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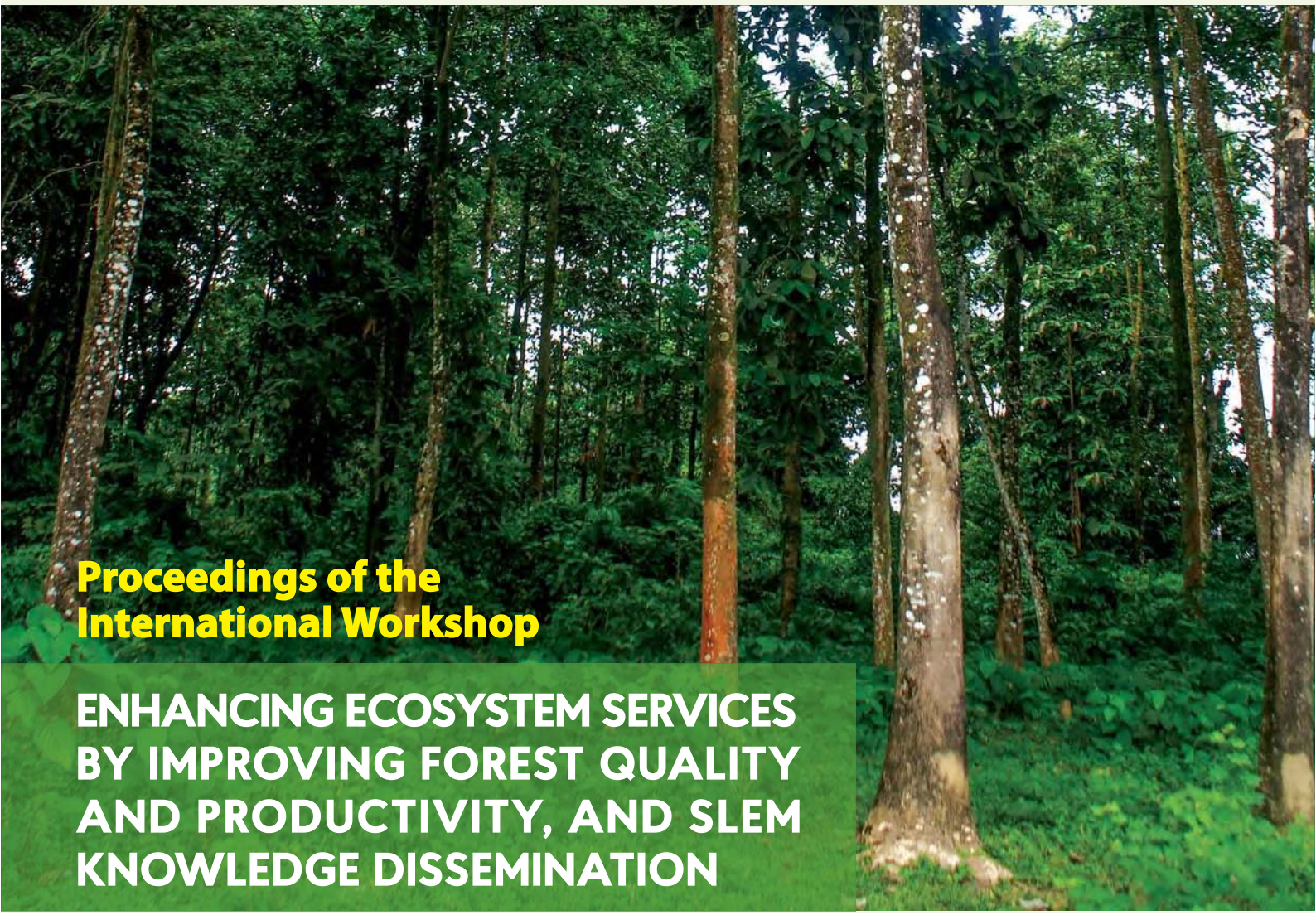

Proceedings of the International Workshop

ENHANCING ECOSYSTEM SERVICES BY IMPROVING FOREST QUALITY AND PRODUCTIVITY, AND SLEM KNOWLEDGE DISSEMINATION




Indian Council of Forestry Research and Education
(An Autonomous Body of Ministry of Environment, Forest and Climate Change, Government of India)
P.O. New Forest, Dehradun - 248006 (INDIA)

आज़ादी का अमृत महोत्सव

LiFE
Lifestyle for Environment

Proceedings of the International Workshop

Enhancing Ecosystem Services by Improving Forest Quality and Productivity, and SLEM Knowledge Dissemination

under

Ecosystem Services Improvement Project

22 to 24 March, 2023

Indian Council of Forestry Research and Education

(An Autonomous Body of Ministry of Environment, Forest and Climate Change, Government of India)

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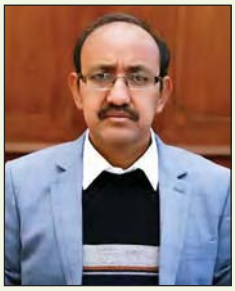


FOREWORD

Forests in India are a significant source of sustenance for tribal and vulnerable populations living inside and on the fringes of the forests. Forests also play a critical role in supporting biodiversity which constitutes a good part of income generation for the forest fringe communities. As a result of anthropogenic pressure, the scale and impact of land degradation and desertification are severe in the country.

Government of India's ambitious Green India Mission (GIM) acknowledges the role of forests on environmental amelioration through climate change mitigation, biodiversity conservation, food security, water security and livelihood security of forest dependent communities. The World Bank is supporting Ecosystem Services Improvement Project (ESIP) and is being implemented with an overall objective to improve forest quality, sustainable land management and NTFPs benefits for forest dependent communities in selected landscapes in Madhya Pradesh and Chhattisgarh.

In the aforesaid background, ICFRE organized an International Workshop on 'Enhancing Ecosystem Services by Improving Forest Quality and Productivity, and SLEM Knowledge Dissemination' under the Ecosystem Services Improvement Project with the aim to develop a mechanism for networking of national and international institutions/ organisations working in the field of restoration of degraded forest lands, forest carbon measurement and monitoring besides sharing of knowledges, experiences and techniques related to nursery management, plantation techniques, restoration techniques for degraded forest lands and dissemination of best practices on sustainable land and ecosystem management.

I am thankful to the invited speakers, panelists and delegates for their participation in the workshop. I appreciate the efforts of scientists, consultants and staff of Biodiversity and Climate Change Division, Directorate of International Cooperation, ICFRE and members of the various committees constituted for organization of the workshop. Efforts made by the editors and rapporteurs for bringing out the proceeding of workshop in an articulate manner are highly appreciated.

Dated: 30 June 2023

(A. S. Rawat)

CONTENTS

ABBREVIATIONS USED

AFOLU	:	Agriculture, Forestry, and Other Land Use
APCCF	:	Additional Principal Chief Conservator of Forests
APOs	:	Annual Plan of Operations
CAMPA	:	Compensatory Afforestation Fund Management and Planning Authority
CCSP	:	Concentric Circular Sample Plots
CEO		Chief Executive Officer
CIFOR-ICRAF	:	Center for International Forestry Research- International Centre for Research in Agroforestry
CLART	:	Composite Landscape Assessment & Restoration Tool
CO_2	:	Carbon dioxide
CSO	:	Clonal Seed Orchard
DDG	:	Deputy Director General
EbA	:	Ecosystem-based Adaptation
ESIP	:	Ecosystem Services Improvement Project
FAO	:	Food and Agriculture Organization
FLR	:	Forest Landscape Restoration
FSI	:	Forest Survey of India
GCF	:	Green Climate Fund
GIM	:	Green India Mission
GHG	:	Greenhouse Gases
GIS	:	Geographic Information System
GIZ	:	German Agency for International Cooperation
GLP	:	Global Land Programme
GOI	:	Government of India
GPWDP	:	Gram Panchayats Watershed Development Plan
ICFRE	:	Indian Council of Forestry Research and Education
ICFRE-FRI	:	ICFRE- Forest Research Institute
ICFRE-HFRI	:	ICFRE- Himalayan Forest Research Institute
ICFRE-TFRI	:	ICFRE- Tropical Forest Research Institute
ICIMOD	:	International Centre for Integrated Mountain Development
IGNFA	:	Indira Gandhi National Forest Academy
IIRS	:	Indian Institute of Remote Sensing
InVEST	:	Integrated Valuation of Ecosystem Services and Tradeoffs
ISRO	:	Indian Space Research Organisation

