tank to store the superfluous runoff, which is recycled to the plastic tanks. In this way farm women save considerable time to fetch water for major house hold requirements. Roof water harvesting has become very popular in Nagaland, which needs emulation elsewhere across the country.

Fig. 4 *Water harvesting ponds in IFD program*

Fig.5. *Kachcha Water harvesting pond in Mon district (Courtesy: UNDP- SLM project in Nagaland)*

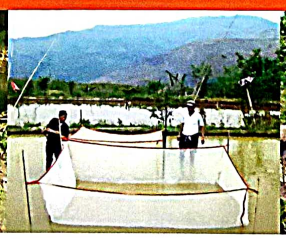


Fig.6 *Fish breeding program in Mon district. (Courtesy: UNDP- SLM project in Nagaland)*

Fig.7. *Bamboo reinforced Kachcha pond in Mokokchung district (Courtesy: UNDP- SLM project in Nagaland)*

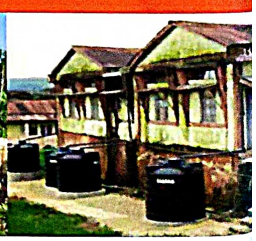


Fig.8 *Roof water harvesting system*

PARTICIPATORY MODEL FOR WATER HARVESTING AND DEVELOPMENT OF COMMUNITY PASTURES IN THAR DESERT

Thar Desert covers 20.875 million ha with a population of 22.5 million human and 23.62 million livestock. The region receives 100 to 400 mm annual rainfall, high temperatures in the months of May and June (40°–43°C), high wind velocity and dust storms. Wind erosion is the dominating land degradation process affecting nearly 11,419,000 ha with droughts occurring nearly in 40 out of 100 years.

The State of Rajasthan covers an area of about 34.22 million hectares largely under arid to semi-arid climate inclusive of Thar Desert of arid western Rajasthan.

Water is the most scarce commodity and critical for survival for all the living beings in western Rajasthan. As of now, per capita availability of water is about half of the national average780 cum/yr against the minimum requirement of 1000 cum/yr. State of Rajasthan has already utilized 72% of total available surface water. Nearly 90% of the drinking water and 60% of the water required for agricultural is being extracted from ground. The average depletion of ground water in the state is more than 40 cm per year. The status of ground water development has reached 138% in 2008. The depletion of ground water in last 25 years in most critical 140 districts is > 10 m, in critical 50 districts 5 - 10 m and in moderate 46 districts is 0-5 m.

Thar Desert thrives on limited water and abundant livestock population, which is 200% of the national average and touches 400% in hyper-arid Jaisalmer and Barmer districts. In general there is scarcity of fodder to the extent of 28% in arid region, which becomes severe up to 100% during drought years, necessitating import of fodder. Traditional water harvesting and community pastures are time tested and indispensible for survival in the Thar Desert. The arid region has about 30 percent of waste lands, of which 1/3rd could be utilized for range /pasture development and afforestation while 20 percent can still be used for modest agriculture.

The issues of water and fodder scarcity were addressed through UNDP project on Sustainable Participatory Management of Natural Resources to control Land degradation in the Thar Desert Ecosystem executed jointly by MoEF, Ministry of Rural Development, Govt. of Rajasthan and the Jal Bhagirathi (JBF) foundation. This study is based on field visits of author to village Tir Singh Garhi in Barmer district and Panchyat Samit Sojat and Rohit in Pali district in 2010-11.

A corpus of fund called Jal Kosh has been raised from the income of selling the harvested water or grass/grass seed from the developed pastures. The funds can be utilized as share of the participants for other welfare works of the society

A Novel Conceptual Participatory Model

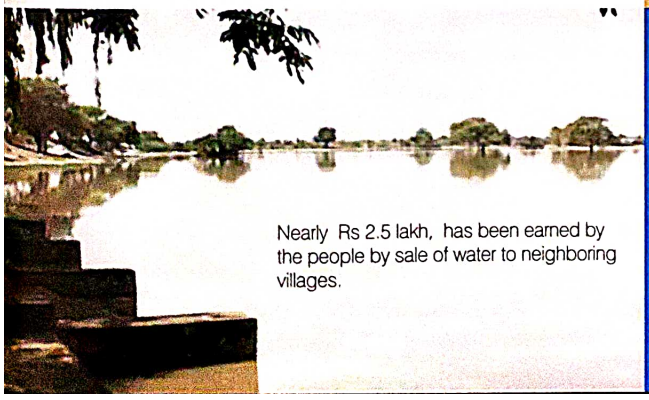
A novel conceptual model has been evolved for developing the water resources and community pastures. At the grass root level, where the water resource/ community pasture is to be developed, Jal Sabha an honorary body, parallel to Gram Sabha is constituted to look after the water resource as well as community pastures development. A corpus of fund called 'Jal Kosh' is raised from the income of selling the harvested water or grass/grass seed from the pastures. The funds could be utilized as share of the participants for welfare activities of the society. This Jal Sabha ensures the utilization of funds and also maintains good rapport with Gram Sabha. A hierarrarkie system in ascending order of 'Jal Samati' guided by 'Jal Parisad' and finally the 'Jal Sansad' is constituted to take care of the developments and advisory at various levels.

The activities of the project were taken on degraded community lands attached with existing pond or a depression, where a nadi or a farm pond could be constructed. The catchment and the community land were often infested with Prosopis juliflora, an invasive specie, which does not allow any grass to come underneath. The basic objective of the Jalbhagirathi Project was to mobilize villagers, develop water resource structures lioke Gawai Talab or nadi (pond), catchment (Agore) development, strengthening the embankment or raising its height to increase the storage capacity in participatory mode and diverting runoff to the pond as per site requirements. Eradication of Prosopis juliflora and development of Silvi-pasture utilizing Cenchrus ciliaris (Dhaman) and Eulaliopsis binata (Seven) grasses with native fodder tree species for developing silvi-pasture system. Tanka (a ground water cistern) to collect runoff water was also constructed for watering seedlings. Up to the 20 beeghas pasture one Tanka was constructed and above the 20 beeghas two Tankas have been constructed. The watering from the Tanka or the farm pond was facilitated through pitcher technique for regular and economic supply of the water. The JBF has developed an excellent rapport in the region with villagers. Now the villagers in the region are eager to undertake development of water resources and pastures willingly.

Molap Talab (Nadi),
Tirsingh Garhi,
Barmer

This Nadi, located near famous Sati Temple at village Tirsingh Soda, has been renovated by JBF, its depths increased, embankments strengthened by the silt scooped out in cleaning and thus capacity augmented on participatory basis. The long standing dispute on water has been amicably resolved through intervention of Shri Gaj singh, Chair person of JBF by providing the share of water to the aggrieved party. During this visit a meeting was organized at nadi with village Jalsabha, in which people expressed that they are interested to develop community grazing lands on the pattern of nadi development on participatory basis. The water of this nadi is being exclusively utilized for drinking. The nadi was filled during the two days rainfall preceding the visit on 26th July, 2010. We were shown a pass book with a balance of nearly Rs 2.5 lakh, which has been earned by the people by sale of water to neighboring villages.

People are very happy with this development as the water of the pond stays throughout the year, which used to dry up by the end of March or April. The wild life and migratory birds have started coming to this pond.



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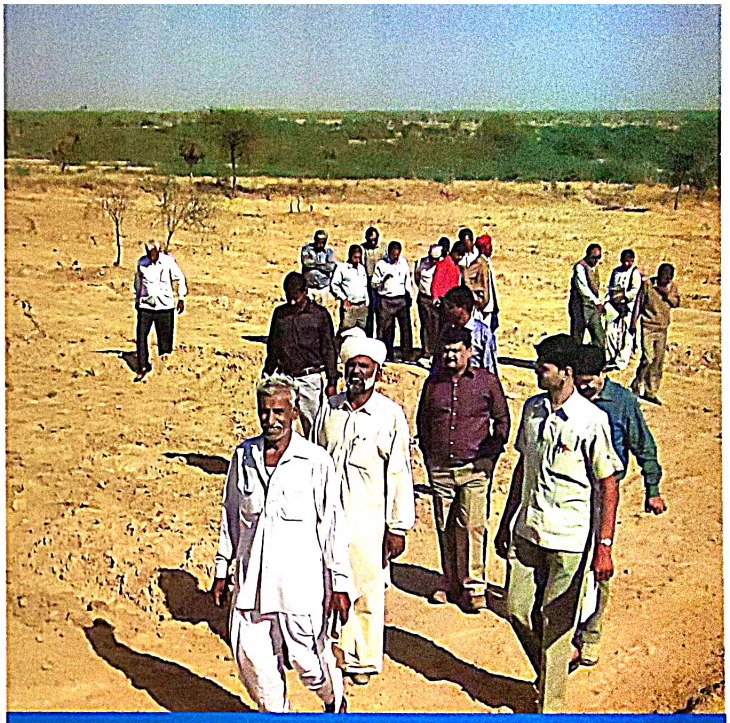


Panchyat Samit Sojat, Distt. Pali

The purpose of the project was primarily for drinking water for humans, livestock and wild life. The Talab caters to the needs of about 8 villages. The Talab is fed by 3 main channels of about 5 km from a catchment " Agore" of 50 ha. The pond was badly infested by water weeds and the catchment by *Prosopis juliflora*. The Gochar land called 'Kharchia' is sodic in nature, infested by *Prosopis juliflora*, which is the main source of fuel wood, however, it does not allow any grass to come underneath. About 4 ha *Prosopis juliflora* was eradicated and water weeds were removed from the submergence area of the Talab. The Bund measuring 10 m width at bottom, 7 m at top and 3 m height was strengthened in a stretch of 300 meters. The height of the bund was also raised to augment storage capacity of pond. The people are very happy with this development as the water of the pond stays throughout the year, which use to dry up by the end of March or April. The wildlife and migratory birds have started coming to this site.

Shiv Nagar Farm Pond

The village Shiv Nagar has a village pond, having runoff contributory area of 700 beeghas. The villagers have jointly taken a vow to eradicate the *Prosopis juliflora* by shramdan from the catchment of the pond. It is amazing to see that the *Prosopis juliflora* has been totally eradicated from the catchment. One side of the farm pond has been made pakka with brick mortar. As an entry point activity, a Shiva temple has also been rejuvenated at the top of the hillock, after that the pasture (Mahadev Gochar) has been named.

Twenty beeghas of pasture has been developed at the village Kerla using the Dhaman grass and *Azadiricta indica, Dalbergia sisso, Bordi, Commiphore wightii, Albizia lebbeck, Salvadora persica, Salvadora olioides,* and *A. nilica*. At this site only one *Tanka* has been constructed. People of this village have harvested the Dhaman and stacked it for future use or for sale during the scarcity period.

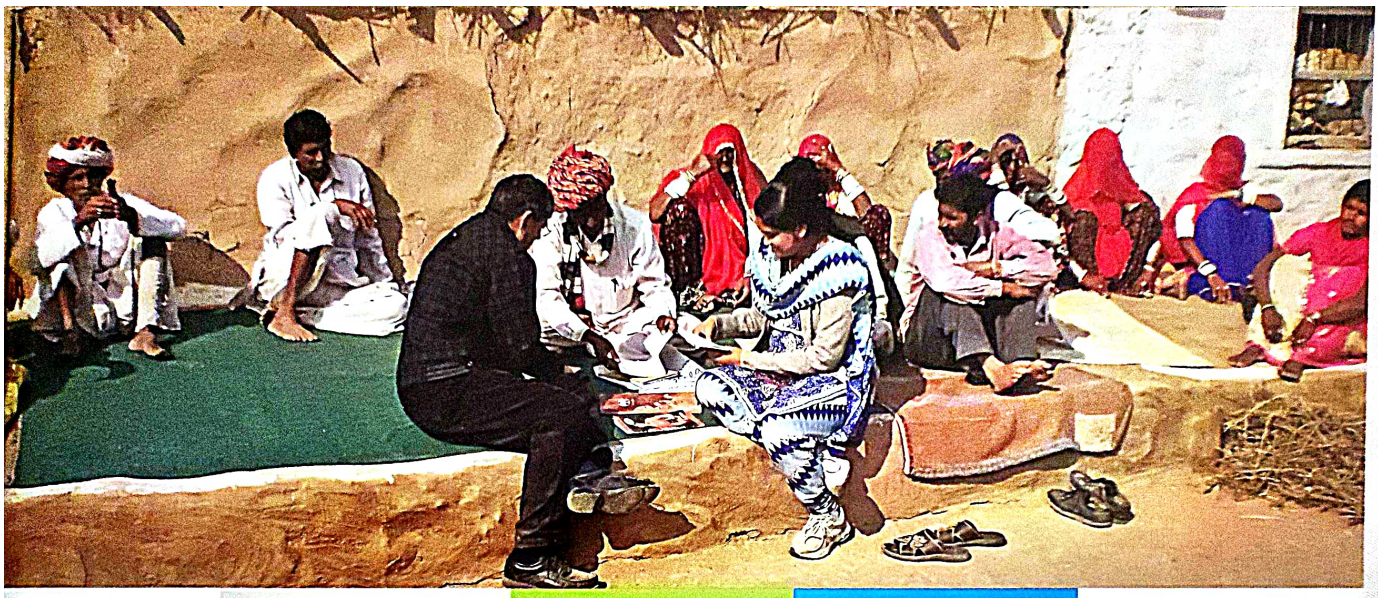
For pasture development, plantation of *Prosopis cinnerari, Tecomella undulate, Azadirctа indica, Zizuphus mauriciana, Cassia siamea* and *A. nilotica* have been done on 20 beeghas of catchment, carved out from big catchment by an earthen bund and ditch, which facilitate runoff in to the farm pond. The pasture has been seeded with Dhaman (*Cenchrus ciliriaris*) grass. The villagers have started collecting grass seeds after a year and sell to other villages and visitors. Two *Tankas* have been constructed in the pasture for watering the seedlings. The pitcher technique has been utilized to water the fodder trees in order to save the labor and use the water economically. The leader of the village was very much dedicated towards the developments.

Under a different program, the village has roof water harvesting in a family *Tanka* almost in all the participating families in the program, 72 nos. toilets, bathrooms and sock pits. Sanitation has been shown through the paintings on the walls. This is a model village with respect sanitation, water harvesting and pasture development have been added on existing program of development.