ITC	:	India Tobacco Company
ITTO	:	International Tropical Timber Organization
IUCN	:	International Union for Conservation of Nature
JFM	:	Joint Forest Management
LDN	:	Land Degradation Neutrality
LULC	:	Land Use Land Cover
LULCC	:	Land Use Land Cover Change
MAI	:	Mean Annual Increment
mha	:	Million Hectare
MISHTI	:	Mangrove Initiative for Shoreline Habitats & Tangible Incomes
MoEFCC	:	Ministry of Environment, Forest and Climate Change
MoEFCC-IRO	:	MoEFCC- Integrated Regional Office
MRV	:	Measurement, Reporting and Verification
NDC	:	Nationally Determined Contribution
NIRANTAR	:	National Institute for Research and Application of Natural Resources to Transform, Adapt, and Build Resilience
NLCMS	:	National Level Cover Monitoring System
NRSC	:	National Remote Sensing Centre
NTFPs	:	Non-Timber Forest Products
PALSAR	:	Phased Array-type L-band Synthetic Aperture Radar
PCCF	:	Principal Chief Conservator of Forests
PME	:	Participatory Monitoring and Evaluation
QPM	:	Quality Planting Material
REDD+	:	Reducing emissions from deforestation and forest degradation, and role of conservation, sustainable management of forests and enhancement of forest carbon stocks
ROAM	:	Restoration Opportunity Assessment Methodology
ROOT	:	Restoration Opportunity Optimization Tool
RS	:	Remote sensing
SDGs	:	Sustainable Development Goals
SFDs	:	State Forest Departments
SLEM	:	Sustainable Land and Ecosystem Management
SOPs	:	Standard Operating Procedures
SRI	:	System of Rice Intensification
STARMAP	:	Spatial Technology Approach for Restoration Mapping and Planning
SSO	:	Seedling Seed Orchards
SUFAL	:	Sustainable Forests and Livelihoods Project
TEV	:	Total Economic Value
UDWDP II	:	Uttarakhand Decentralized Watershed Development Project II
UN	:	United Nations
UNCCD	:	United Nations Convention to Combat Desertification
UNFCCC	:	United Nations Framework Convention on Climate Change
UNDP	:	United Nations Development Programme
USD	:	US Dollar

EXECUTIVE SUMMARY

India is known for its diverse forest ecosystems and mega biodiversity. It ranks 10th amongst the most forested nations of the world with nearly one fourth of its geographical area under forest and tree cover. About 300 million population in India is estimated to be directly or indirectly dependent on forests for their sustenance, most of whom are rural poor, with little land holding and limited livelihood options. With such high degree of dependence on the forest, the per capita availability of forest land in India is 0.06 ha which is much lower than the global average of 0.64 ha. Increased pressure on forest resources of the country over the last few decades has threatened the livelihoods of millions of forest-dwellers and other poor people living in the vicinity of the forests. The pressure on existing forest resources is immense in India. In this context, it is imperative to preserve the forests and manage them sustainably, so as to ensure secure livelihood of the forest-dependent communities as well as conserve the biodiversity.

The World Bank is supporting Ecosystem Services Improvement Project (ESIP) with an overall objective to improve forest quality, sustainable land management and non-timber forest produces (NTFP) benefits for forest dependent communities in selected landscapes of Madhya Pradesh and Chhattisgarh. ESIP supports the goals of Green India Mission by demonstrating models for adaptation-based mitigation through sustainable land and ecosystem management and livelihood benefits. ICFRE as one of the project implementing agencies of ESIP is implementing the components on measurement and monitoring of forest carbon stocks and capacity building of State Forest Departments, and scaling-up of sustainable land and ecosystem management (SLEM) best practices to prevent land degradation and desertification.

The International Workshop on 'Enhancing Ecosystem Services by Improving Forest Quality and Productivity, and SLEM Knowledge Dissemination' was organized by Indian Council of Forestry Research and Education (ICFRE) under the World Bank funded Ecosystem Services Improvement Project with the objective to develop a mechanism for networking of national and international institutions/ organizations working in the field of restoration of degraded forest lands, forest carbon measurement and monitoring besides sharing of knowledge, experiences and techniques related to nursery management, plantation techniques, restoration techniques for degraded forest lands and dissemination of best practices on sustainable land and ecosystem management.

Deliberation, discussion and experience sharing were made on the following themes during the workshop:

- Nursery Management, Plantation and Restoration Techniques,
- Enhancing Carbon Sequestration Potential of Forests and Assessment of Forest Carbon Stocks and
- SLEM Knowledge Sharing and Dissemination: Sharing of ESIP Learnings, Success Stories, Best Practices and Case Studies

Each session comprised of talks by distinguished and eminent experts/ specialists. About 248 delegates (174 delegates in physical mode and 74 delegates in virtual mode) from National and International Research organizations from Bangladesh, Bhutan, Malaysia, Nepal, Myanmar, Thailand and Japan, representatives of the international organizations viz. the World Bank, FAO, GCF, GIZ, ICIMOD, IUCN, UNDP, and

representatives of Ministry of Environment, Forest and Climate Change, academic institutions, State Forest Departments, Science & Technology institutions and NGO participated in the workshop.

Recommendations of the Workshop: Following recommendations were made during the workshop:

1. Nursery Management and Plantation Techniques for Productivity Enhancement

- Availability of Quality Planting Material to the stakeholders and quality standards of planting stock for degraded sites needs to be ensured.
- To exploit the true potential of the tree genetic resources awareness of the tree growers to retain trees for a minimum production cycle need to be developed.
- Domestic forest certification mechanism needs to be developed.
- Promoting use of short rotation crops to encourage farmers in tree planting activities with definite financial incentives.
- Promoting mosaic clone cultivation to maintain the genetic base and ensuring profitability for the grower's community and other stakeholders.
- At least one Hi-tech nursery at a Forest Range level needs to be established.

2. Forest Landscape Restoration Techniques for Improving Forest Quality and Productivity

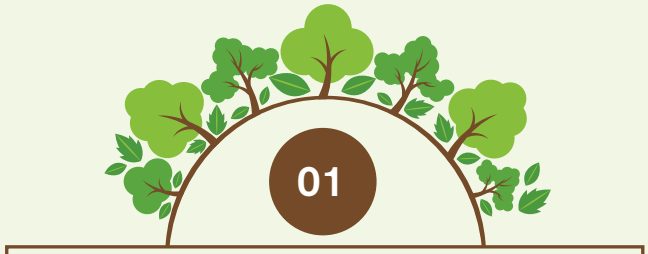
- Use of pioneer tree species in restoring degraded lands, stabilizing disturbed ecosystems and ensuring better survival of climax species.
- Adoption of Integrated Farming System (IFS) including agroforestry practices in Forest Landscape Restoration approaches.
- Adopting innovative techniques like Restoration Opportunity Assessment Methodology (ROAM) to achieve Forest Landscape Restoration with a flexible and affordable framework to rapidly analyze degraded areas.
- Regional collaboration amongst collaborating government and other partners, for restoring mountain landscapes.
- Promotion of local species with proper soil and moisture conservation practices, and method of planting for restoring degraded lands.
- "Community Water Stewardship" on water use planning need to be inbuilt in land restoration projects.

3. Enhancing Carbon Sequestration Potential and Assessment of Forest Carbon Stocks

- Expanding use of geospatial techniques in mapping and monitoring biophysical parameters for forest and plantation management and accurate carbon stock assessment.
- Promote REDD+ activities and financial incentives in community-based forest management for the enhancement of carbon sequestration.
- Promoting climate change mitigation and adaptation practices in the AFOLU sector.
- Strengthening of the national forest monitoring system, implementation of REDD+ strategy, participation in the voluntary carbon market.
- Accessing finance from Green Climate Fund for forest sector climate change mitigation and adaptation projects and leveraging domestic financing through green bonds.
- Forest and tree plantation programmes to be more remunerative with definite market for ecological services including mitigation/ adaptation to climate change and the market aligned with Article 6 of the Paris Agreement.
- Plantation owners should have long-term management plan certified by accredited agencies.
- Indo Flux network needs to be developed by bringing together all the institutions involved in eddy covariance-based carbon flux studies of forests in the country. Scientists/ researchers can use flux data to better understand forest ecosystem functioning, and to detect trends in climate and carbon sequestration.
- Government of India need to promote its own forest carbon market to incentivize small and marginal farmers. Carbon credits generated through these projects should be named differently for the credits generated from public and private lands.
- Government of India should include bamboos and palms in the forest definition for the purpose of market mechanism under Article 6.4 of Paris Agreement and same need to be communicated to UNFCCC. ICFRE can send an *aide-memoire* to the MoEF&CC on this issue.
- Transboundary ecosystems in the South East Asia region need to be protected.

4. Sustainable Land and Ecosystem Management (SLEM) Knowledge Sharing and Dissemination

- Broad agrifood system-oriented approaches by integration, optimization, diversification and innovations to be included in action plans for sustainable land management.
- Integrating various technical, social and institutional approaches for landscapes restoration including traditional water harvesting structures and small land irrigation systems like "*Nualas*", for enhancing contribution in building climate resilient watershed.
- Innovative approaches in PME (Participatory Monitoring and Evaluation) with financial autonomy in Gram Panchayat and Women Aam Sabha to ensure regular flow of funds by way of income generation.
- Capacity building of the stakeholders and sharing of knowledge on SLEM best practices of local communities in sustained use of natural resources and better management of forest and land resources.
- Scaling up and adopting SLEM best practices (vermicomposting, application of biofertilizers and biopesticides for integrated farm development for sustainable land productivity, Wadi system- A tree-based farming system, lac cultivation for livelihood generation and biodiversity conservation, rain water harvesting and augmentation of water resources, system of rice intensification, and Azolla cultivation) need to be promoted for sustainable land productivity.
- Entrepreneurship interventions in agribusiness growth centres should be channelized for livelihood growth.
- Implementation of recommendations of Roadmap developed for institutional and policy mainstreaming of sustainable land and ecosystem management in India to combat land degradation and desertification under ESIP.
- Documentation and dissemination of standard methodologies for the assessment of various ecosystem services among the various stockholders.
- Promotion of practices like use of nets for collection of Mahua flowers in Madhya Pradesh need to be scaled up in other parts of the country for prevention of forest fire.



BACKGROUND

In India, about 300 million people are directly or indirectly dependent on forests for their sustenance, most of whom are rural poor, with little land holdings and limited livelihood options. With such high degree of dependence on the forest, the per capita availability of forest land in India is 0.06 ha which is much lower than the global average of 0.64 ha. Forests in India are a significant source of sustenance for tribal and vulnerable populations living inside and on the fringes of the forests. Forests also play a critical role in supporting biodiversity which constitutes a good part of income generation for the forest fringe communities.

As a result of anthropogenic pressure on natural resources, the scale and impact of land degradation and desertification are severe in the country. Degraded landscapes are more prone to invasion by invasive alien species, which compete with native species and lead to further land degradation, productivity reduction and biodiversity loss. Managing land that is undergoing degradation and desertification, is therefore a significant priority in the context of achieving India's national targets, international commitments related to Nationally Determined Contribution (NDC), Land Degradation Neutrality (LDN), Bonn Challenge Target and Sustainable Development Goals (SDGs), biodiversity conservation, and climate change mitigation and adaptation.

Government of India's Green India Mission (GIM) under the National Action Plan on Climate Change recognizes that climate change phenomena will seriously affect and alter the distribution, type and quality of natural resources of the country and the associated livelihoods of local communities. GIM also acknowledges the role of forests on environmental amelioration through climate change mitigation, biodiversity conservation, food security, water security and livelihood security of forest dependent communities. With an overall objective to improve forest quality, sustainable land management and NTFPs benefits for forest dependent communities in selected landscapes in Madhya Pradesh and Chhattisgarh, the World Bank is supporting Ecosystem Services Improvement Project (ESIP). This project supports the goals of GIM by demonstrating models for adaptation-based mitigation through sustainable land and ecosystem management and livelihood benefits. One of the objectives of the project is to improve the quality and productivity of the existing forests so as to ensure sustained flow of ecosystem goods and services, and to ensure the sustainable harvesting and value addition of NTFPs to provide economic benefits to forest dependent communities in selected landscapes of Chhattisgarh and Madhya Pradesh. The project has the components on (i) Strengthen capacity of government institutions in forestry and land management programs, (ii) Investments for improving forest quality in selected landscapes and (iii) Scaling up sustainable land and ecosystem management in selected landscapes.

ICFRE as one of the project implementing agency of ESIP organized an international workshop on 'Enhancing Ecosystem Services by Improving Forest Quality and Productivity, and SLEM Knowledge Dissemination' from 22 to 24 March 2023 at Dehradun.

The purpose for organization of an international workshop was to develop a mechanism for networking of national and international institutions/ organizations working in the field of forest carbon measurement and monitoring, restoration of degraded forest lands, besides sharing of

knowledge, experiences and techniques related to nursery management, plantation techniques, restoration techniques for degraded forest lands and dissemination of best practices on sustainable land and ecosystem management. Agenda of the international workshop is placed at Annexure I.

1.1. Themes of the Workshop

Theme 1: Nursery Management and Plantation Techniques for Productivity Enhancement

Considerable investment has been made in developing forest nurseries by the State Forest Departments under GIM and other forestry programmes. In India, besides management of natural forests, considerable amount of timber is supplied from farm forestry and agroforestry. Nurseries will continue to play a vital role in promoting farm plantation and enrichment plantation of degraded forests. Proper nursery management techniques are fundamental for producing quality planting stocks which are the foundation of any planting programme. Restoration of forests will be achieved through plantations raised by quality planting stocks. The theme focused on production of quality planting stocks, appropriate nursery techniques, management of forest nurseries and techniques for restoration of degraded lands.

Theme 2: Enhancing Carbon Sequestration Potential of Forests and Assessment of Forest Carbon Stocks:

India's forest sector target in its Nationally Determined Contribution (NDC) is to create additional carbon sink of 2.5 -3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030. The theme focused on achieving the forestry sector goal of NDC through effective implementation of GIM and to develop synergies with other greening/ plantation programmes being implemented in the country. Effective protocols for measurement and assessment of forest carbon stocks needs to be developed. The outcomes of the forest carbon stocks assessment carried out by ICFRE and learning of the project partners under ESIP were also shared.

Theme 3: Sustainable Land and Ecosystem Management (SLEM) Knowledge Sharing and Dissemination

ESIP Implementing Agencies (Madhya Pradesh and Chhattisgarh State Forest Departments and ICFRE) and Uttarakhand Watershed Management Directorate shared their learnings, best practices, case studies and success stories developed/ implemented under the ESIP, GIM and other projects on sustainable land and ecosystem management.

Dissemination and sharing of knowledge on Sustainable Land and Ecosystem Management (SLEM) best practices facilitated capacity building of the stakeholders and adoption of proven, tested and cost effective SLEM best practices for achieving Land Degradation Neutrality (LDN) targets and sustainable development goals (SDGs). Knowledge sharing and dissemination on SLEM will contribute globally in terms of capacity building of the stakeholders in restoration of degraded lands.

About 248 delegates (174 delegates in physical mode and 74 delegates in virtual mode) from National and International Research organizations from Bangladesh, Bhutan, Malaysia, Nepal, Myanmar, Thailand and Japan, representatives of the international organizations viz. the World Bank, FAO, GCF, GIZ, ICMOD, IUCN, UNDP, and representatives of Ministry of Environment, Forest and Climate Change, academic institutions, State Forest Departments, Science & Technology institutions and NGO participated in the workshop. List of the participants is placed at Annexure II.