Potalia

At this site, a nadi has been constructed in this program which serves 3 villages for drinking water of the livestock and also humans. The participants told that in the first year the water was collected from the catchment but seeped down. After the silt and clay deposits, the water will stayed in the nadi, was the right belief of people.

Encroachment was a serious issue on the community lands in this region. Through the good will of JBF people were convinced with project activities and the land was made free from encroachment to a large extent. Pasture has been developed in the Catchment of Nadi by removing the *Prosopis juliflora* and then planting Dhaman grass with *Azadiricta indica, Dalbergia sisso, Prosopis cinneria, Techomella undulate, Acacia senegal, Cassia fistula, Albizia lebbeck, Salvadora persica, Salvadora olioides*. Plants have also been provided with watering through the pitcher technique. Two *Tankas* have been constructed for watering the seedlings. There was serious problem of blue bulls particularly in this village. Therefore people wanted that there trees be protected through tree guards. However, it seems to be a costly preposition as per the project out lays.



Panchyat Samit Sojat, Distt. Pali

Kerla

The pasture development at this degraded site has been done on a land called 'Khader', which is undulated, class seven to eight land with small gullies and badly infested by the *Prosopis julifliora*. Hence eradication of the obnoxious plant was the major work followed by the land shaping using the JPC and tractors. Twenty beeghas of pasture has been developed at the village Kerla using the Dhaman grass and *Azadiricta indica, Dalbergia sisso, Bordi, Commiphore wightii, Albizia lebbeck, Salvadora persica, Salvadora oliοides* , and *A. nilica*. At this site only one *Tanka* has been constructed. People of this village have harvested the Dhaman and stacked it for future use or for sale during the scarcity period.

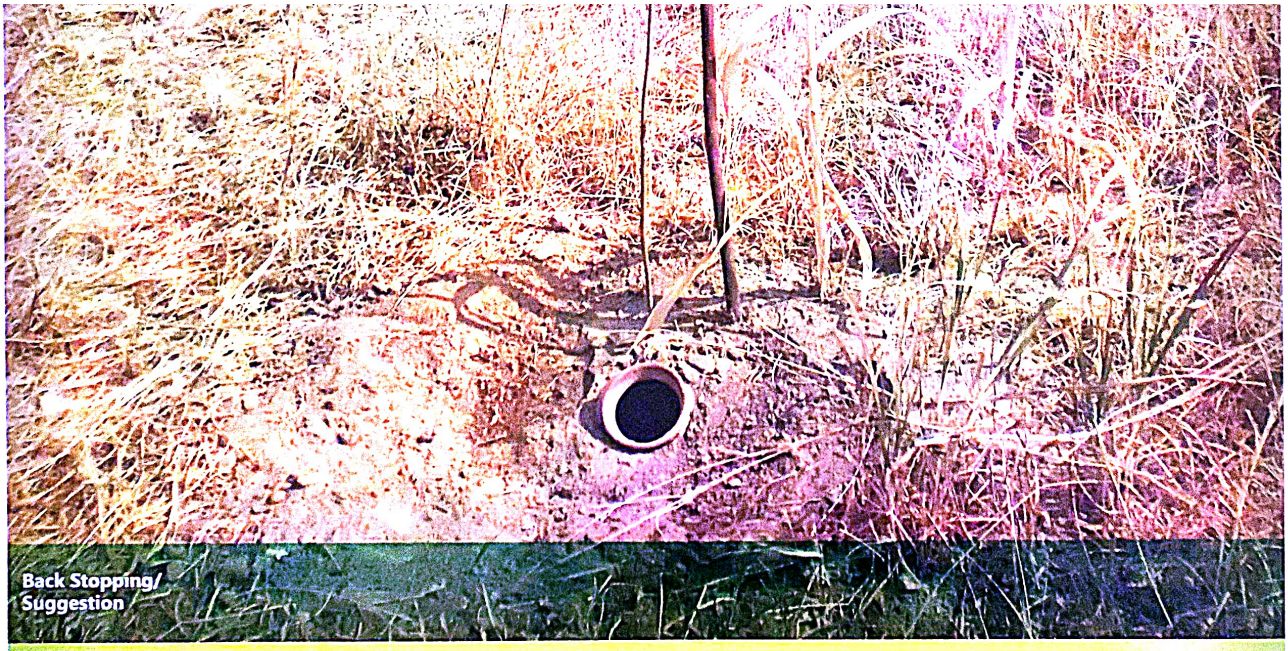
Rupwas

At Rupwas, the land was highly sodic having pH 8.3 and EC 0.69. The site was also badly infested with *Prosopis juliflora*. People have eradicated the *Prosopis juliflora* by uprooting and removing the roots in about 25 beeghas of degraded land and rest of the land still requires similar treatment. Two *Tankas* have been constructed for watering the seedlings. Villagers have made a 2-3 m deep ditch and putting the earth on the one side to form a very high embankment. The thorny prunings of *Prosopis juliflora* have been inserted on the top of the bund. The ditch along with thorny bund has protected the pasture land from blue bulls. This kind of protection can be emulated on other sites in the project. Two *Tankas* have also been constructed for watering the seedlings.

Mandavas

The developments at this site were around a village nadi of about 60 beeghas, of which 33 beeghas was under submergence and 27 beeghas was upland. The nadi caters to the drinking water need of 4-5 villages. About 40 beeghas land has been reclaimed in this village by uprooting water weeds of the nadi and the *Prosopis juliflora* from the upland pasture lands. An Anicut has been strengthened for improving the water storage in the nadi.

The nadi caters to the drinking water needs of 4-5 villages. About 40 beeghas land has been reclaimed in this village by uprooting water weeds of the nadi and the *Prosopis juliflora* from the pasture lands. The Anicut has been strengthened for improving the water storage in the nadi.



Back Stopping/ Suggestion

The targets of pasture development and carbon sequestration seem to be too high in view of slow growth of vegetation in the arid region, limited availability of community lands due to encroachments and severe infestation of *Prosopis juliflora*. Hence, targets are required to be revised by interim modification of the Project document. As water resource development is equally important, hence the targets of pasture developments should be viewed in the light of de-encroachment of community lands and mobilization of people for these activities.

Excellent work has been initiated by Jal Bhagirathi, having a amazing rapport with people on social issues such as water harvesting, pasture development and other social needs of the region. On account of this goodwill, many community lands have been made free from encroachment, a few water disputes have been solved and people have been mobilized to undertake water resource and pasture development on community lands.

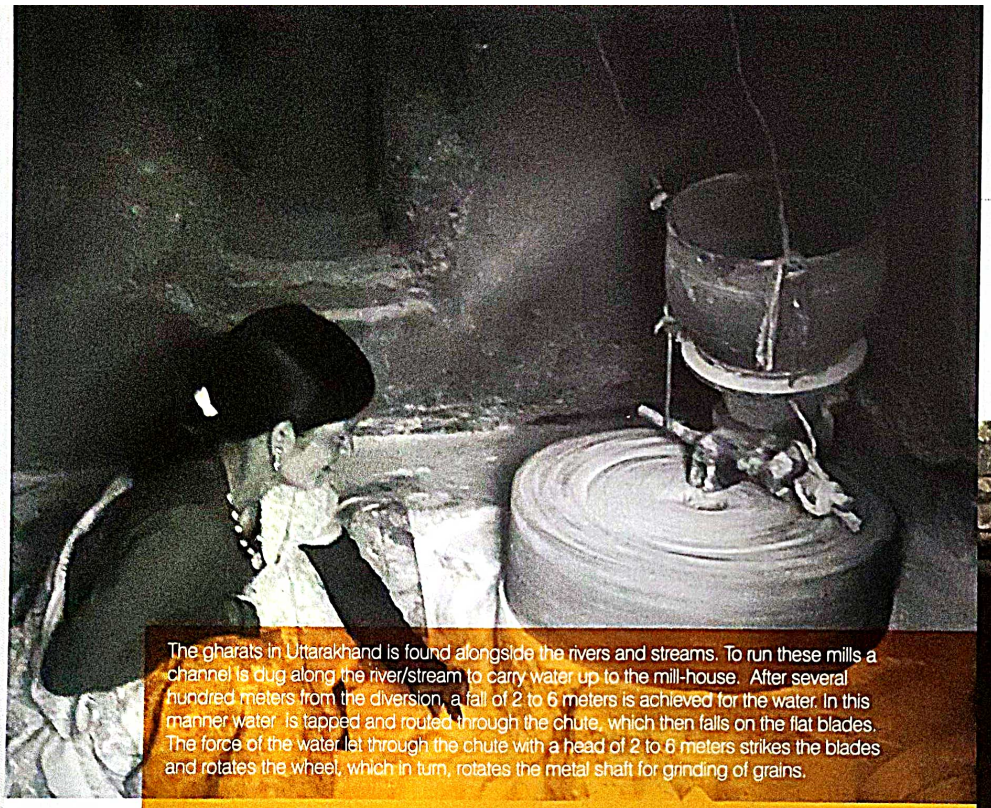
Uprooting of the *Prosopis juliflora* is the herculean task, which is followed by the pasture development. It is highly invasive species and does not allow grasses to grow underneath hence considered undesirable on pasture land. However, this is the only source of fuel wood and fencing in the region, which is so important to protect the field from wild animals like blue bulls. Hence, *Prosopis juliflora* is also considered blessings in disguise by many except the ecologist. Its total eradication may have adverse effect on carbon sequestration since the growth of the grasses and trees is very slow during establishment phase. A partial removal or thinning the population drastically or beheading the plants and establishing fodder trees and grasses in pasture without loss of time may be considered. Coppice shoots can be regularly cut and utilized as fuel wood or fencing material. In this way Pasture can be established while replacing *Prosopis juliflora* gradually by fodder species without much adverse affect on carbon sequestration.

It was advised to use community pastures in rotational fashion to utilize them year round after their development. The pasture land can be divided in 2-4 segments viz. east, west, north and south and grazed in staggered fashion. When one or two segments are under grazing the others should be under rest for recovery.

REJUVENATION OF GHARATS (WATER MILLS)

FOR SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT IN UTTARAKHAND

Man has always tried to develop technology that converts energy from a natural resource into an energy he can harness to his advantage. As elsewhere, the people inhabiting the mountainous tracts of Uttarakhand too apparently found themselves constrained by the harsh physical conditions of the region. Apart from other natural features, the Himalayan regions are well known for their gushing rivers and streams directly fed by the snowy Himalayan Mountains. The upper reaches of Uttarakhand are known as the water-repository of India. People in the past realized the natural potential of these gushing waters as an energy resource and utilized its potential in many ways. One of the remarkable ways in which they utilized the natural resource was by way of the gharats.



The gharats in Uttarakhand is found alongside the rivers and streams. To run these mills a channel is dug along the river/stream to carry water up to the mill-house. After several hundred meters from the diversion, a fall of 2 to 6 meters is achieved for the water. In this manner water is tapped and routed through the chute, which then falls on the flat blades. The force of the water let through the chute with a head of 2 to 6 meters strikes the blades and rotates the wheel, which in turn, rotates the metal shaft for grinding of grains.

The wooden blades are fitted to a thick vertical wooden shaft, tapering at both ends. Two round millstones, hewn locally, are fitted at the top of the shaft to act as the grinding mill. It is interesting to note that the fitness and quality of grain can be determined even in this nature-run process for which a groove is made into the upper grinder to set a tapered iron piece that holds the shaft and grinder simultaneously. Traditionally, channels divert the water from stream/ river to the mill. A device is also incorporated in the channel to divert the water if the water mill is not in operation. This device redirects water. It's a simple but an ingenious construction and can be maintained with simple understanding of the principles involved.

These gharats are constructed from locally available material such as wood, stones, bamboo, and reeds. Apart from the technological aspect. These gharats also have an important sociological dimension. Socially, they have been the meeting points for villagers to get together. The widespread use of gharats and its popularity owe much to its simple and cost effective mechanism.

Following are the advantages inherent in the indigenous watermill technology

Simple technology

- Locally designed and built
- Involving mainly local materials
- Low capital cost
- Almost no running costs
- Easily managed and maintained
- Better taste of the grind material

The project funded Rs.36, 000/- per Gharat in the areas of Sumati, Baisani and Posari villages of Bageshwar District.

The project on Sustainable Land Water and Biodiversity Conservation and Management for Improved Livelihoods in Uttarakhand Decentralized Watershed Management implemented by the Watershed Development Department, Uttarakhand undertook the task of rebuilding and rejuvenating these watermills as these Gharats had low efficiencies ranging from 10%- 15% only.

With the advent of Sustainable Land and Ecosystem Management (SLEM) in 2009-10 in Bageshwar Division, 17 Water Flour Mills have been identified in the project for renovation and planned to improve phase wise. The project improvised such 13 mills in 2010-11 and subsequently 4 mills in 2011-12.

Before the intervention, all the beneficianes were organized into groups and trained. The groups had visited Himalayan Environmental Studies and Conservation Organisation (HESCO) at Pipalkoti, Chamoli.

Interventions

The details of the interventions taken by the project to improve gharats are

1. Before the intervention, the condition of Gharat was very poor, the roof was kacha and made from timber and grass and which need regular maintenance in the form of replacement of kacha roof and plastering of wall and floor with clay after every mansoon. The traditional gharats were vulnerable to natural disasters such as earthquake and floods The project facilitated the construction of the permanent structures.
2. To improve the milling efficiency of Gharats, earthen water canals were replaced by cement canals. Some of the Gharat grinding stones were changed from 6" (15 cm) thick to 14" (35 cm) thick to improve the quality of the flour (Atta) and in some the rotating wooden shaft were also improved.

Operational Management

1. Managing the mills by deploying SHG members alternatively for one day in the mills.
2. Traditionally, no cash charges are taken from the customers for milling, but a portion of the milled materials popularly known as Bhag or Bhagwari is taken @ of 8 to 10% is kept by the members as reward
3. In case of the SHGs, Bhagwari is taken @ of 10%.

Environment Impacts

The wooden roofs and floors of the traditional mills are replaced by pacca Gharat houses constructed through cement, concrete and iron to reduce pressure on forest.

Social Impacts

Due to low milling capacity of the traditional Gharat, the locals were going outside for milling which was time consuming and costly . The flour from the watermills is rather coarse as compare to one being milled on power/diesel mills, and therefore has more fiber content. Hence, the flour is considered to be nutritive, healthy and tasty. Thus, the watermills have been able to contribute the benefit of quality flour among the more end users.