02

SESSIONS OF THE WORKSHOP

2.1. Inaugural Ceremony

The Chief Guest of the workshop, Sh. Ashwini Kumar Choubey, Hon'ble Minister of State, Ministry of Environment, Forest and Climate Change, Government of India inaugurated the workshop "Enhancing Ecosystem Services by Improving Forest Quality & Productivity and SLEM Knowledge Dissemination" on 22 March 2023 virtually.

Sh. Arun Singh Rawat, Director General, ICFRE welcomed the Chief Guest and other dignitaries. In his welcome address he highlighted that ecosystem-based adaptation, nature-based approaches and SLEM practices are being widely used for conservation of natural resources, forests, biodiversity and restoration of degraded lands. He also stressed upon the need of increased participation of local communities for human well-being and maintaining ecosystem services. He figured out that total value of ecosystem services (TEV) for India is USD $1.8 trillion/year and regions like Terai Arc landscape and Jim Corbett have the TEV of 390 billion (US$6 billion) and USD $2,153,174.3, respectively. He elaborated that the World Bank funded Ecosystem Services Improvement Project is supporting the goals of Green India Mission by demonstrating models of adaptation-based mitigation through sustainable land and ecosystem management.

Dr. Anupam Joshi, Senior Environmental Specialist, the World Bank in his address mentioned that the World Bank visualized this International Workshop as an important event because mainstream forestry has been losing its significance around the world. He raised concern over fulfilling the targets of Bonn Challenge and other targets of forest sector globally. He pointed out that India is still lagging behind in achieving the target of 33% of forest and tree cover as mentioned in its National Forest Policy. He suggested to have meaningful investments in the forestry sector to double the income of farmers. He cited the example of ongoing Ecosystem Services Improvement Project in the States of Madhya Pradesh and Chhattisgarh where very good targeted investments have resulted in increasing the subsistence income of the marginalized sections of the forest fringe communities.

Sh. Pravir Pandey, Additional Secretary & Financial Advisor, Ministry of Environment, Forest and Climate Change (MoEFCC), Govt. of India stressed on the convergence of the financial flows from the Ministry to various State Forest Departments and the various organizations under

the umbrella of the MoEFCC. At present the funds from Ministry are being utilized in isolation whereas a strong convergence among various verticals and cross cutting schemes need to be synthesized. He mentioned that the funds amounting to almost Rs. 1,000 crores have been earmarked for the flagship schemes and projects such as Green India Mission, Forest Fire Prevention and Integrated Wildlife Habitat Improvement Scheme. A large number of Annual Plan of Operations received from the States for utilizing the CAMPA Funds, required to be examined carefully so as to avoid duplication of financial resource use from different schemes. These funds should be optimally and rationally utilized in synergy so as to benefit the marginalized sections of the society. He also highlighted that Rs. 16,000 crores Sovereign Green Bonds have emerged as an important financial instrument to deal with the threats of climate change and challenges related to agriculture, food, and water supplies for the communities. The environmental projects should be connected with capital markets and investors to channel the investments towards sustainable development. He added that adequate amount of funds has been given to various organizations involved in forestry research, training and capacity building. He emphasized that the research activities undertaken by ICFRE and other organizations must be meaningful and fruitful and should be beneficial for the Ministry as well as for communities, civil societies etc.

Sh. B. K. Singh, Additional Director General of Forest (Forestry), MoEFCC, Govt. of India complemented ICFRE for successful implementation of the ESIP in the states of Chhattisgarh and Madhya Pradesh and desired that same to be replicated in other states. He reiterated that the forestry personnel should be commended for not only maintaining the forest areas but also increasing the forest and tree cover in the past three decades. The MoEFCC has also geared to meet the international commitments. He mentioned that India has restored 9 mha of degraded land till the year 2020 against the Bonn Challenge target of 26 mha. He further elaborated that the implementation of the World Bank funded ESIP Project has given a lot of opportunities, learning lessons and many demonstrative models that have been initiated as community welfare activities. In future the State Forest Departments of Madhya Pradesh and Chhattisgarh can maintain the carbon flux towers established under ESIP with technical support from ICFRE to generate data on forest carbon fluxes. He also highlighted the fact that MoEFCC has decided to reorganize all institutes of the Ministry to make them more effective and set up a new platform i.e. National Institute for Research and Application of Natural Resources to Transform, Adapt, and Build Resilience (NIRANTAR) framework. He also highlighted that the *Mangrove* Initiative for Shoreline Habitats & Tangible Incomes (MISHTI), launched by Hon'ble Prime Minister of India, as a significant step in providing nature- based solution for mitigating the effects of cyclones and storm surges and fight against the climate crisis.

The Chief Guest, **Sh. Ashwini Kumar Choubey**, Hon'ble Minister of State, Ministry of Environment, Forest and Climate Change, Government of India stated that the International Workshop was organized at a time when India is setting new goals for the next 25 years of 'Amrit Kaal'. He appreciated the efforts of ICFRE in developing a roadmap for institutional and policy mainstreaming of Sustainable Land and Ecosystem Management (SLEM) in India with the help of the World Bank, as a follow up of announcement made by the Hon'ble Prime Minister of India to set up a Centre of Excellence on Sustainable Land Management at ICFRE, Dehradun to address the issues of land degradation and desertification. He emphasized that the nature will protect those who protect the nature and mentioned that we as a nation never exploited the nature instead, we worshiped the nature and stressed on sustainable utilization and circular economy for conservation of forests and natural resources. He congratulated ICFRE for organizing the international workshop and emphasized the importance of the forests by quoting a Shloka from Atharva Veda *"Vanah Basanti Janatah Sarveya"* meaning *Forests are the habitat of Vegetation and Wildlife.* He concluded his address with a quote from Ramayana "Nature Will Protect Those Who Protect the Nature".

Ms. Kanchan Devi, Director (International Cooperation) and Project Director, ESIP, ICFRE proposed a vote of thanks to the Chief Guest, Director General, ICFRE, Senior officers from MoEFCC, the World Bank, representatives of the State Forest Departments, international delegates, representatives of the S&T institutions, representatives of the academic institutions, representatives of the NGOs, and representatives of the Press and Media for gracing the occasion. She also thanked the officers, scientists and staff of ICFRE who were involved in organisation of the workshop in various capacities and at different stage.

2.2. Keynote address
Rethinking Forestry for Planet People Profit

Dr. Anupam Joshi, Senior Environmental Specialist, the World Bank

Rapporteurs:

- Sh. Monish Mullick, Sr. Consultant, COE-SLM
- Dr. Krishna Giri, Scientist-D, ICFRE

Dr. Anupam Joshi Senior Environmental Specialist, the World Bank delivered a keynote address on Rethinking Forestry for Planet People Profit and highlighted that forests have been traditionally managed for selected outputs, such as timber and non-timber forest products, species conservation and for their cultural values. India has managed to retain a good forest cover and maintained a robust network of protected areas, but the objective of its National Forest Policy 1988 of achieving 33% forest and tree cover remains a challenge. He also mentioned that only in recent times forestry is seen as a potential low-cost solution for addressing multiple challenges ranging from climate change to poverty. He emphasized that the time is now ripe to rethink forestry and make it an investment-friendly, ecologically secured and economically attractive sector. This would require, amongst other things, a shift from contemporary approaches in forestry to a forward looking one, where there is room for policy and institutional reforms, increased focus on ecosystem services and support for forest-dependent communities for improving and enhancing their livelihood opportunities. This is achievable within one generation but the long-term benefits of a renewed forestry sector will be inter-generational.