Economic Impacts

1. With the renovation of watermill in the sample villages, the milling capacity of the traditional watermills increased from 80 kg/day to 105 kg/day during July to October. The increase was of 42kg/day to 63 kg/day from November to March. . Whereas for April to June, the efficiency increased from 25 to 35kg/day

Table 1: Impact of renovation on milling efficiency of watermill (Kg/day)

Name of the SHGs	July-October		November-March		April- June	
	Before	After	Before	After	Before	After
Gharat SHG Sumati	80	100	40	60	25	30
Jay Siddhnath SHG Baisani	80	115	44	70	25	45
Bhagvati Mata SHG Posari	80	100	42	60	25	30
Average	80	105	42	63.3	25	35

2. Composite analysis of the sample villages together shows increase in average efficiency from 49Kg/day to 67.78 Kg/day (38.3% increase) on the basis of current level of milling (Table:1 & 2)
3. Increase in milling capacity has positively affect the income. Since, SHG still follows traditional rituals by charging 10% as Bhagwari
4. The composite analysis of the study reveals that average per capita income in terms of Bhagwari has been increased from 11.27 quintals to 19.51 quintal reflecting annual increase of 73.1% over the traditional gharats (Table:2).
5. With increased of the Bhagwari the per capita income of a household was estimated to be Rs. 6243 against Rs.3606 per year in case of traditional gharats showing an increase of 73.1%

Table 2: Income from Bhagwari

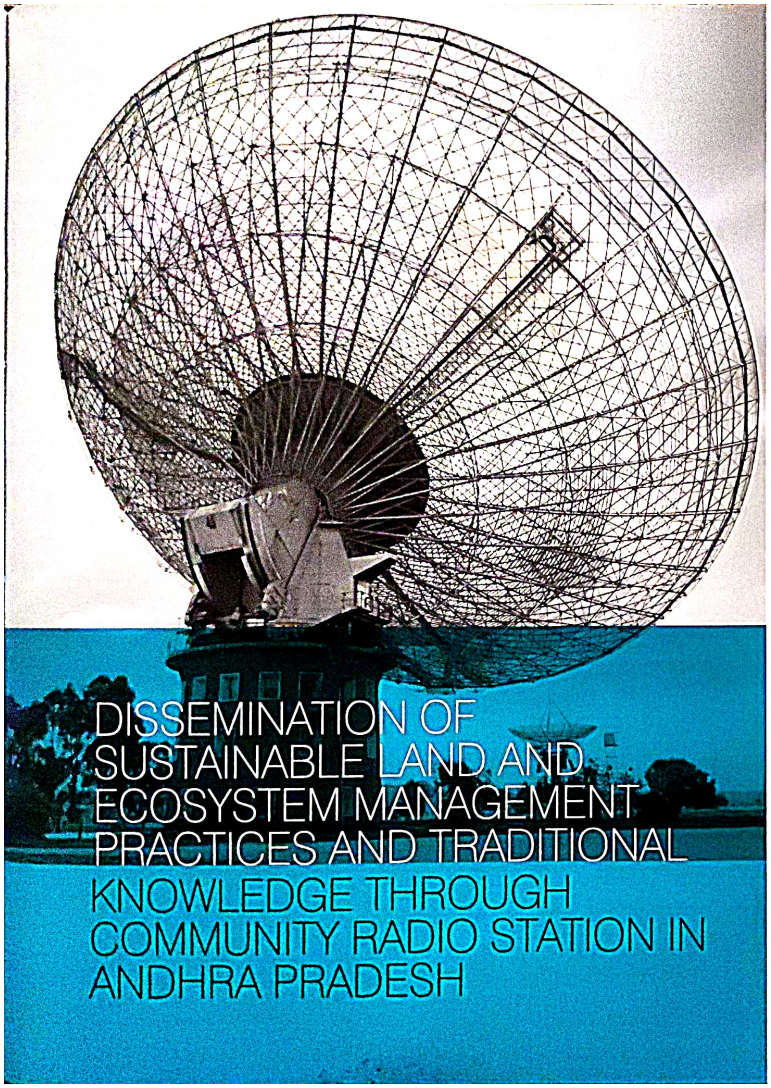
Time of operation (Rs.)*	Milling (Days)	Milling (Kg/day)	Total Milling (Kg)	Bhagwari (Kg.)	Value of Bhagwari (Rs.)*	Income per members
Before Interventions						
April- June	78	25	1950	195	3120	624
July- Oct	52	80	4160	416	6656	1331
Nov-March	123	42	5166	516	8256	1651
Total	253	49(Av.)	11276	1127	18032	3606
After Interventions						
April- June	78	35	2730	273	4368	873
July- Oct	86	105	9030	903	14448	2890
Nov-March	123	63	7749	775	12400	2480
Total	287	67.78 (Av.)	19733	1951	31216	6243

**Value of Bhagwari @Rs.16/Kg and five members from SHGs*

Replication and up Scaling

These interventions have brought the increased knowledge among the SHGs about the additional benefit in terms of milling grains to grinding spices, husking paddy and generating electricity. This has encouraged the gharat managing SHGs to upgrade their existing improvised gharats for such purposes.

Some of the SHGs have installed equipments and tools for generating electricity with the facilitation of Uttarakhand Renewal Energy Development Agency, Bageshwar



DISSEMINATION OF SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT PRACTICES AND TRADITIONAL KNOWLEDGE THROUGH COMMUNITY RADIO STATION IN ANDHRA PRADESH

The media world is moving towards globalization and Colossal media enterprises of commercial nature have been formed and increasingly spanning the globe with their programmes. The media productions from developing countries, including India, China, Brazil etc., are now gaining wider distribution in large-scale commercial media. Globalization of media is important for the increasing awareness but community media plays much important role for the development, sustainability and cultural security of the communities.

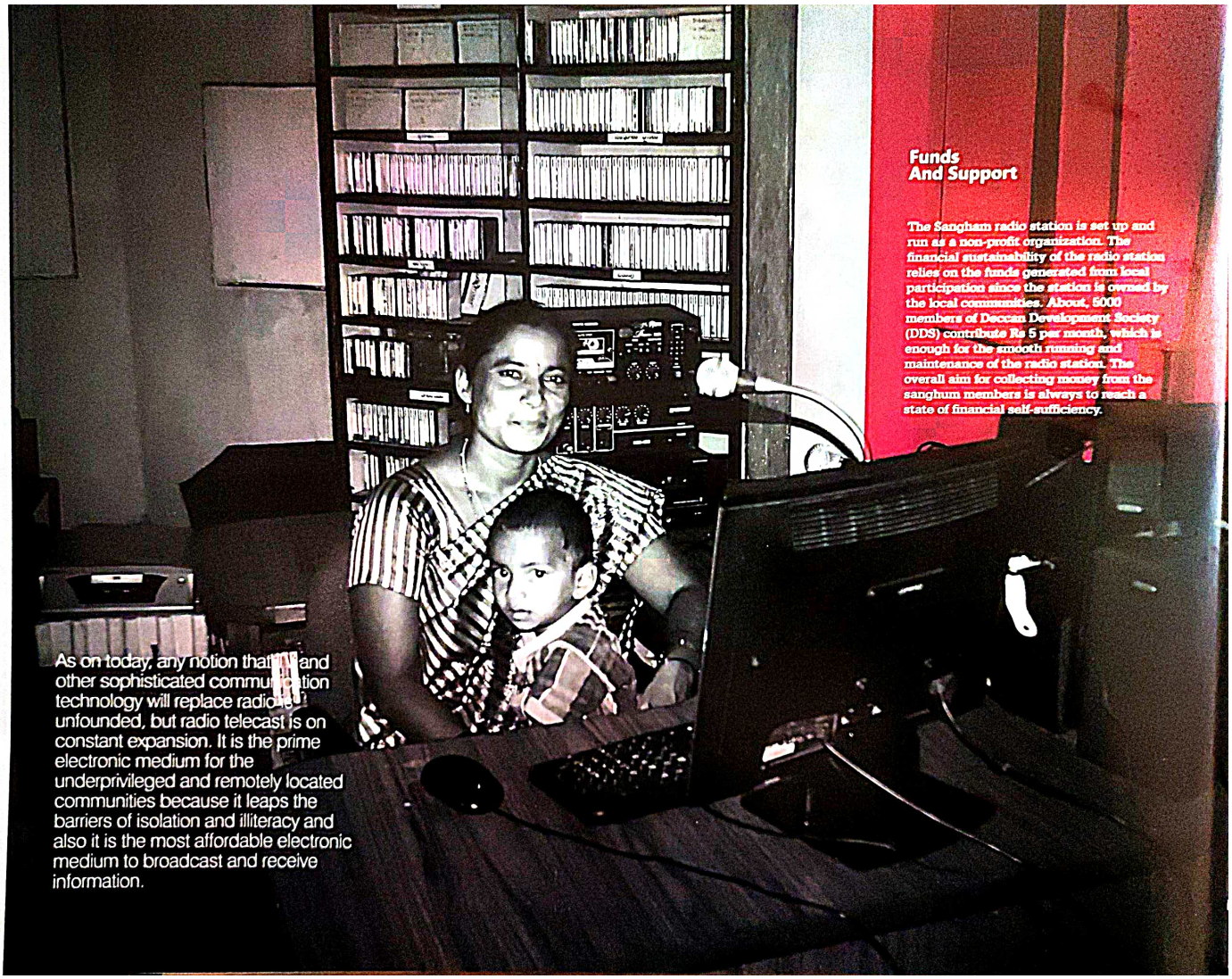
The Community media is complementary rather than being antagonistic and mutually exclusive, since the community media presents local content with a local flavor and language. The importance of the community media such as community radio stations lies with the element of proximity since people are more enthusiastic to know on a daily basis about the local happening, issues of the common people, and events unfolding next to their place of abode.

The local communities of the Zaheerabad district in Andhra Pradesh under the organization Deccan Development Society (DDS) have started a community radio broadcasting station (Sangham radio) with the help on UNESCO under the program 'Women Speak to Women' in 1999. The Deccan Development Society has been working with the community for several years in the region. The radio station is located in Machnoor Village, Jharasangam Mandal, in Medak District of Andhra Pradesh. It is about 110kms to the south west of Hyderabad, Andhra Pradesh.

The radio broadcasting station got license in 2007 from Government of India and since then the station is broadcasting programs covering different local issues. The radio station is operated by a group of trained local women. The waves of this station reach almost every corner of the district covering 45 km radius (100 villages) in four mandals of Zaheerabad, Jharasangam, Raikode and Nyalkal with population above 150,000 individuals, for the communication of information related to agriculture, agro-biodiversity and local traditions for the betterment and long term sustainability. Today with the help of this radio station the farming communities of the region are encouraged to listen and participate in discussions on issues specific to the region.

Sangham radio station is the only station in India owned, run and managed completely by local woman belonging to socially backward community. Its operation and management by the trained local women is a major breakthrough, where the deprived rural women of the region today are equipped with this technology and the platform, where they can express their thoughts, knowledge and ideas on the local issues.

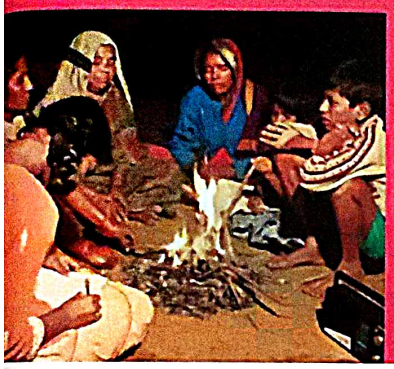
The radio station broadcasts program using an FM band for two hours daily from 7pm to 9pm. The major thrust of the programs is to establish community leadership for woman and to end media exclusion of the marginalized. The programs of the station covers diverse array of issues related to food sovereignty, ecological agriculture, traditional knowledge, local traditions and community care of natural resources etc.



Funds And Support

The Sangham radio station is set up and run as a non-profit organization. The financial sustainability of the radio station relies on the funds generated from local participation since the station is owned by the local communities. About, 5000 members of Deccan Development Society (DDS) contribute Re 5 per month, which is enough for the smooth running and maintenance of the radio station. The overall aim for collecting money from the sanghum members is always to reach a state of financial self-sufficiency.

As on today, any notion that TV and other sophisticated communication technology will replace radio is unfounded, but radio telecast is on constant expansion. It is the prime electronic medium for the underprivileged and remotely located communities because it leaps the barriers of isolation and illiteracy and also it is the most affordable electronic medium to broadcast and receive information.



Community Participation for Program Development

The DDS Community Media Trust (CMT) formed by a group of rural women from backward and marginalized communities manage the radio station. The content of the program are developed by the local participation in which over 20 women and a few men meet every month to chart out the programmes which are to be broadcasted. There is a continuous interaction between producers and the listeners related to the programs and the radio itself acts as a principal channel for this interaction, in addition to this the radio station also airs its phone number to get feedback on regular basis for the improvement and development of the programs. There are unrestricted opportunities for the community members, as individuals or groups, to produce programmes and were also helped by the radio station staff using the technical production facilities available at the station. This makes the sangham radio station truly community driven, as they are involved in programme development and management. The programs aired by the radio station covering subject including farm extension, cultural discussions on agriculture subjects and weather based crop advisory in the local language. The Sangham radio also air community cultural programs includes local music, poetry, and so on for the cultural conservation.

Role of Sanghum Radio Station in Sustainable Land and Ecosystem Management

Sanghum radio station is the only one of its kind helping the marginalized communities in various ways. The programs of the radio station are creating general awareness about the issues related to agricultural land management and also to conserve agro-biodiversity in the region. The Sanghum radio station is giving voice to local community which are having rich knowledge base related to traditional agricultural practices, ethnoveterinary practices etc., which is undermined by the mainstream media. In Zheerabad district of Andhra Pradesh this radio station is have done excellent work with respect to awareness creation and serving an great medium of communication and dissemination of information for the betterment of the local society. It is advisable to start and support such community radio stations in remotely located areas for better dissemination and should be up-scaled.