2.3. Session-II

NURSERY MANAGEMENT AND PLANTATION TECHNIQUES FOR PRODUCTIVITY ENHANCEMENT

- **Chair: Sh. Bharat Jyoti**
  Director, IGNFA, Dehradun
- **Co-chair: Sh. Subhash Chandra**
  CEO, CAMPA, MoEFCC, Govt. of India

- **Session Talks:**

1. Nursery and plantation techniques: Dr. R.C. Dhiman, CIFOR-ICRAF
2. Productivity enhancement of the forest plantations through planting stock improvement - ICFRE initiatives: Dr. H.S. Ginwal, Dean (Academic), Forest Research Institute Deemed to be University, Dehradun
3. Recent advances in breeding, nursery and plantation techniques for enhancing productivity in short rotation tree species: Dr. Mohan Varghese, Senior Principal Scientist, ITC Life Sciences and Technology Centre, Bengaluru
4. Nursery techniques for raising quality planting stock of Himalayan conifers: Dr. Sandeep Sharma, Director, ICFRE-Himalayan Forest Research Institute, Shimla
5. Conservation and Sustainable Teak Forest Management in Thailand: Prof. Yongyut Trisurat, Kasetsart University, Bangkok, Thailand
6. Potential of *Shorea roxburghii* G. Don as forest plantation species and for rehabilitation of degraded areas: Dr. Ho Wai Mun, Forest Research Institute Malaysia

- **Rapporteurs:**
  Dr. Gaurav Mishra, Scientist-D, ICFRE
  Sh. Muthu Prasad T., Scientist-B, ICFRE

A total of six talks were delivered by the eminent speakers in this session of the workshop. The first speaker, **Dr. R.C. Dhiman** from CIFOR-ICRAF delivered a talk on Nursery and Plantation Techniques and highlighted the importance of Quality Planting Material (QPM) in increasing productivity. He raised concern over lack of availability of QPM in the Indian sub-continent. He also emphasized that while selecting the parenting material for vegetative propagation, it should be ensured that the parenting material should be juvenile enough for better growth. He hailed the innovative irrigation methods and silvicultural practices for the success of agroforestry in the Indian sub- continent. He also expressed concern that the current rotation period is being fixed in an opportunistic and arbitrary manner according to the individual needs without any scientific basis. Tree growers need to be guided to retain trees for a minimum production cycle to exploit the true potential of the tree genetic resources.

Dr. H. S. Ginwal, Scientist 'G' and Dean (Academic), Forest Research Institute Deemed to be University, Dehradun delivered a talk on Productivity enhancement of the forest plantations through planting stock improvement - ICFRE initiatives**.** He mentioned that the lack of good-quality planting material is a major constraint to adoption of agroforestry innovations. Sincere efforts have been made by ICFRE institutes for the improvement of forest tree species using genetic tools. He stated that seed stands, seed production areas, clonal seed orchards and vegetative multiplication gardens have been established under the Planting Stock Improvement Programme. He emphasized that to achieve maximum productivity and to cope with commitments, cloning techniques can help maximize genetic gain. He also highlighted that ICFRE has released new clones and varieties that are being widely used by farmers, forest departments, forest development corporations and wood-based industries. He praised ICFRE's achievement for signing a Non-exclusive License Agreement for commercial propagation/ supply/ sale of planting stock of the released clones. Finally, he advocated that more focus should be given on the integration of improved clones into farmlands to double the farmer's incomes.

Dr. Mohan Varghese, Senior Principal Scientist (Silviculture), ITC Life Sciences and Technology Centre, Bengaluru delivered a talk on Recent advances in breeding, nursery and plantation techniques for enhancing productivity in short rotation tree species. He highlighted the need for ensuring deployment of genetically superior planting stock, and employing the best propagation technique, along with scientific management practice for maximizing and sustaining the productivity for plantations. He stated that Seedling Seed Orchards (SSO) and Clonal Seed Orchards (CSO) should be properly maintained for genetic diversity. He elaborated that industry-oriented traits in clones fetch a good market and the paper industry prefers traits like pulp yield. He also advised that mosaic clone cultivation should be promoted than monoclonal cultivation to ensure genetic diversity as well as optimum profit. He claimed that the hybrid seeds give higher yield than clones, but there are limitations due to difficulty in breeding. Finally, he emphasized the need for convergence of breeder and nursery manager for achieving desired results.

Dr. Sandeep Sharma, Director, ICFRE- Himalayan Forest Research Institute, Shimla delivered a talk on Nursery techniques for raising quality planting stock of Himalayan conifers. He stated that nursery techniques play a significant role in the production of quality seedlings and establishing productive plantations. He explained the standardized nursery techniques of important Himalayan conifers viz., *Abies pindrow, Picea smithiana, Cedrus deodara, Pinus gerardiana, Juniperus polycarpos* and *Taxus wallichiana* developed by ICFRE-HFRI, Shimla have been subsequently transferred successfully to various stakeholders and are being utilized for raising quality planting stock. He also raised concern over incidences of forest fires in Western Himalaya that cause tremendous damage to conifer forests every year. He advocated for the production of quality planting stock, site specific Standard Operating Procedures (SOPs) for nursery production and culling of inferior nursery stock.

Prof. Yongyut Trisurat, Professor of Forestry, Kasetsart University, Bangkok, Thailand delivered a talk on Conservation and Sustainable Teak Forest Management in Thailand and highlighted that the country has a target of bringing 40 percent of the total area under forest cover, which at present is around 31.6 percent. With the financial support of the German Government, the International Tropical Timber Organization (ITTO) and Kasetsart University, Thailand have executed the Teak Plantation in Mekong Project. The project provided an opportunity to build-up sustainable forest management capacities. He expressed concern that India and Thailand have less Mean Annual Increment (MAI) in Teak as compared to Malaysia and Cambodia. He informed that Teak is the preferred species for small landholders and private sectors due to its high timber value and for intercropping. He also highlighted that poor quality of seedling materials and silvicultural techniques and expensive wood certification process are posing challenges to teak plantations. He believed that the availability of quality planting material, financial incentives, and domestic certification mechanisms can boost the teak plantation.

Dr. Ho Wai Mun, Research Officer from Forest Research Institute, Malaysia delivered a talk on Potential of *Shorea roxburghii G.* Don as forest plantation species and for rehabilitation of degraded areas. She added that the mining sites are mainly converted into agriculture lands, housing estates and recreation areas. She explained that her study has explored the possibility of *Shorea roxburghii* for rehabilitation of degraded sites.

2.4. Session-III

FOREST LANDSCAPE RESTORATION TECHNIQUES FOR IMPROVING FOREST QUALITY AND PRODUCTIVITY

- **Chair: Dr. Dhananjai Mohan**
  PCCF, Uttarakhand
- **Co-chair: Mr. Pankaj Agarwal**
  Dy. Director General of Forest,
  MoEFCC-IRO, Dehradun

- **Session Talks:**

1. The potential of pioneer species to the restoration programme on degraded forest: Dr. Rosdi Bin Koter, Head of Forest Plantation Programme, Forest Research Institute, Malaysia
2. Leveraging innovative tools and technologies for accelerating forest landscape restoration towards meeting 2030 Bonn Challenge commitment of India: Ms. Archana Chatterjee, Programme Manager, IUCN-India
3. Innovative financing mechanisms for restoring mountain landscapes in the Hindu Kush Himalaya: Dr. Bhaskar S. Karky, Resource Economist and Carbon Finance Specialist, ICIMOD, Kathmandu
4. Forest restoration efforts of community forestry in Nepal: Success stories from Province-1, Nepal: Mr. Nabin Bhattarai, Hokkaido University, Japan
5. Rejuvenating landscapes - transforming lives in rural India: The Ecosystems based Adaptation: Mr. Sandeep Jadhav, Director, WOTR, Pune
6. Sustainable Land and Ecosystem Management Opportunities in Myanmar (Case Studies on Mangrove Ecosystem): Dr. Win Maung Aye, Assistant Director, Watershed Management Division, Forest Department, Nay Pyi Daw (Myanmar)
7. Restoration of degraded common lands: Ms. Himani Sharma, Programme Manager, Foundation for Ecological Security, Anand
8. Restoration of forest ecosystem services through eco-budget in Karnataka: Dr. M. Balasubramanian, Assistant Professor, Centre for Ecological Economics and Natural Resources, Institute for Social and Economic Change, Bengaluru

- **Rapporteurs:**
  Dr. Gaurav Mishra, Scientist-D, ICFRE
  Sh. Muthu Prasad T., Scientist-B, ICFRE

The session started with the opening remarks by the Chair, Dr. Dhananjai Mohan, PCCF Uttarakhand on the aim and importance of the United Nations Decade on Ecosystem Restoration. He mentioned the 10 flagship initiatives and highlighted about the Restoration of the River Ganga, as one of flagship program of UN decade. The session was mainly focused on various techniques/ methods of Forest Landscape Restoration (FLR) for the improvement of forest quality and productivity. In session III, eight talks were delivered by eminent resource persons from different countries.