SUSTAINABLE MANAGEMENT OF RESOURCES FOR LIVELIHOOD IMPROVEMENT THROUGH WATERSHED MANAGEMENT IN HILLS OF UTTARAKHAND

The Himalayan system covers about 18% geographical area of India, accounting for nearly 50% of its forest cover and supporting livelihood of more than 600 million people. Although the Himalayas are the largest store house of fresh water, origin of mighty rivers likes

Ganges and Yamuna but overexploitation of forests, depleted forest cover, excessive runoff and soil erosion are root causes of hydrological imbalances, drying up of springs and scarcity of water, which is major concern in the state of Uttarakhand. About 70% of the population of the State is engaged in agriculture, which cover hardly 14% of its area. Hill agriculture is characterized by small and scattered holdings in the form of rain fed terraces under low cropping intensity with traditional crops, without use of fertilizers thus producing low yields. More than 55% of the cultivated land in the state is rain-fed where traditional faming is in vogue. The rain-fed hilly regions show a grave picture of ecosystem fragility, land degradation, water scarcity and poverty. Hill people subsist mostly on the forest resources, which make 64%, and partly on horticulture, livestock rearing and tourism. The forests are under depilated condition due to high biotic pressure and unscientific management. Both agriculture and forestry sectors are poorly developed primarily because of inaccessibility and vulnerability of terrain, weak investment capacity of people and limited exposure to modern technology.

Watershed management is the well accepted approach for land management and livelihood security in hilly region, endowed with well defined watersheds. However, Himalayan watersheds suffer seriously by mass wasting and landslides, soil erosion and often by natural calamities through meandering of rivers, torrential rainfall on fragile ecosystem under excessive human pressure. The challenges of hilly inaccessible rain fed region are to improve rural livelihood and quality of life.

Watershed development envisaging integrated management of land and water resources, improved farming system using high yielding cultivars, improved technology for enhancing productivity and income and livelihood security. Harvesting of rain water and its appropriate use, alternative source of energy and fodder to reduce pressure on forests, development of agro-based cottage industries, alternative source of livelihood, and market links is equally important to reap benefits of hard labor of hill farmers.

A large number of watershed programs have been developed the State of Uttarakhand under various schemes like, National Watershed Project on Rain-fed Agriculture (NWPRA), Integrated Watershed Management Project (IWMP) and foreign aided projects. A success story of one

IWDP watershed in Almora district implemented by the Agriculture Department of Government of Uttarakhand is presented.

Study Area

A typical Himalayan watershed of 598 ha at 1370 to 1980 m elevation Developed, at 55 Km from Almora covering six villages namely covering Natdol, Kawani, Bhangadevli, Manduli, Hotpulla and Nain villages was developed in Almora distnct. The average annual rainfall of the area is 1440 mm and temperature ranged from from -5oC to 28oC .Forests occupy more than 60% in the upper reaches. Natural vegetation consisted of tropical pines and oak forests, which was heavily lopped for fuel and fodder particularly near habitations. Agriculture and horticulture plantations are common in valley portion and the lower reaches of the watershed. The major crops of the region are paddy, maize, potato and millets like Mandua and Jhigora. Apple, walnut, pear, peach, plum and mango are common fruit plants. The watershed program was implemented during 2008-12 with financial support of 72 lakhs from the Central Government.

The watershed plan was prepared after the participatory rural appraisal exercise conducted by the stakeholders. The needs

of the area were consolidated and the location specific bottom up plan and activities were designed by the people with minimum guidance from the top. The water activities envisaged: soil and water conservation, control of gully erosion, rain water conservation and harvesting for improving stream flow and agriculture. Improved diversified farming system was adopted using, vegetables, fruits, animals and poultry. Self Help Groups were formed for marketing the produce.

Fig. 1
Stone check dams for controlling the gully erosion

Fig. 2
Water conservation pits for recharging springs

A typical Himalayan watershed of 598 ha at 1370 to 1980 m elevation Developed, at 55 Km from Almora covering six villages namely covering Natdol, Kawani, Bhangadevli, Manduli, Hotpulla and Nain villages was developed in Almora district. The average annual rainfall of the area is 1440 mm and temperature ranged from from -5oC to 28oC .Forests occupy more than 60% in the upper reaches. Natural vegetation consisted of tropical pines and oak forests, which was heavily lopped for fuel and fodder particularly near habitations. Agriculture and horticulture plantations are common in valley portion and the lower reaches of the watershed. The major crops of the region are paddy, maize, potato and millets like Mandua and Jhigora. Apple, walnut, pear, peach, plum and mango are common fruit plants. The watershed program was implemented during 2008-12 with financial support of 72 lakhs from the Central Government.

The watershed plan was prepared after the participatory rural appraisal exercise conducted by the stakeholders. The needs of the area were consolidated and the location specific bottom up plan and activities were designed by the people with minimum guidance from the top. The water activities envisaged: soil and water conservation, control of gully erosion, rain water conservation and harvesting for improving stream flow and agriculture. Improved diversified farming system was adopted using, vegetables, fruits, animals and poultry. Self Help Groups were formed for marketing the produce.

Soil and Water Conservation Activities

Dry stone check dams supported by the vegetation were constructed in the upper and middle reaches for controlling gullies, widening of Nullah to arrest runoff and sediment loss (Fig.1). Landslides Road side stone masonry wall Pustas were constructed and stabilized by vegetation to control landslides.

Recharge Pits

Large numbers contour trenches and recharge pits (1mx1mx1m) were dug out on slopes for conserving rain water for recharging streams and making perennial flow of springs. After digging pits, 30-40 mm size stones are filled up to the height of 25 cm, then sand is filled to another 25 cm and then the remaining pit is filled with stones having larger size of 100-150 cm Fig.2). This has resulted in increased base flow and revitalized the stream flow. Farmers also draw the water directly from the small storage for drinking. The streams, which used to dry up earlier, resumed a perennial flow of water.

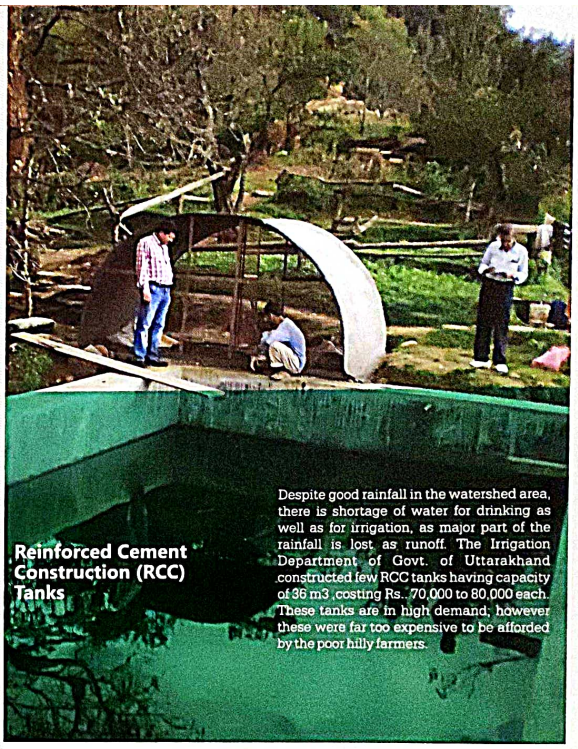


Fig.4 *RCC tanks for Irrigation, poultry and Fish farming*

Reinforced Cement Construction (RCC) Tanks

Despite good rainfall in the watershed area, there is shortage of water for drinking as well as for irrigation, as major part of the rainfall is lost as runoff. The Irrigation Department of Govt. of Uttarakhand constructed few RCC tanks having capacity of 36 m3 ,costing Rs.. 70,000 to 80,000 each. These tanks are in high demand; however these were far too expensive to be afforded by the poor hilly farmers.

Polythene Tanks

Considering high demand for the tanks by the farmers and heavy construction cost on RCC tanks, Soil Conservation Department introduced Polythene tanks, which were much cheaper than RCC tanks. The construction cost of polythene tanks of the same capacity worked out to be Rs. 20,000 to 25,000 each. Farmers are willing to share up to 50% cost of construction of polythene tanks (Fig.3). So far 36 tanks have been constructed in the watershed on 50% subsidy. These tanks

are being utilized for cultivation of vegetables and crops through small irrigationchannel (Guhl) and micro-irrigation, which is 100% subsidized by the Government. Polythene tanks have quite popular with farmers and changed the face of agriculture scenario and become. These are in great demand now.

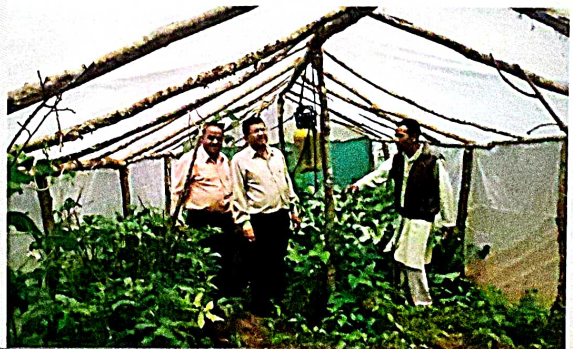


Fig .5 *Vegetable cultivation in a poly house*

RCC Tanks for Irrigation and Fish Farming

A few enthusiastic farmers have also constructed RCC tanks of the capacity of 60 m3 (10mx 4mx 1.5m) with trapezoidal design on 50% subsidy. Diversification of these tanks for vegetable cultivation, fish culture and poultry farming has helped in recovering the cost of RCC tanks (Fig.4).

Diversification Through Cash/ Vegetable Crops

Availability of water has induced remarkable shift in cropping pattern and crop diversification. Traditional crops are being replaced by improved varieties of cash crops, vegetables and fruits. For this purpose, more than 40 poly houses have been made to grow quality vegetables like peas, chillies tomato, capsicum, cabbage, cauliflower and cucurbits etc. Kiwi fruit has also been introduced in the area and performing well (Fig.7). however, there is dearth of market facilities. Quality fodder production has been popularized for livestock rearing and help reduce pressure on the forests. Artificial insemination and distribution of quality bulls and bucks is being done for breed improvement and milk production in the watershed area.

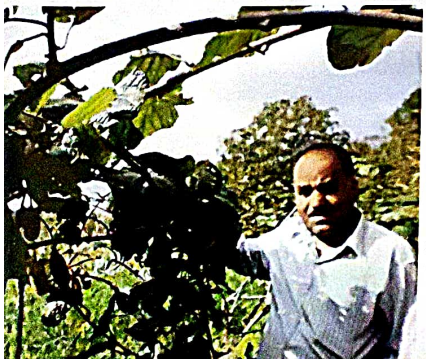
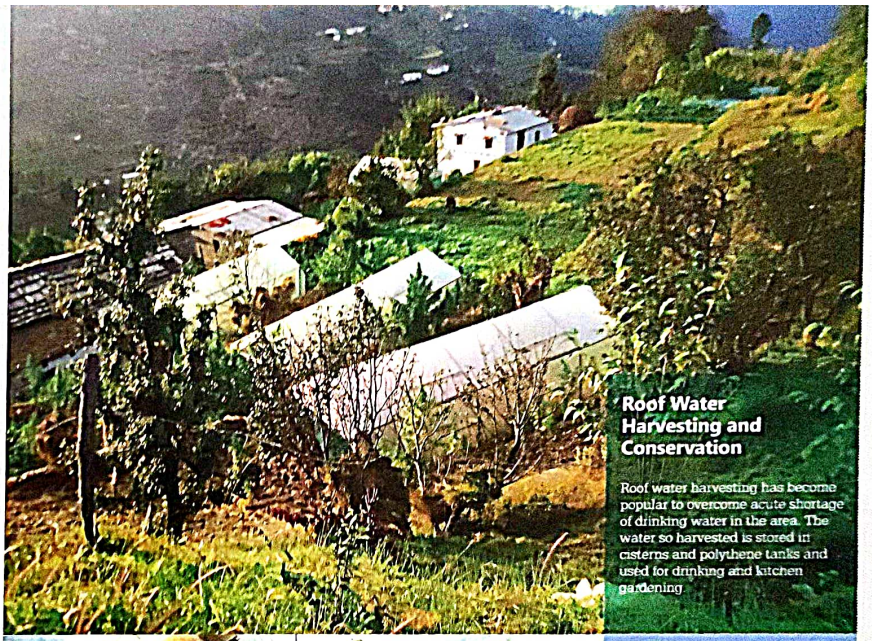


Fig.7 Kiwi fruits- in the watershed area

Fig .6 *Series of poly Ploy houses for growing cash crops*



Roof Water Harvesting and Conservation

Roof water harvesting has become popular to overcome acute shortage of drinking water in the area. The water so harvested is stored in cisterns and polythene tanks and used for drinking and kitchen gardening.

Fig.8 *Back yard poultry for improvement of family nutrition and income*

Backyard Poultry

On the initiative of project authorities, backyard poultry has become very popular in the watershed area (Fig 8). About 5-10 birds are kept by the majority of the project farmers for improving their family nutrition and supplementing income. One piece of egg is sold at the rate of Rs. 8-9 and broiler for Rs. 500-600.

Zero Energy Storage Structure

The watershed villages are located in remote areas and the marketing facility for fruits, vegetables, milk and flowers are very poor. Some farmers have built up zero energy storage structures of 4mx3m and 2m deep having capacity of 40 boxes of fruits/vegetables for cooling for about 15-20 days. They also store milk for few hours. This helps farmers to get good prices of produce by increased shelf life of vegetables, fruits, eggs and milk (Fig. 9).

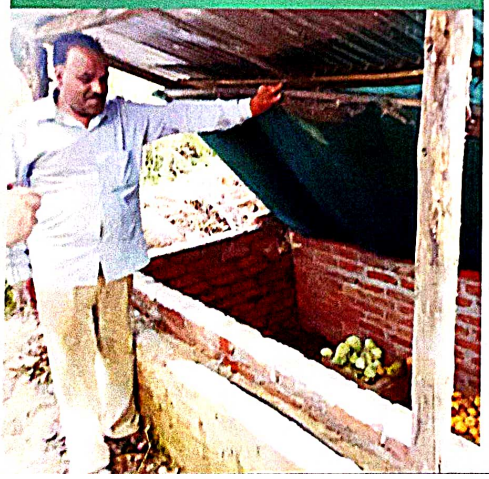


Fig.9 *Zero Energy storage chamber for enhancing shelf life*

Impact of Watershed Management and up Scaling

Interacting with few farmers in the watershed area has shown that there has been improvement in their productivity and income due to better irrigation facilities and diversification to cash and vegetable crops. There has been more production of fodder and improved breeds of animals which have resulted in increase in the milk yield in the watershed area as seen by the example of two farmers (Table 1). This was also true for other farmers participating in the program, however, they were not willing to reveal their income.