Dr. Rosdi Bin Koter, Head of Forest Plantation Programme, FRI, Malaysia delivered a talk on Potential of pioneer species to the restoration programme on degraded forest. He talked about *Macaranga tanarius*, a pioneer tree species in Malaysia, as a suitable species for planting at various altitudes (200 to 2000 m asl). He also talked about the phenological behaviour and high germination percentage of *M. tanarius* and suggested to include pioneer tree species for restoration of degraded lands as these can help in stabilization of disturbed ecosystems and became an integral part in restoration.

Ms. Archana Chatterjee, Programme Manager and Mr. Nishant Jain, IUCN-India delivered a talk on Leveraging innovative tools and technologies for accelerating forest landscape restoration towards meeting 2030 Bonn Challenge commitment of India and talked about the tools and techniques for accelerating forest landscape restoration, so that India's commitment to restoring 26 mha of degraded land can be achieved. She discussed the linkage between different Rio conventions and Forest Land Restoration (FLR). She showcased the FLR principles and highlighted that FLR is not only about planting trees but should also include the restoration of agricultural lands through the Integrated Farming System including agroforestry practices. She also discussed the Restoration Opportunity Assessment Methodology (ROAM) and Restoration Opportunity Optimization Tool (ROOT).

Dr. Bhaskar S. Karky, Resource Economist and Carbon Finance Specialist, ICIMOD, Kathmandu, Nepal delivered a talk on Innovative financing mechanism for Restoring Mountain Landscapes in Hindu Kush Himalaya. He emphasized that there is a need to customize the solutions with financial incentives. Speaking about REDD+ initiative, he elaborated that Hindu Kush Himalaya governments and partners must collaborate to concerted efforts for restoring the mountain landscape of the region. During discussion about the synergy between FLR and REDD+, he said that both are similar with very fine differences between them, as FLR is participatory system while REDD+ is MRV system.

Mr. Nabin Bhattarai, Researcher, Hokkaido University, Japan delivered a talk on Forest restoration efforts by community forestry user groups in Nepal and cited to be the perfect example of FLR. He showcased the collective actions taken by communities for planting to check the soil erosion in the Tinjare community forest in Nepal and also highlighted some of the good practices adopted in the area like the alternative of forest products and the promotion of clean energy, which can improve the condition in only two decades. He also elaborated on the challenges/ problems of community forestry like limited resources, lack of innovations, climate change and limited knowledge of silviculture.

Sh. Sandeep Jadhav, Director, WOTR, Pune delivered a talk on Rejuvenating landscapes - transforming lives in rural India: The Ecosystems based Adaptation (EbA) and emphasized that EbA is a promising solution to tackle ecosystem degradation, climate change and low agricultural production, which are the root causes of rural poverty. He also added that EbA can build resilience and decrease the vulnerability of local communities towards climate change, which can also help in conserving the natural and biological resources. He also emphasized on the integration of ecosystem and economy for the successful landscape rejuvenation.

Dr. Win Maung Aye, Assistant Director, Watershed Management Division, Forest Department, Nay Pyi Daw, Myanmar delivered a talk on Sustainable Land and Ecosystem Management Opportunities in Myanmar (Case Studies on Mangrove Ecosystem) presented three different case studies on Mangrove management for promoting sustainable land and ecosystem management opportunities. In his presentation, he mainly focused on the planting rules to be followed for the restoration of degraded mangroves.

Ms. Himani Sharma, Programme Manager, Foundation for Ecological Security, Anand, Gujarat delivered a talk on Restoration of Degraded Common Lands and said that one fourth of the dryland areas in India could be considered as *Common's*. She showcased several models for ecological restoration like CORE and CLART. She also talked about the Forest Management Tool for preparing the working plans of forest departments.

Dr. M. Balasubramanian, Assistant Professor, Centre for Ecological Economics and Natural Resources, Institute for Social and Economic Change, Bengaluru delivered a talk on Restoration of forest ecosystem services through eco-budget in Karnataka which mainly focused on the economic losses that occurred in Karnataka due to depleting forest cover in the past six years caused mainly by forest land conversion for non-forest purposes followed by forest fires and other natural calamities.

2.5. Session-IV

ENHANCING CARBON SEQUESTRATION POTENTIAL AND ASSESSMENT OF FOREST CARBON STOCKS

- **Chair: Sh. Rajesh Kumar**
  DDG (Retd.), FSI, Dehradun
- **Co-chair: Dr. Nitin Kulkarni**
  Director, ICFRE-TFRI, Jabalpur

- **Session Talks:**

1. Assessment of carbon stock in India's forests: Mr. Prakash Lakhchaura, Dy. Director General, Forest Survey of India, Dehradun
2. Role of AsiaFlux Network on measurement of carbon flux from tropical peatland: Dr. Lulie Melling, Director, Sarawak Tropical Peat Research Institute, Malaysia
3. Role of geospatial data in carbon monitoring in Cambodia, Malaysia, Philippines and India: Dr. Ram Avtar, Associate Professor, Hokkaido University, Japan
4. Forestry, land use and ecosystem services under the Green Climate Fund: Mr. Ben Vickers, Land Use, Forests and Ecosystems Senior Specialist, Green Climate Fund, Songdo, Incheon City, Republic of Korea
5. Bhutan's initiative on forest carbon assessment: Mr. Dawa Zangpo, Deputy Chief Forestry Officer, Department of Forests and Parks Services, Ministry of Energy and Natural Resources, Bhutan
6. Bangladesh initiatives on forest carbon assessment and ecosystem services valuation: Mr. Zaheer Iqbal, DCF, Bangladesh Forest Department
7. Assessment of forest carbon stocks in Nepal: Mr. Thakur Subedi, Research Officer, Forest Research and Training Centre, Ministry of Environment and Forest, Nepal
8. Ecosystem services resulting from the Khasi Hills Community REDD+ Project: Mr. Tambor Lyngdoh, Founding Chairman (Synjuk) cum Community Conservator of Forest & Project Director, Khasi Hills Community REDD+ Project, Meghalaya
9. Developing a domestic forest carbon market in India: Dr. Promode Kant, Chairman, Expert Appraisal Committee (INFRA-2), MoEFCC, Govt. of India

10. ISRO's initiative on measurement of forest carbon exchange – status, challenges and way forward: Dr. Kiran Chand Thumaty, Scientist 'F' and Head, Forestry Resources Division, Forestry & Ecology Group, Remote Sensing Applications Area, National Remote Sensing Centre
11. Understanding carbon exchange of western Himalayan foothill forests though Eddy Covariance measurement: Dr. Taibanganba Watham, Scientist/Engineer-SD, Indian Institute of Remote Sensing, Dehradun

- **Rapporteurs:**

  Dr. Krishna Giri, Scientist D, ICFRE

  Dr. Sandeep Pandey, Sr. Consultant, COE-SLM

Sh. Rajesh Kumar, Chair of the session gave a background of the session and highlighted the significance of forest carbon sequestration and carbon stock assessment as per the UNFCCC guidelines and requirement of the country. A total of 11 session talks were delivered by the eminent speakers in this session.

The first speaker of the session **Sh. Prakash Lakhchaura,** Deputy Director General, Forest Survey of India delivered a talk on Assessment of Forest Carbon Stock in India's Forest. He raised concern on emission of greenhouse gas and increasing global temperature. He stressed on net zero CO_2 emissions and urgency of Near-Term Integrated Climate Action. He enchanted five nectar elements, '*Panchamrit*', given by the Hon'ble Prime Minister of India in Glasgow on enhancing non-fossil energy and renewable energy, reducing carbon emission and intensity and achieving net zero target, to deal with climate change. He highlighted the role of Forest Survey of India in estimation and monitoring of forest carbon stock, assessment of forest cover and change, and growing stocks.