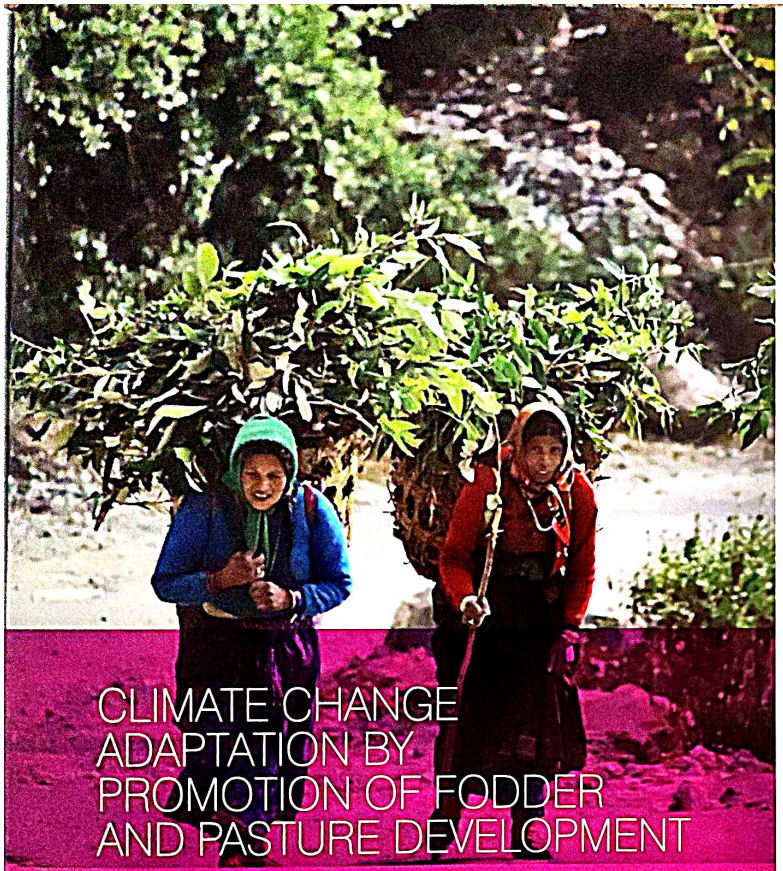
Encouraged by the past results, Government of Uttarakhand is focusing on the implementation of watershed development in other untreated areas of the state through various schemes and international funding. Watershed development is a very promising in the hilly areas of the State due to direct benefits, which would generate employment opportunities and boost socio-economic conditions of hilly people. However, there is a need to lay more emphasis on development of non-arable land for fuel fodder, afforestation with multipurpose tree species, community based forest protection measures to reduce pressure on the forest resources by creating alternative sources of energy. A good green cover and conservation of the forests may be the remedy of many problems of the hilly region. This will also help reduce out migration of the youth from the watershed areas and improve quality of life for hilly people.

Table 1 Impact of Watershed Management

Name of farmer	Treatment area (ha) area (ha)	Income before intervention	Income after intervention
Sh DayaKishan Belwal	1.7 ha	Rs. 1.5 to 1.7 lakhs	Rs. 2.5 to 3.0 lakhs
Sh. M.L. Sharma	1.0 ha	Rs. 1.2 lakhs	Rs. 2.4 lakhs
Sediment loss*	598	9.2 t/ha	4.9 t/ha
Peak discharged*	598	28 %	18%

***Source** *Joshi and Negi, (2006)*

The studies on an adjoining watershed have revealed (Table 1) that watershed development reduced peak rates of runoff and sediment loss from the treated area and prevented land degradation in the hills of Uttarakhand, which is required for sustainable land management of resources and livelihood improvement in Uttarahand.



CLIMATE CHANGE ADAPTATION BY PROMOTION OF FODDER AND PASTURE DEVELOPMENT

FOR ANIMAL BASED FARMING SYSTEM IN HILLS OF UTTARAKHAND

Global warming as a consequent of climate change has become a worldwide concern especially in dry regions. According IPCC, 2013 the rate of warming per decade has been [1951 -2012; 0.12 (0.08 to 0.14°C)]. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. Climate Change projects increased in amount and intensity of precipitation, higher runoff in wet season, extreme events like floods, hot and cold waves and droughts, reduced rainfall in dry areas and impacting the hydrological cycle culminating increased evaporative demand, water requirement of crops, reduced water availability, drought like situation causing lowering crop yields in tropic and subtropics. Animal based farming system, agro-forestry, use of multi-purpose fodder trees, crop diversification, fodders and forest-based enterprises have tremendous adaptation potential for alleviating adverse impacts of climate change and improving livelihood.

India has about 17% of the world's livestock population, which is the source of livelihood of 75% small and marginal farmers, particularly in arid and semi-arid regions. Livestock contribute 15-20% to the household income of farmers, about 9% to the National GDP and 25% to agricultural GDP. Incidences of farmers committing suicide in distressed states of Maharashtra, Karnataka and Andhra Pradesh were confined exclusively to families surviving on rain fed agriculture. Those depending partly or fully on dairy husbandry for livelihood were able to withstand stress (Hegde, 2006). Besides genetic potential and animal health care, availability of fodder and feed, which declines due to drought, shrinking grazing land and pastures and low priority on fodder crops are big handicap in realizing vast livestock potential in the country.

Fodder Situation in India

The area under cultivated fodders in India is 8.3 M ha, which has remained static for the last 3-4 decades. Sorghum (2.6 M ha) and Berseem (Egyptian clover) 1.9 M ha account for 54% area under fodder crops. Sizeable fodder demand is fulfilled via pastures and common property resources, which are dilapidated due to overgrazing. The fodder supply situation in India is extremely precarious. The livestock is chronically underfed due to wide gap between demand and supply (Table 1). About 54% of the fodder needs are met from crop residues of paddy, wheat, sorghum, maize, pearl millet, groundnut, beans and gram, 18% from grassland and only 28% from cultivated fodder. Despite huge demand for fodder, crop residues are burnt in many regions of Punjab, Haryana and Uttar Pradesh.

Table 1: Feed and Fodder Availability and Requirement in India (2005-06)

Feed	Requirement (mt)	Availability (mt)	Shortfall (%)
Concentrate	123	45	63.41
Green Fodder	1025	390	61.95
Dry Fodder	570	443	22.28

Source: *Hegde (2006)*

Over 90% marginal farmers (69.4% medium and 21.75% small), owe 90-95% livestock, who are unable to devote their small holdings for fodder as grain production is their priority. About 4.4% of the cropped area is devoted to crops with little scope of increasing due fierce demand on land for other uses. A little increase in area under fodder crops in peri-urban regions is for the want of milk sheds and intensive dairying. The deficiency of fodder in arid, semi arid region turn pathetic during drought years but the perpetual shortage of fodder in middle hills of Uttarakhand despite high rainfall is alarming in view of decline of pastures of temperate regions due to upward shifting of cultivation line on account of climate change. Therefore adequate emphasis on fodder production and pastures is essential for adaptation of climate change and counteract the adverse impact on animal production system.

Forage Production on Waste Lands

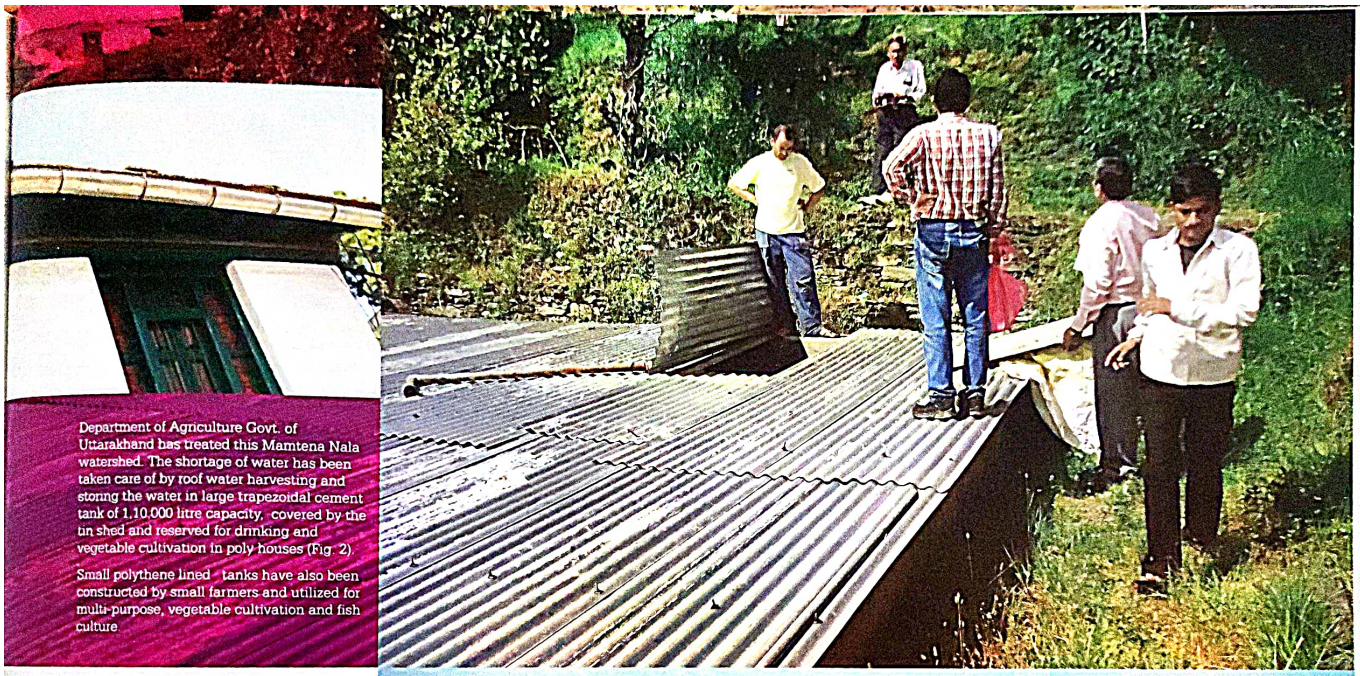
Waste lands occupy more than 30% of geographical area of the country covering large proportion of sandy wastes and barren lands in dry regions and ample of denuded hills of Uttarakhand. These are the ideal resource for developing forages by greening such lands by native and exotic fodder trees, hardy grasses, silvipastures and agro-forestry. In arid western Rajasthan, seeding of range lands by the seven grass (Eueloliopsis binnata) prior to the rainy season and controlled grazing have been found very effective in range management by the Jaisalmer Research Centre of Central Arid Zone Research Institute. The native and exotic fodder trees like Acacias, Prosopis cineraria, Ziziphus sp., Ardu (Ailanthus excelsa), Hardwikia binnata, Albizzia lebback and shrubs like stylo, seratro, hedge lucerne and forage legumes can be utilized in dry regions. Marginal less fertile lands can be utilized for cultivating drought tolerant horticultural species such as Zuzube, custard apple, tamarind, Indian gooseberry, etc, wherein grasses can be grown as intercrop. The bunds and borders of these fields should be used for growing fodder and fuel tree species like subabul, gliricidia, acacia, sesbania, etc. which become reliable sources of fodder during scanty summer period.

Common Property Resources

Generally, about 5% to 10% of the land area in every village in Rajasthan llocally known as Oran, Gochar and Agore are reserved for community pastures, whose productivity has severely eroded due to uncontrolled grazing. Such lands should be developed a improved silvipastures involving local community. An example is set by a village Laporia near Jaipur, where excellent pastures have been developed by the village society called Gram Vikas Navyuvak Mandal through an innovative Chauka System envisaging rain water harvesting in small rectangles, which are developed as pastures. The rainwater is diverted to village ponds and utilized for multiple uses of humans and livestock, crops, fodders and recharging ground water.

Forage Production In A Hilly Watershed

In a hilly Mamtena Nala watershed near Almora, the situation of fodder was extremely deplorable particularly on southern slopes, which are bone dry and hardly any grass is visible. Most of the rainfall is lost as runoff from the hilly slopes and drought like situation prevails after the rainy season. The Bisna Eco Resort in this watershed faces acute shortage of water and rural people confront chronicle problem of fodder scarcity Women in hills have to walk miles to get head load of fodder from the trees and bushes and spent about 50% of their working hours to arrange the fodder and fuel wood. Livestock, which is an integral part of hill agriculture, is left to survive on tree stumps and dry bushes. The situation of forage becomes precarious in winters due to freezing temperatures and very slow growth of the vegetation. Traditionally, mixture of cowpea + maize and tree foliage is utilized to meet fodder needs in hilly region (Fig.1).



Department of Agriculture Govt. of Uttarakhand has treated this Mamtena Nala watershed. The shortage of water has been taken care of by roof water harvesting and storing the water in large trapezoidal cement tank of 1,10,000 litre capacity, covered by the tin shed and reserved for drinking and vegetable cultivation in poly houses (Fig. 2).

Small polythene lined tanks have also been constructed by small farmers and utilized for multi-purpose, vegetable cultivation and fish culture.

Package of Practices in Hills

Conservation of rain water is the first step on slopy terrain, which was achieved by digging large number of recharge pits and contour trenches on hill slope prior to the rainy season. The grass seeds were sown on the lower side of the brim (Fig. 3).

Grass germinates and gets advantage of the better moisture regime and grew well. The watershed became full of grass for grazing during the rainy season. The extra grass is cut during the post rainy season, dried and saved on the tree trunks for scarcity period of winters (Fig. 4).

Fig. 3 *Recharge pits for conservation rainwater*

Fig. 4 *Staking of Dry grass for winter season*

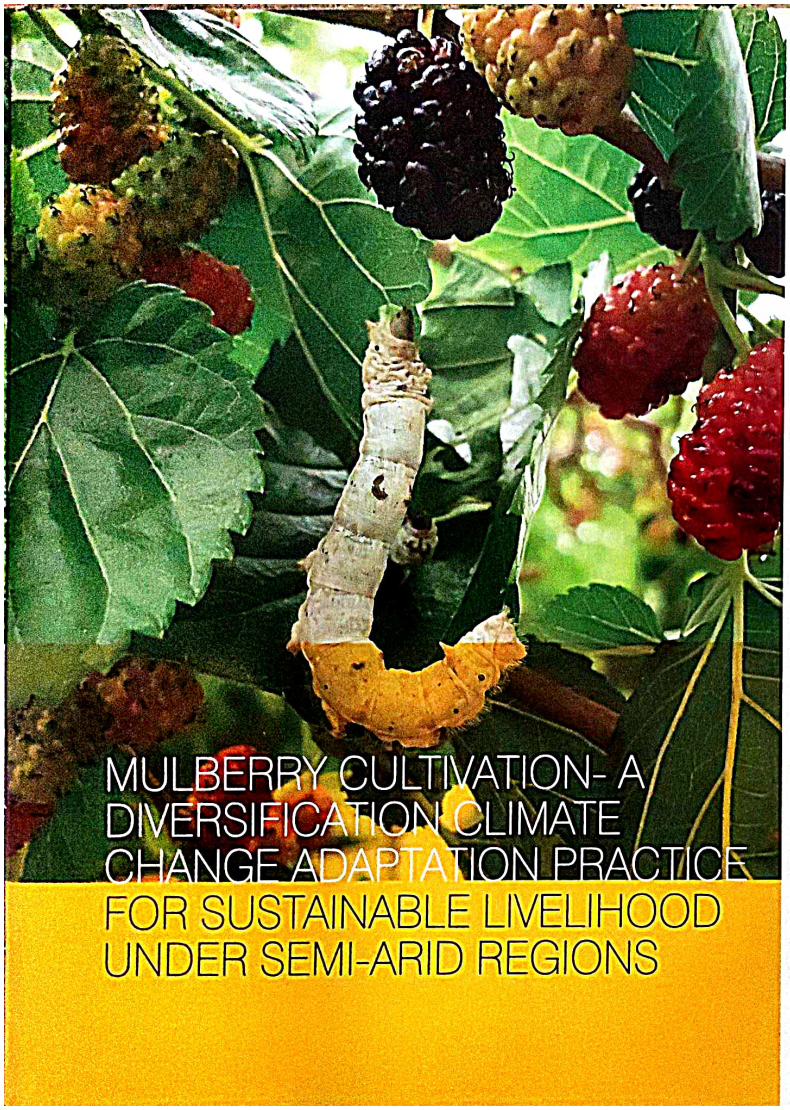
Utilizing Terrace Risers for Growing of Napier

Construction of Bench terraces is expansive, which are exclusively utilized for crops and vegetables and can hardly be diverted for fodder crops. However, the risers were utilized for growing fodder Napier grass, which provides good quality fodder and strengthen the riser against erosion (Fig. 5). Suitable fodder trees in hilly region are: Oak, Alder (Alanus nepalensis),

Acacia catechu and Grevetia opiva, Morus alba, Bahuniam pepuria with large number of grass species like Dichanthium annulatum and Cenchrus ciliaris etc.

Strategy for Forage Production

1. The waste lands,common property resources, field bunds, terraces risers and hedges should be utilized for fodder production. At least 5-10% cultivated land should be diverted to grow fodder for improved/ quality animals.
2. Selection and breeding of high yielding and stress tolerant fodder varieties and popularizing with improved package of practices.
3. Developing high fodder value crop genotype without compromising on grain yield.
4. Timely harvesting and processing/ storage of crops to prevent wastage. Feeding chaffed stalk is reported to reduce wastage by 25-30% and methane emission by 10%.
5. Spare crop residues from burning and industrial uses and utilize for fodder.
6. Set up fodder banks in surplus fodder years to meet scarcity needs (Fig 6).
7. Economize transportation by converting fodder into compact feed blocks for (Fig. 7).



MULBERRY CULTIVATION- A DIVERSIFICATION CLIMATE CHANGE ADAPTATION PRACTICE FOR SUSTAINABLE LIVELIHOOD UNDER SEMI-ARID REGIONS

Excerpts of changes in climate system since 1950 have revealed warming of atmosphere and ocean, diminishing in snow and ice cover, rise in sea level and increased in concentration of green house gases (IPCC, 2013). The rate of warming per decade has been (1951 -2012; O.12 [0.08 to 0.14°C]. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. In the Northern Hemisphere, 1983-2012 was likely the warmest 30-year period of the last 1400 years (Fig. 1; IPCC, 2013). IPCC (2007) projected an increase of mean surface temperature by 2.0 to 4.5°C by turn the of 2100. There has also been increased in amount and intensity of precipitation, higher runoff in wet season, probability of occurrence of extreme events like floods, hot and cold waves and droughts and reduced rains in dry areas. These changes adversely affect all aspects of hydrological cycle, culminating in increased evaporative demand, reduced water availability, increased water requirement of crops and water stress or drought like situation causing lowering of crop yields more in tropic and subtropics especially when the temperature rise is more than 3°C. Studies at Indian Agricultural Research Institute (IARI) have indicate that there is possibility of loss of 4-5 million tons of wheat production in the country with every degree rise in temperature (Agarwal, 2007).

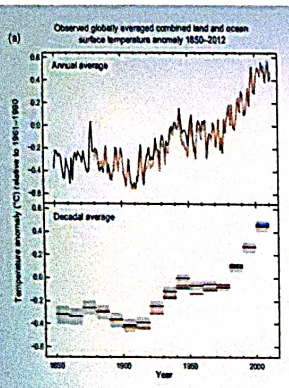


Table1. Average Yield of rain fed crops in dry States during in past decade (Yield kg/ha)

Crop	2003-04	2011-12	% reduction
Bajra	1168	920	21.3
Smaller millets	569	445	22.1
Gram	789	694	14.0
Sorghum	938	928	1.0
Pigeon pea	608	477	21.5

(**Source:** *Indiasat*)

Dryland States of Rajasthan, Maharashtra, Karnataka and Andhra Pradesh are prone to Desertification Land degradation and Drought (DLDD) and likely to suffer most due to impacts of climate change. With an exception to sorghum, the average yields of major dry land crops in the above States have shown a decline of 14 to 22% during the period 2003-04 to 2011-12 (Table 1). Sorghum, being a C4 plant, does not show significant response to increase in CO2 and hence its yield is not much affected. Besides, large scale adoption of improved varieties of sorghum might offset the adverse impact of climate change on sorghum production.

Adaption Strategies

Large number of adaptation studies such as agronomic practices, drought resistant cultivars, date of planting, crop geometry, alternative farming system, conservation tillage, runoff water harvesting, diversification and use of multi-purpose perennial trees in farming system may help reduce negative impacts of climate change. Studies at IARI have further shown that wheat production at 1°C increase in temperature can be reduced from 4-5 million tonnes to 1-2 million tonnes if large percentage of farmers could change the time of planting (Fig. 2) and grow better adapted varieties (Agarwal, 2007).

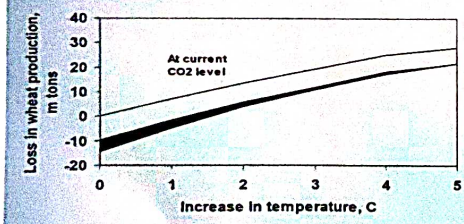


Fig 2 *Projected losses in wheat production due to increase in temperature at current and 550 ppm CO2 levels. The shaded area indicates losses that can be offset by adaptation options that is change in planting dates and variety (Source: Agrawal, 2007)*

Crop diversification invoking multipurpose perennial tree species, agro-forestry and forest-based enterprises have tremendous adaptation potential to alleviate climate change impacts on decreasing crop yields and improving incomes and livelihood. In the present case properties hardy multipurpose Mulberry tree species has been utilized for diversification and climate change adaptation.

Mulberry-a Multipurpose Perennial Species for Climate Change Adaptation

Mulberry is known as 'Kalpavriksha' because of its numerous uses and livelihood support to dependent inhabitants. Besides providing raw material for sericulture industry, mulberry leaves are excellent fodder, used for green manuring, twigs for basket making, fuel wood and trees for providing shade in tea/coffee plantation. Mulberry is grown from temperate to tropical climate and occupies about 2,82,244 ha area in India. Nearly 90 percent of the area falls in the tropical zone of Karnataka, Andhra Pradesh and Tamil Nadu states, where mulberry cultivation supports sericulture industry throughout the year. Mulberry leaves are rich food for the silkworm (Bombyx mori) and has major economic value in sericulture since the quality and quantity of leaf produced per unit area have a direct bearing on cocoon harvest. In sub-tropical zone, plains of West Bengal, Jammu and Kashmir and Uttarakhand are also suitable for its cultivation. In the state of Uttarakhand about 4,000 families are growing mulberry with a turnover of 3.00 crores. There are many species of Morus, of which M. alba, M. indica, M. serrata and M. laevigata grow wild in the Himalayas. Most of the Indian varieties of mulberry belong to M. indica. Being a deciduous plant only two flushof mulberry allow only two yearly harvest of cocoon in Uttarakhand region. In addition, moonga silkworm, a polyphagous insect, can be reared on variety of hosts in hilly region.

Mulberry is a fast growing woody perennial with deep root system, capable of growing both under rain-fed and irrigated conditions, as sole or intercrop and as shade provider plant to plantation of coffe/tea. Mulberry cultivation offers an alternative to traditional sorghum, millets, groundnut and cotton cropping in peninsular India, where cost of irrigation and insecticides are major deterrent. Under climate change scenario projected to intensify quest for water, increased frequency of drought and extreme weather events, diversification of agriculture by adopting mulberry cultivation and silkworm rearing becomes an dependable alternative and source of sustainable livelihood to engage family labor in sericulture year round l in place of low yielding dry land crops. An on farm trial of 1.5 ha at Sri Aurobindo Krishi Vigyan Kendra, Gaddipally, diversified adaptation strategy of mulberry cultivation enabled a farmer to earn Rs 1,86,975 per hectare per year from six cuttings of mulberry. He invested Rs 1 03,450 in the first year for making provision for drip irrigation and Rs 70,000 in the second year. Kanva-2, S-36 and Victona-1 (V-1) were utilized, which have potential to produce 10-12 t/ha per harvest (35-45 t/ha/yr) quality leaves, however, V-1 hybrid has potential to produce up to 70 t/ha/year.

The well drained, fertile, clayey black cotton soils having good moisture holding capacity and 6.2-6.8 pH were suitable for mulberry cultivation. One 30-35 cm deep ploughing by mould board plough followed by 2-3 disking/cultivation are required to achieve good tilth. A basal dose of 20 tonnes/ha well decomposed FYM or compost was thoroughly incorporated. Branches of 6-9 months old plants, having 15 mm diameter and 15-18 cm length with three to four healthy buds were utilized for preparation of cuttings and planting directly in the field. The planting of the crop was performed at spacing of 90X90 cm and in paired rows 90+55 cm x 60 cm on raised beds with furrows for irrigation /drainage. Subsequently drip irrigation was laid down (Fig.3). Moon bean is being intercropped in mulberry for additional income. First weeding was carried out two months after planting and second after two to three months. Thereafter weeding was done after every shoot or leaf harvest. The plantation was performed during the onset of the monsoon and after cession of rains. Irrigation was done at regular intervals of 8-14 days or as and when required. In the first year, 100 N: 50 P: 50 K/kg/ha/year was applied in two splits. The half of nitrogen and entire phosphorus and potash was applied at two months after plantation.

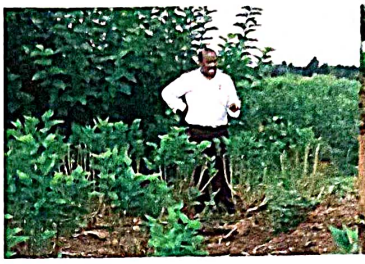


Fig 4 *Mulberry crop at different stages of cuttings*

Fig 5 *Mulberry crop at different stages of cuttings*

Fig 6 *Silkworm at full maturity stage*

The remaining 50 kg N/ha was applied after leaf harvesting. After six months of plantation, mulberry attains a height of 1.5 to 1.75 m and is ready for first harvest by bottom pruning. The second leaf harvesting is 12 weeks after the first and the third after 12 weeks from the second harvest by shoot harvest. From the second year onwards, harvesting was done at an interval of 70 days by the shoot harvest method (Fig. 4). In fact entire crop area was divided in four quarters and the harvesting was followed in rotation to obtain the leaves regularly (Fig. 5), which were fed to silkworm (Fig 6). The expected yield of varieties is Kanva-2, 32-35; S-36, 38-45; and Victoria-1, 60-70 tonnes/ha/year. Mulberry can be successfully grown as an intercrop (mixed tree) between rows of tea/coffee as shade plants. Besides providing shade, a substantial quantity of leaves can be obtained for silkworm rearing and for feeding cattle and goats. Furthermore, the pruned shoots are a good source of firewood. Intercropping of pulses can also be taken at early stages for making system more economic.

Fig. 7 *Silkworm at Cocoon stage*

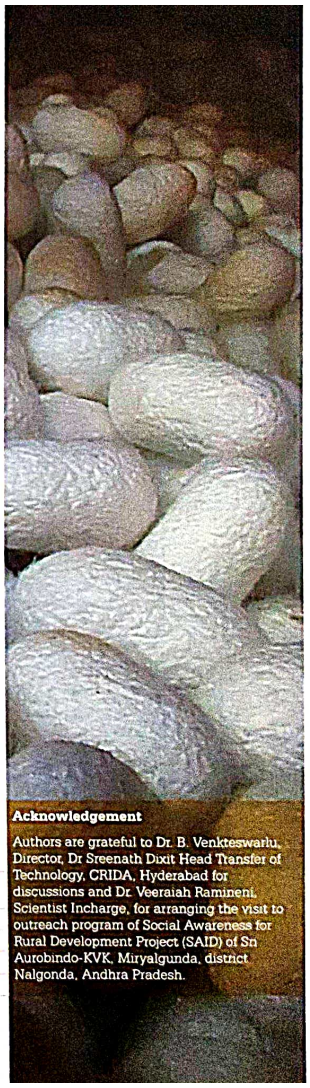
Rearing of Silkworm and Production of Cocoons

Nymph stage of silkworms is very delicate just after hatching, hence very soft leaves fed at this stage. These worms are kept in incubation rooms in trays at optimum temperature and humidity (25°±2°C and 80± 5%). Caterpillars are voracious feeder .In a span of 22-28 days silkworm gain 10,000 times in volume and 8,000 times in size. The worms change the mould four times during the growth period and become. The worm becomes sluggish after achieving the full growth and stop eating, turn transparent and semi-circular in shape. At this stage these worms are transferred to the isolation trays from active growing population. In about 72 hours such worms change to cocoon, which are sold by auction for further processing and extraction of silk (Fig. 5). In local market a kilo of cocoon can fetch about Rs. 300- 400 .On an average 15 oz worms can be reared from the produce of an hectare, which may yield about 1050 kg cocoon in two crops earning about Rs. 3,01,500/. Generally, farmers limit up to selling of cocoon, the economics of which is given Table 2. It is evident from the data that the mulberry cultivation for silkworm cocoon rearing provides 4-5 times higher income than any of the dry land cropping system It is an excellent climate change adaptation practice and a mechanism of drought proofing, making lush green fodder available to the livestock and provide sustainable livelihood to the all the members of the family throughout the year. The income can be multiplied many fold if cocoon are processed as per the recommendations of the Silk Board, and raw silk is extracted and sold in the market by establishing cottage industry and capacity building of Self Help Groups. 8).