Dr. Lulie Melling, Director, Sarawak Tropical Peat Research Institute, Malaysia delivered a talk on 'Role of AsiaFlux Network on Measurement of Carbon Flux from Tropical Peatland' and gave special emphasis on AsiaFlux, a regional research network of long-term study of climate change in relation to carbon, water and energy fluxes in Asia. The network can help in multi-scale monitoring for GHG budget, biomass, and region-specific indicators for ecosystem sustainability. She stressed on a new research frontier the 'Tropical Peatland' and various challenges encountered during assessment of forest stand structure and floristic composition, carbon flux measurements, and above ground and below ground biomass. The researchers can use this knowledge to develop more effective approaches to conserve and increase the potential for carbon sequestration of these critical ecosystems and reduce the impact of human activities on them.

Dr. Ram Avtar, Associate Professor and Director, Global Land Programme (GLP), Hokkaido University, Japan made a presentation on Role of geospatial data in carbon monitoring in Cambodia, Malaysia, Philippines and India. He highlighted the role of geospatial techniques to mitigate climate change and support decarbonization. He stressed on importance of Phased Array-type L-band Synthetic Aperture Radar (PALSAR) satellite data on forest cover mapping and deforestation monitoring, biomass information and agricultural yield estimation. He also explained the estimation of canopy height in the tropical forest plantations using InSAR (Interferometric Synthetic Aperture Radar) technique, UAV technology in classification of tree species and monitoring land use land cover change. The study will enable policymakers to implement the Paris Agreement by relying on updated information about forest biophysical parameters as well as implementation of forest management practices for REDD+ assessment.

Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) tool helps managers and policy makers about the impacts of alternative resource management choices on economy, human well-being, and environment in an integrated way.

Dr. Ben Vickers, Land Use, Forests and Ecosystems Senior Specialist, Green Climate Fund, South Korea in his talk on Forestry, Land Use and Ecosystems under the Green Climate Fund, elaborated the significance of Green Climate Fund (GCF) set up by UNFCCC which is serving as a hub of the climate finance supporting developing countries to transition to low-emission, climate-resilient societies. The GCF had approved about US$11 billion of investment in over 200 projects and programmes worldwide, of which 84 include components in the sectors of forestry, land use and ecosystem services. The scientific priorities of the GCF also include oceans, blue carbon, methane, peatlands, fires etc.

Dr. Dawa Zangpo, Deputy Chief Forestry Officer, Forest Monitoring and Information Division, Bhutan in his talk on Bhutan's Initiative on Forest Carbon Assessment, discussed about the country's stand on carbon neutral policy and nature-based solution to combat climate change. He suggested the use of biomass expansion factor, national forest inventory, estimation of LULC, implementation of REDD+ strategy and participation in voluntary carbon market.

Mr. Zaheer Iqbal, Deputy Conservator of Forests, Bangladesh in his talk on Bangladesh Initiatives on Forest Carbon Assessment & Ecosystem Services Valuation, highlighted the initiatives taken by the government on Forest Carbon Assessment and Ecosystem Services raising concern on complete valuation and safeguard matters of the ecosystem. He further elaborated the efforts taken by the Government mentioning the World Bank supported Sustainable Forests and Livelihoods (SUFAL) project and initiatives of Forest Department to improve the condition of Sundarban Mangroves. He mentioned that opportunities like restoration, reforestation, social forestry in village common forests; and challenges like finalization of REDD+ process, uncertainty of afforestation programme and carbon buyers' condition should be addressed attentively.

Mr. Thakur Subedi, Forest Research and Training Center, Nepal highlighted the assessment of forest carbon stocks of Nepal. He elaborated that two-phase stratified systematic cluster sampling design to monitor land cover has been implemented for extensive field inventory all over the country. Nationwide forest resource assessment assessed the forest carbon using two phase stratified systematic sampling with four concentric circular sample plots to measure the trees of different sizes. Species specific allometric equation is used for volume calculation and that was converted to biomass by multiplying it with its wood density. Branch and foliage biomass are calculated using specific ratio to the stem volume. He highlighted important challenges like irregular pattern of settlement, heterogeneous community, migration and population pressure and accuracy of National Level Cover Monitoring System that are yet to be addressed properly.

Mr. Tambor Lyngdoh, Founding Chairman (Synjuk) Cum Community Conservator of Forest & Project Director, Khasi Hills Community REDD+ Project, Meghalaya along with his team made a presentation on Ecosystem Services Provided by REDD+ Implementation on tribal community land in Meghalaya and highlighted the ecosystem services provided by Synjuk organization of the REDD+ Project, on tribal community land in Khasi Hills. This REDD+ project is one of the few in Asia that is managed by indigenous communities. He discussed the achievements of project in the form of indigenous community transition to alternative livelihoods like reduction in grazing through stall-fed livestock and poultry rearing, use of controlled environment agriculture, high-value crops and products to avoid shifting cultivation, and fruit tree cultivation.

Dr. Promode Kant, Chairman Expert Appraisal Committee (INFRA-2), MoEFCC, Government of India delivered a talk on Developing a domestic forest carbon market in India. He highlighted that ICFRE has constituted an Expert Committee for developing a draft on domestic forest carbon market and discussed in details the draft prepared by the Expert Committee. Further, he explained various modes of carbon sequestration carried out in India. He also mentioned that compliance carbon market under the Kyoto Protocol and a few voluntary carbon markets have been established over the past three decades but with very limited success on account of the extremely high transaction costs involved. Finally, he suggested for promoting and encouraging tree plantation and creating market for ecological services with minimal transactional cost aligning with the Paris agreement.

Dr. Kiran Chand Thumaty, Scientist, NRSC, Hyderabad delivered a talk on ISRO's Initiative on Measurement of Forest Carbon Exchange: Status, Challenges and Way Forward. He highlighted remote sensing-based modeling and principles and methodology of eddy covariance flux tower for assessment of carbon pool and carbon balance. He expressed that data gaps, representation across all forest types, funds and technical man-power and logistic support are major constraints, and looking way forward for a national framework to assimilate and analyze existing data sets, and capacity building in the area of eddy-covariance science should be prioritized.

Dr. Taibanganba Watham, Scientist, ISRO-IIRS, Dehradun delivered a talk on Understanding carbon exchange of western Himalayan foothill forests though eddy covariance measurement. He highlighted that eddy covariance technique to measure carbon dioxide exchange at ecosystem level across varying time scale in North Western Himalayan foothills by applying process-based model Biome BGC. He suggested that eddy covariance tower observation is a perfect test bed to compare various modeling to offset the human generated CO_2 emission and mitigate climate change. He stated that integration of remote sensing data and process-based model can help in achieving accurate estimation of forest productivity and carbon sequestration potential of the forests. The carbon flux estimates and the environmental controls provided by this study would contribute significantly for calibration and validation of ecosystem models for estimation of the carbon budget.

2.6. Session-V

SUSTAINABLE LAND AND ECOSYSTEM MANAGEMENT (SLEM) KNOWLEDGE SHARING AND DISSEMINATION

- **Chair: Dr. Renu Singh**
  Director, ICFRE-FRI, Dehradun
- **Co-chair: Mr. Pradeep Raj Karat**
  CEO CAMPA, Odisha Forest Department

- **Session Talks:**

1. Advancing knowledge sharing and capacity building for restoring forests and landscapes: Dr. Illias Animon, Forestry Officer, FAO- Regional office for Asia Pacific, Bangkok
2. Enhancing ecosystem services by building climate resilient watersheds: Mrs. Neena Grewal, Project Director - Uttarakhand Decentralized Watershed Development Project-II, Uttarakhand, Dehradun
3. Forest landscape restoration under ESIP – success stories from the state of Madhya Pradesh: Mr. S.P. Sharma, APCCF, Madhya Pradesh Forest Department, Bhopal
4. ESIP initiatives in restoration of degraded forests in Chhattisgarh: Mr. Arun Kumar Pandey, APCCF, Chhattisgarh Forest and Climate Change Department, Raipur
5. ESIP Learnings: Forest carbon stocks measurement and scaling up of SLEM best practices in the states of Madhya Pradesh and Chhattisgarh: Dr. R. S. Rawat, Project Manager, ESIP, ICFRE, Dehradun

- **Rapporteurs:**

Dr. Krishna Giri, Scientist-D, ICFRE

Dr. Arun Kumar Thakur, Consultant, ESIP

Dr. Nepolion Borah, Consultant, ESIP

Mr. Illias Animon, Forestry Officer, FAO Regional Office for Asia and the Pacific, Bangkok delivered a talk on Advancing knowledge sharing and capacity building for restoring forests and landscapes. He emphasized on sustainable use of forest resources, quality and restoration for better future. He added that regional strategies and action plans are needed for promoting and accelerating the forest landscape restoration in Asia Pacific regions. The restoration efforts are constrained by governance, institutional, finance, capacity, technical and knowledge barriers. Therefore, he reiterated the need for more targeted investments with stronger multi-stakeholder and context-based social, technical and institutional approaches and it requires transformative change and adaptive management in the forest landscape restoration programs. He elaborated that a regional strategy and action plan for Forest Land Restoration (FLR)

in Asia-Pacific, with six strategic priorities, is endorsed by FAO member countries. This includes promoting learning, collaboration and coordinated action on FLR, and supporting the use of various technical, social and institutional approaches for different landscapes and restoration objectives.