Fig 8 *Unreeling Silk after processing of cocoon at Dehradun , U.K.*

Table 2 Comparative Economics crops and diversified climate adaptation practice

Particulars	Sorghum+Redgram (Rainfed)	Groundnut	Cotton	Mulberry
Cost of cultivation Rs ha?[1]	19,622	18,500	5,1310	1,03,450
Gross income Rs ha?[1]	49,230	24,640	92,764	2,90,425
Net benefit Rs ha?[1]	29,608	6,140	41,454	1,86,975
B C Ratio	2.7:1	1.33:1	1.78:1	2.83:1



Acknowledgement

Authors are grateful to Dr. B. Venkteswarlu, Director, Dr Sreenath Dixit Head Transfer of Technology, CRIDA, Hyderabad for discussions and Dr. Veeraiah Ramineni, Scientist Incharge, for arranging the visit to outreach program of Social Awareness for Rural Development Project (SAID) of Sri Aurobindo-KVK, Miryalgunda, district Nalgonda, Andhra Pradesh.

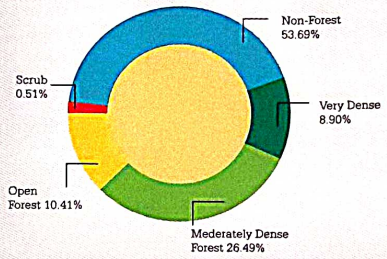
THE ROLE OF THE VAN PANCHAYATS IN SUSTAINABLE LAND AND ECO-SYSTEM MANAGEMENT

The Van Panchayat (VP) system is a prominent and successful example of participatory management of common natural forest resources in the state of Uttarakhand. Forests of Uttarakhand perhaps have longer history of peoples participation in forest management than any other part of the country. They owe their origins to the British Colonial Forest policy and were born out of conflicts and compromises that followed the settlement and reservation of forests in the hills at the turn of the 19th century. In 1910-17, the British government tightened its control over forest resources by notifying 7,500 square kilometers of commons as reserve forests, thus restricting people's access to forest produce. Elaborate rules were put in place for strict restrictions on the logging of fodder trees and grazing rights, prohibited agricultural extension, and the use of Forest fire for higher grass production. This sparked off a series of agitations by the local inhabitants who set forests on fire in protest. This forced the Government to pass the "Van Panchayat Act" in 1931, according to which 30% of the forests (Class I Forests and Civil Forests) were given back to the villagers, to be controlled and managed by the relatively autonomous Panchayats.

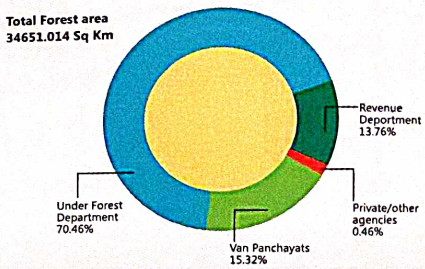
The VP is therefore the oldest people's institution involved in local management of natural resources. About 12089 Van Panchayats have been established in Uttarakhand. These Van Panchayats manage a forest area of about 5,44,964 hectares forming about 15.32 percent of the total area of the state in eleven hill districts (administrative units; Uttarakhand Forest Statistics 2009-10). Most of these have been carved out of civil (protected) forests under the jurisdiction of the Revenue Department. The area under each Van Panchayat ranges from a fraction of a hectare up to over 2,000 hectares.

The State forests are controlled and governed by the forest department. For historical reasons, state forests have been classified into 'un-demarcated' and 'demarcated' patches. Un-demarcated forests are known as 'civil soyam' forests and are not marked by boundary pillars. The department cannot impose prohibitions on these patches as regards rights of access and use. These were usually patches of forests between the village boundary and the demarcated state forest patches. A demarcated forest is an area notified under the Indian Forest Act of 1927. Locals can access such forests unless prohibited. For instance, the forest department can close plantation zones from use or stop the granting of timber rights from a degraded forest to promote regeneration. Demarcated forests are further categorized into 'demarcated protected forests' and 'reserved forests'. In Uttarakhand, most demarcated forest patches are 'reserved forests'.

Forest Cover in Uttarakhand



Forest Areas according to Management/Control against total Forest Area of state



The Working of the Van Panchayats in Uttrakhand

Initially the Van Panchayats were either carved out of reserve forests and governed by the Indian Forest Act, 1927 or carved out of civil soyam land and governed by the District Schedule Act, 1931. However, the 'Van Panchayat regulation 2005' has consolidated these two types of Van Panchayats into "Gram-Van" (village forest).

The Forest Panchayat Act (Forest Councils Act) of 1931 empowered the local community to form relatively autonomous (at local level) management committees for hill forests. This devolution of powers to control and manage forest for subsistence purpose is the earliest example of co-management of natural resources by the state and local communities in India. Since then, Van Panchayats or Forest Panchayats have been incorporated under Section 28(2) of the Indian Forest Act, 1927. Under this act, villagers can create community managed forests from forests controlled by the revenue department. to get Van Panchayat status the 'Gram Sabha' (village assembly) applies to the divisional commissioner and the application is to be signed by at least 66% of the adult population of the village. While all Van Panchayats in the state are governed by the Forest Panchayat Act, at village level, rules and regulations may differ.

The act entitles the villagers to demarcate the boundary of their Panchayat forests, protect it from illegal tree felling, fires, encroachments and cultivation. As per the Van Panchayat Rules, villagers themselves make the rules for day-to-day management. These rules relate to monitoring, dispute resolution mechanisms, selection of guards for enforcement of rules, fines for rule breakers, management of finances, equitable distribution of usufructs, and use of surplus earnings for the community. However the financial authority for the forest and soil works is vested with revenue and forest officials. The Forest Department is responsible for providing technical help to the villagers and it must be consulted before harvesting forest produce such as resin and timber. The officials of the Revenue Department are consulted for the enforcement of rules and sanctions.

The rules appear designed to ensure sustainable use of forest resources. In the case of firewood, extraction is restricted to 'dry-wood' only and, in the case of timber, only 'dried-trees' can be felled upon payment of a stipulated fee. There are quantitative restrictions on the extraction of firewood, fodder and leaf litter. Penalties are imposed in case of rule violations. Van Panchayats are

typically created in civil soyam forests in the vicinity of the villages. While a major objective is to rejuvenate and manage patches of civil-soyam forests for local use, it also prevents neighbouring villages from intruding into this zone, once formally demarcated as a 'Van Panchayat' forest.

The specific function of the Van Panchayats are as follows:

a) Prevent indiscriminate felling and tempering of fencing by villagers.

b) Ensure equitable distribution of forest produce amongst members.

c) Earmark eligible trees for felling.

d) Prevent encroachment of forest land by villagers for agricultural and other purposes.

e) Fix boundary pliers and ensure proper maintenance of pillars.

f) Carry out forestry operations as per advice of forest experts from forest department.

In the process of discharging these functions, Van Panchayat committees are allowed to impose fines, seize and impound cattle and forfeit weapons of violators/offenders. In addition to such formal measures, informal social sanctions can also be used. The Van Panchayats have the ability to raise revenues by selling grass, fallen twigs, stones and slates to local markets, tapping resins and felling trees with prior approval of the forest department and auctioning mature trees. Forests governed by VPs thus co-exist with state forests, often adjacent to one another. In this context, as with most others involving common property resources, it is thus evident that the management institution has evolved endogenously. The evidence suggests that local communities are more motivated to form a VP and manage forest areas under their control more effectively when these forests are more valuable to them and become degraded.

Impact of the Van Panchayats

Firewood and fodder extraction from the Himalayan forests is main cause of degradation of these forests. Excessive lopping results in stunted growth of trees and reduction in regenerative capacity; it also implies villagers have to spend more time within the forest in the future in seeking firewood and fodder. Ensuring sustainability of the forests and local livelihoods is thus a key policy issue. Though the VPs are not able to make a significant difference to other kinds of activities such as tree cutting, timber extraction or livestock grazing probably because such activities are harder to monitor than extraction of firewood and fodder, On average Van Panchayats in Uttaranchal are able to reduce the incidence of lopping by about 13 percentage points, which is significant compared with the average rate of lopping of 66 percent . These results are consistent with the hypothesis that more degraded forests are more likely to be converted to VP forests, and VP management subsequently improves forest quality, bringing them back on par with other forests.

Role of Van Panchayats in Watershed Development

Under the SLEM project, the VPs have been authorized by the State Government of Uttrakhand (GO, 2.12.09) to treat the reserve forest area, under any project, within a prescribed plan, so that the holistic treatment of any micro watershed (MWS)can be achieved. This is one of the first examples of institutional innovation for treatment of forest and non-forest areas. This unique institutional innovation leads to a synergistic model between the reserve forest area and area outside the reserve forest enabling the whole area to be treated within a prescribed plan.

Generally the Forest department is the only agency to undertake works in the forest areas. The SLEM approach involves land treatment at the MWS level, this may include areas both in reserve forests as well as areas which are outside the reserve forests, and under the gram Panchayat. Therefore the detailed plan for the watershed treatment are prepared with the consent of the concerned District Forest Officer with participation and implementation by the VP. In case some areas fall outside the boundary of the gram Panchayat , but within the concerned MWS, funds were directly transferred to the concerned Van Panchayat. This enabled the VP to undertake activities in the inter-Gram Panchayat spaces but within the MWS and ensured the treatment of the complete water shed.

Biodiversity groups have also been formed for each of the Van Panchayats for the maintenance of the watershed structures. In a bid to make this model self sustaining, the biodiversity group is given an amount of money as a corpus to carry out the works. Several other activities under the SLEM project have played a role in reduction in pressure on forests and aided the role of the Van Panchayats. The Bio gas intervention has been able to replace the fuelwood by 75 to 80% and Fuel wood load from the forest has been reduced from estimated 40,950 to 8,830 kg per year. The net 32,120 kg of biomass conserved is equivalent to protecting 30 trees annually and reducing more than 58 tons of CO_2 emissions per year. Women drudgery has been reduced as they are saving approx 2.5 hrs daily on account of firewood collection and water availability. Biogas production from each plant is estimated at 438 cum equivalent to 2010kg firewood valued at Rs 8040/year.

REDD-plus for Sustaining Himalayas a Case for Van Panchayats

The concept of REDD and REDD-plus

Reducing Emissions from Deforestation in developing countries (REDD) was introduced in UNFCCC negotiation as a potential approach for climate change mitigation in 2005. With inclusuion of Conservation and sustainable management of forests REDD is referred to as "REDD-plus". REDD plus is a mechanism to create an incentive for developing countries to reduce forestation and Forest degradation, protect, better manage and wisely use their forest resources, contributing to the global fight against climate change. REDD is a cutting-edge forestry initiative that aims at tipping the economic balance in favour of sustainable management of forests so that their formidable economic, environmental and social goods and services benefit countries, communities, biodiversity and forest users while also contributing to important reductions in greenhouse gas emissions.

Providing incentives REDD-plus incentives for Community based forest management (Van Panchayats)

a case for Uttarakhand: The Van Panchayat system as an institution at village level or village group level in particular has considerable potential for involving local communities in conservation and management of forests. REDD plus implementation is an iterative process, requiring regular appraisals and improvements at local (i.e., REDD projects) through international (i.e., UNFCCC) levels. Involving and passing financial incentives to local

communities can make the REDD plus a success at local (sub-national) and National level. Forest dwelling communities in India have been successful in transforming the deteriorating state of their natural forests to sustainable management, thereby avoiding deforestation and the subsequent release of CO2 emissions into the atmosphere. Van Panchayats and community based forest management in Uttarakhand have been successful in conserving the forest resources. All these activities and measures can fit into mitigation measures, with sizable potential for increasing the sequestration of carbon. There is excellent scope and opportunity for integrating the REDD plus initiative within the community controlled/managed forest and JFM activities. For this purpose, methodologies and modalities for a procedural framework will need to be worked out to ensure people's participation and sharing of the benefits accruing from REDD plus incentives.

Cancun Agreements And Redd Plus Safeguards

The Cancun agreement on REDD+ policy approaches decided on the scope of REDD+ that developing country Parties will implement and contribute to mitigation actions in the forest sector by undertaking the following activities, as deemed appropriate by each Party, in accordance with their respective capabilities and national circumstances

(a) Reducing emissions from deforestation;

(b) Reducing emissions from forest degradation;

(c) Conservation of forest carbon stocks;

(d) Sustainable management of forest;

(e) Enhancement of forest carbon stocks;

Cancun Agreements further decided that countries are to follow safeguards ensuring, for instance, the full participation of indigenous peoples, local communities and other stakeholders. The Cancun COP decision on REDD-Plus prescribes that actions should be consistent with the conservation of natural forests and biological diversity, ensuring that REDD-Plus actions are not used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests and their ecosystem services, and to enhance other social and environmental benefits.

The Three Phases of REDD-plus

The UNFCCC has agreed that REDD-plus will be implemented in three phases. The first phase involves the country developing a national REDD+ strategy or action plan, policy approaches, capacity building, [illegible] In the second phase, countries implement [illegible] In the third phase, countries [illegible] and verified.

REDD-plus Readiness for India

Considering the global mitigation potential of REDD plus, pilot/demonstration projects and REDD readiness activities have been initiated globally by multilateral institutions and bilateral arrangements. An implementation approach for REDD plus actions is needed in India. India has strong tradition of forest conservation that makes fit case for implementing a pilot study on REDD plus with the involvement of participating communities. Acknowledging the role of conservation of forest carbon stocks by the Van Panchayat communities in Uttarakhand, ICFRE with financial support from Uttarakhand Forest Department implementing Pilot REDD+ project in Van Panchayats of Uttarakhand. The Project envisages community participation in measuring, reporting and verification (MRV) of carbon in Van Panchayts, capacity building of participating communities and finally registering the project with voluntary carbon markets for providing financial incentives participating REDD plus Van Panchayat communities.

ANALYSIS OF BEST PRACTICES PROPERTIES AND THE ASSOCIATED BENEFITS

S no.	Name of Best Practice	Land use type	Agro-ecological Zones	Intensity of land degradation	Problem	Impact of best of the best practice	Land degradation	Biodiversity	Climate change adaptation	Socio-economic
1	On farm conservation of Genetically Important crop Landraces of Rajmash for Sustainable land and Ecosystem Management in Chamba District of Himachal Pradesh	Crop Land	Western Himalayas, warm subhumid (to humid with inclusion of perhumid) ecoregion [A15C(BA)4(5)]	Low	Biological degradation	+++		✓	✓	✓
2.	Managing Ground Water for Adaptation to Climate Change in Southern India	Community land	Deccan Plateau (Telangana) and Eastern Ghats, hot semi-arid ecoregion (K6D2)	Medium	Drought	+++	✓		✓	✓
3.	Integrated farm Development for Sustainable land Productivity in Nagaland	Crop land/ Community land	North-eastern Hills (Purvachal), warm prehumid ecoregion (D2A5)	High	Biological degradation/ Water erosion	++	✓	✓		✓
4.	Lac Cultivation for Livelihood Generation and Biodiversity Conservation in Madhya Pradesh	Community land/Forest land	Central Highlands (Malwa and Bundelkhand), hot subhumid (dry) eco-region (I6C3(4)	Medium	Biological degradation	+/-	✓		✓	✓
5.	Land Shaping for Climate Change Adaptation and Sustainable Livelihoods in Sundarbans	Crop land	Assam and Bengal Plain, hot subhumid to humid (inclusion of perhumid) eco-region (Q8C(BA)5)	High	Biological degradation	+++	✓	✓		✓
6.	Chauka System for Management of Common Property Resources for Sustainable Livelihood and Adaptation to Climate Change in dry Regions of Rajasthan	Crop land/ Community land	Northern Plain (and Central Highlands) including Aravallis, hot semi-arid ecoregion (N8D2)	High	Biological degradation/ Wind erosion	+++	✓			✓
7.	Dissemination of Sustainable land and Ecosystem Management Practices and Traditional Knowledge Through Community Radio Station in Andhra Pradesh	Community land	Deccan Plateau (Telangana) and Eastern Ghats, hot semi-arid ecoregion (K6D2)	Medium	Drought/ Biological degradation	+++	✓	✓	✓	✓
8.	"Wadi" A Tree based Farming System Model (TBF) for Sustainable land and Ecosystem Management	Crop land/ Community land	Deccan Plateau (Telangana) and Eastern Ghats, hot semi-arid ecoregion (K6D2)	Medium	Biological degradation/ Drought	++	✓		✓	✓
9	Agarbatti Preparation from Degraded Bamboo Forest of Madhya Pradesh	Community land/Forest land	Central Highlands (Malwa and Bundelkhand), hot subhumid (dry) eco-region (I6C3(4)	Medium	Biological degradation	++		✓	✓	✓
10.	Rehabilitation of Degraded Bamboo Forests in Madhya Pradesh	Forest land	Central Highlands (Malwa and Bundelkhand), hot subhumid (dry) eco-region (I6C3(4)	Medium	Biological degradation	+++	✓	✓		✓
11.	Agro-Biodiversity Innovations for Sustainable land and Ecosystem Management in Odisha	Crop land	Eastern Plateau (Chhotanagpur) and Eastern Ghats, hot subhumid eco-region (J23C3(4)	Low	Biological degradation	+/-		✓	✓	✓
12.	Sustainable land and Ecosystem Management in Shifting Cultivation Areas of Nagaland	Community land/Forest land	North-eastern Hills (Purvachal), North-eastern Hills (Purvachal), (D2A5)	High	Biological degradation/ Water erosion	++	✓		✓	

S no.	Name of Best Practice	Land use type	Agro-ecological Zones	Intensity of land degradation	Problem	Impact of best of the best practice	Land degradation	Biodiversity	Climate change adaptation	Socio-economic
13.	Participatory Model for Water Harvesting and Development of Community Pastures in Thar Desert	Community land	Western Plain, Kachchh and part of Kathiawar Peninsula, hot and eco-region (M9E1)	High	Wind erosion/ Drought	+/-	✓		✓	
14	Rejuvenation of Gharats (Water Mills) For Sustainable Land and Ecosystem Management in Uttarakhand	Community land	Warm subhumid to humid with Inclusion of perhumid ecoregion (A15 C (BA) 4/5)	Medium	Biological degradation/ Water erosion	+/-			✓	✓
15.	Rain Water Harvesting and Augmentation of Water Resources For Sustainable Land and Ecosystem Management in Uttarakhand	Community land/Forest lands	Warm subhumid to humid with Inclusion of perhumid ecoregion (A15 C (BA) 4/5)	Medium	Biological degradation/ Water erosion	+	✓		✓	
16.	Aonla based agro-forestry as sustainable land and ecosystem management practice in semi-and dry regions	Crop land	Northern Plain (and Central Highlands) including Aravallis, hot semi-arid ecoregion (N8D2)	Medium	Biological degradation/ Water erosion	++	✓	✓	✓	✓
17.	System of Rice Intensification for Sustainable Land and Ecosystem Management	Crop land	Deccan Plateau (Telangana) and Eastern Ghats, hot semi-arid ecoregion (K6D2)	Insignificant	Biological degradation/ Wind erosion	++	✓		✓	
18.	The Role of the Van Panchayats in Sustainable land and eco-system Management	Community land/Forest land	Warm subhumid to humid with Inclusion of perhumid ecoregion (A15 C (BA) 4/5)	Low	Biological degradation/ Erosion	+++	✓	✓	✓	✓
19	Mangrove Afforestation in Sundarbans with Community participation to combat climate change and sustainable land and ecosystem management	Community land/Forest land	Assam and Bengal Plain, hot subhumid to humid (inclusion of perhumid) eco-region (Q8C(BA)5)	High	Biological degradation	+++	✓	✓	✓	✓
20	Sustainable Management of Resources for Livelihood improvement through Watershed Management in Hills of Uttarakhand	Community land/Forest lands	Warm subhumid to humid with Inclusion of perhumid ecoregion (A15 C (BA) 4/5)	Medium	Biological degradation/ Water erosion	++	√	√	√	√
21	Climate Change Adaptation by Promotion of Fodder and Pasture development for Animal based Farming System in Hills of Uttarakhand	Community land/Forest lands	Warm subhumid to humid with Inclusion of perhumid ecoregion (A15 C (BA) 4/5)	Medium	Biological degradation	++	√		√	√
22	Mulberry cultivation- A diversification climate change adaptation practice for sustainable livelihood under semi-arid regions	Crop Land	Deccan Plateau (Telangana) and Eastern Ghats, hot semi-arid ecoregion (K6D2)	Medium	Biological degradation/ Drought	++	√		√	√

Land use type: Cropland/ Forest land/ Jhum land/ Mixed land use/ Community land/ Grazing land/ other

Agro-ecological zones:

Climate: Humid/ Sub-humid/ Semi-arid/Arid

Problem: Erosion by water/ Erosion by wind/ Biological degradation

Intensity of degradation: High/ Medium/ Low/ insignificant

' **Impacts of best practice with respect to land degradation minimizing:** +++ very positive; ++ positive; + slightly positive; -/+ neutral

TEMPORAL IMPACT ANALYSIS

S No.	Name of Best Practice	Short Term	Long Term	Comments
1.	On Farm Conservation of Genetically Important crop Landraces of Rajmash for Sustainable land and Ecosystem Management in Chamba District of Himachal Pradesh	++	+++	Landraces of crops have originated through agricultural innovation and adaptation in the past 10,000 years or so. They exhibit yield stability and are an important part of traditional low in-put agriculture systems. Considering the importance of the landraces efforts made with respect to on farm cultivation will play significant role in landraces conservation.
2.	Managing Ground Water for Adaptation to Climate Change in Southern India	++	+++	In the face of climate change, overexploitation of ground water is a serious concern in many states. Empowering communities with skills and knowledge to manage extraction is crucial in case of groundwater retention.
3.	Integrated farm Development for Sustainable land Productivity in Nagaland	++	+++	The IFD model is based on the concept of complementary integration of all the components of agriculture, livestock, soil and water conservation and land development works on a plot of land will lead to increase in land productivity and socio-economic status of peoples.
4.	Lac Cultivation for Livelihood Generation and Biodiversity Conservation in Madhya Pradesh	+/-	++	Cultivation of lac not only provides livelihood to the communities, but also aids to the conservation of forests and eco-systems. While it can be cultivated on marginal and degraded lands It also has the potential to provide livelihood during the drought periods.
5.	Land Shaping for Climate Change Adaptation and Sustainable Livelihoods in Sundarbans	+++	+++	Land shaping an effective agro-technology helps to harvest water for growing vegetables after the kharif paddy. It also allows for pisciculture as well as duck rearing and growing of fruit crop/vine vegetables alongside the pond and land embankments leading to increase in livelihood.
6.	Chauka System for Management of Common Property Resources for Sustainable Livelihood and Adaptation to Climate Change in dry Regions of Rajasthan	+++	+++	The Chauka system is a local innovation in Rajasthan for pasture improvement and run-off harvesting and augmentation of groundwater. It is generally developed on community land and helps in developing resilience to combat extreme events due to climate change.
7.	Dissemination of Sustainable land and Ecosystem Management Practices and Traditional Knowledge Through Community Radio Station in Andhra Pradesh	+++	+++	Radio telecast is the prime electronic media for the remotely located communities because it leaps the barriers of isolation, illiteracy and affordability. The community radio station presents local content in local flavor and language for local consumption and outreach.
8.	"Wadi" A Tree based Farming System Model (TBF) for Sustainable land and Ecosystem Management	++	++	The model has the essential features for sustainability in species diversity and flexibility in crop selection. It combines agro-horti-forestry with in-built soil and water conservation strategies to enhance land productivity and to combat climate change
9.	Agarbatti Preparation from Degraded Bamboo Forest of Madhya Pradesh	++	++	Agarbati production uses traditional skills and renewable forest resources and requires low capital investment. It creates home based income generating activities for the community especially women.
10.	Rehabilitation of Degraded Bamboo Forests in Madhya Pradesh	+++	+++	Improvement of degraded bamboo forest for forest improvement and livelihood generation, thereby leading to enhancement of ecological services and economical security.
11.	Agro-Biodiversity Innovations for Sustainable land and Ecosystem Management in Orissa	++	+++	Indigenous and traditional communities depend on and are custodians of agro-biodiversity maintained within agricultural landscapes. These communities are adapting to change and developing resilience through strategies based on traditional wisdom and agricultural innovations.
12.	Sustainable land and Ecosystem Management in Shifting Cultivation Areas of Nagaland	++	+++	A mix of land use through an integrated approach combining improved soil and water conservation measures, intensive organic farming and livestock breeding helps wean the community away from harmful jhum practices.
13.	Participatory Model for Water Harvesting and Development of Community Pastures in Thar Desert	++	+++	Community rain water harvesting for sustainable utilization and to combat climate change resulting in enhancing water availability for multiple use and for sustainability in Thar desert.

S No.	Name of Best Practice	Short Term	Long Term	Comments
14.	Rejuvenation of Gharats (Water Mills) For Sustainable Land and Ecosystem Management in Uttarakhand	+/-	+	Rejuvenation of Gharats has led to positive social, environmental and economic benefits. Improved productivity in milling grains, grinding spices and producing electricity has encouraged the local community to up-grade and replicates this traditional innovation.
15.	Rain Water Harvesting and Augmentation of Water Resources For Sustainable Land and Ecosystem	++	+++	In-situ conservation of rain water and ex-situ harvesting of the run-off, it's collection and use are traditional ways of recycling and augmentation of water resources and drought proofing strategy in dry areas. This practice will help in developing rain water harvesting in rain fed areas and hilly regions.
16.	Aonla based agro-forestry as sustainable land and ecosystem	++	++	Aonla a hardy low water requiring plant can be grown on marginal and salt affected saline/sodic soils. It can be grown profitably in agro-forestry system in arid and semi-arid areas, thereby leading to increase in land productivity and livelihood generation.
17.	System of Rice Intensification for Sustainable Land and Ecosystem Management	++	+++	The SRI practice reduces water requirements in rice cultivation while increasing yields and reducing input need such as chemical fertilizers and pesticides. The practice helps in development of plants and enhancing production by efficiently using the soil, water and nutrients.
18.	The Role of the Van Panchayats in Sustainable land and eco-system Management	+	+++	The VP system is a prominent and successful example of participatory management of common natural forest resources in Uttarakhand. VPs have been authorized by the State Government to treat the reserve forest area, under any project, within a prescribed plan, so that the holistic treatment of any micro watershed (MWS) can be achieved.
19.	Mangrove Afforestation in Sunderbans with Community participation to combat climate change and sustainable land and ecosystem ecosystem management	+++	+++	Mangrove afforestation in Sundarbans with community participation to combat climate and livelihood generation. The mangroves forest present a natural buffer, a bulwark against coastal erosion and seawater ingress in Sundabans and other mangrove regions of the country. Afforestation in Sundanbans will help the local communities in developing mitigation strategies with respect to climate change, biodiversity conservation and livelihood generation.
20.	Sustainable Management of Resources for Livelihood improvement through Watershed Management in Hills of Uttarakhand	++	++	Watershed management is an effective way of natural resource management in sustainable manner and livelihood generation among the hilly regions of the country.
21.	Climate Change Adaptation by Promotion of Fodder and Pasture development for Animal based Farming System in Hills of Uttarakhand	++	+++	Fodder and pasture development plays significant role in enhancing the resilience of local communities practice animal based farming systems.
22.	Mulberry cultivation- A diversification climate change adaptation practice for sustainable livelihood under semi-arid regions	++	+++	Crop diversification and agro-forestry systems plays significant role in enhancing livelihood and developing strategies to combat climate change in semi-arid regions of the country

– – negative; – slightly negative; – /+ neutral; + slightly positive; ++ positive; +++ very positive