Ms. Neena Grewal, Project Director, Watershed Management Directorate, Uttarakhand delivered a talk on Enhancing ecosystem services by building climate resilient watersheds. She highlighted that the World Bank funded Uttarakhand Decentralized Watershed Development Project II (UDWDP II) also referred to as Gramya II focuses on building climate resilience by rejuvenating the natural resource base by reducing soil erosion, runoff loss, and improving groundwater recharge. She mentioned that the primary strength of the project was its decentralized planning process for developing Gram Panchayats Watershed Development Plan (GPWDP) undertaken with all the primary stakeholders. The innovative actions initiated with introduction of PME (Participatory Monitoring and Evaluation), and Women Aam Sabha proved to be successful in bringing holistic measures in the planning and development processes. The project also introduced various initiatives on use of alternate energy, expansion of animal husbandry activities and agribusiness growth centers. She also added

that an attempt was made to create an ecosystem of remunerative markets through creating Farmer Interest Groups and Farmer Federations, capacities for aggregation, cleaning, grading and packing of farm products. The project has resulted in doubling the income of farmers through strategic synergy between soil moisture improvement, demonstration of integrated crop management practices and cluster development approach.

Sh. S.P. Sharma, APCCF, Madhya Pradesh delivered a talk on Forest landscape restoration under Ecosystem Services Improvement Project (ESIP) – success stories from the state of Madhya Pradesh. He stated that ESIP is supporting the Green India Mission in the state of Madhya Pradesh. The project has followed a holistic approach of forest landscape restoration. He added that various activities of the project during implementation are being monitored by a GIS based methodology the STARMAP (Spatial Technology Approach for Restoration Mapping

and Planning). He further highlighted that the Project interventions in the State are in tune with emerging global expectations of ecosystem services, carbon sequestration and emerge into a larger picture of forest landscape restoration which may help combat climate change.

Sh. Arun Kumar Pandey, APCCF (JFM), Chhattisgarh delivered a talk on ESIP initiatives in restoration of degraded forests in Chhattisgarh. He informed that the project is focused towards ensuring sustained flows of ecosystem services and carbon sequestration. In order to ensure the delivery of sustainable benefits to local communities, sustainable harvesting and value addition of non-timber forest products need to be prioritized. He also highlighted that the capacity and skills of the Forest Department, Forest Development Agencies, and local communities are being enhanced for improving management of forest and land resources and providing benefits to local communities.

Dr. R. S. Rawat, Scientist 'E' and Project Manager, ESIP, ICFRE delivered a talk on ESIP Learnings: Forest carbon stocks measurement and scaling up of SLEM best practices in the states of Madhya Pradesh and Chhattisgarh. He stated that the World Bank funded 'Ecosystem Services Improvement Project' (ESIP) supports the goals of the Green India Mission by demonstrating models for adaptation-based mitigation through scaling up of SLEM and livelihood benefits. The project aims to improve forest quality; land management and non-timber forest produce by enhancing the livelihoods for forest dependent communities. ESIP has introduced new tools and technologies for management of natural resources, including biodiversity and carbon stocks monitoring. He highlighted that as part of the Project, two Eddy Covariance carbon flux towers one each in Madhya Pradesh and Chhattisgarh have been established for measurement of forest carbon exchanges. He has shared the learnings of the SLEM best practices

(Rain water harvesting and augmentation of water resources lac cultivation for livelihood generation and biodiversity conservation, integrated farm development by preparation and application of biofertilizers and biopesticides for productivity enhancement, WADI: a tree-based farming system, conservation of water resources and enhancing productivity through drip irrigation systems and sprinkler irrigation systems, Azolla cultivation, and restoration of degraded ecosystem through distribution of improved cookstoves) scaled up in the selected landscapes of Chhattisgarh and Madhya Pradesh under ESIP.

2.7. Concluding Session : Wrap up and Way Forward

PANELLIST:

- Sh. A.S. Rawat, Director General, ICFRE, Dehradun
- Dr. Promode Kant, Chairman, Expert Appraisal Committee (INFRA-2), MoEFCC
- Dr. Anupam Joshi, Senior Environmental Specialist, the World Bank
- Dr. Lulie Melling, Director, Sarawak Tropical Peat Research Institute, Malaysia
- Dr. Bhaskar S. Karky, Resource Economist and Carbon Finance Specialist, ICIMOD, Kathmandu

Sh. A.S. Rawat, Director General, ICFRE stated that sessions of the workshop were very effective and presentations made by all the speakers were very fruitful for sharing the knowledge for enhancing ecosystem services by improving forest quality and productivity, and sustainable land and ecosystem management. Experience sharing and learnings from Ecosystem Services Improvement Project by ICFRE and Madhya Pradesh, Chhattisgarh State Forest Departments were really eye opening. ESIP interventions had made improvement in the ecosystem services in the project areas as evident from increase in the ground water level, growing stock enhancement and improvement in the biodiversity. Further, he stated ICFRE is implementing a project for valuation of the ecosystem goods and services in the country through standardizing necessary methodologies for valuation of ecosystem services. He also flagged the following issues as far as recommendations of the workshop's sessions:

- Availability of quality planting materials is one of the main concerns for productivity enhancement and forest quality, and more focus should be on developing quality planting stocks for restoration of forest landscapes and forestry plantation programmes. ICFRE has submitted standards/ protocols for establishing the Hi-Tech Nurseries in each Forest Division in the State Forest Departments for raising quality planting stocks.
- Development of the standards for the quality planting materials is the demand of the hour.
- Domestic forest certification mechanism needs to be developed.
- Research need to be conducted on shortening of the rotation period of the important timber species.
- FLR models and techniques developed by the different organizations need to be scaled up for restoration of the degraded forest landscapes.
- Regional cooperation of the Governments is needed for sustainable management of Hindu Kush Himalayan transboundary landscapes.

- Suitable actions need to be initiated for implementation of the REDD+ activities.
- Country specific volumetric equations for important tree species need to be developed with the involvement of research organizations.
- Domestic forestry carbon market needs to be established and necessary recommendation will be submitted to the Government for taking necessary decisions.
- ICFRE has established carbon flux towers for monitoring real-time carbon exchanges between atmosphere and vegetation. Networking of the carbon fluxes towers are required for sharing of the data and knowledge for devising suitable strategies for sustainable land and ecosystem management.
- SLEM best practices scaled up by ICFRE under the ESIP need to be adopted by the State Forest Departments of the country as well as neighbouring countries for forest landscapes restoration and livelihood generation.

Dr. Promode Kant, Chairman, Expert Appraisal Committee (INFRA-2), MoEFCC stated that workshop was organized in a very effective way. He flagged the following issues as deliberated during the workshop:

- Domestic forest carbon market needs to be established for promoting sustainable management of forests and in achieving the forestry sector target of the NDC.
- Participation of the neighbouring countries in the workshop was useful for sharing their knowledge and experiences in productivity enhancement and same need to be adopted.
- MoU needs to be signed with the organizations / institutions of the neighbouring countries for sharing of knowledge and learnings.
- Forest lands are diverted under the provision of the Forest Right Act, and impacts of the same on forest productivity need to be seen by the policy makers.
- Bamboo and palm need to be included in the forest definition that would be helpful in getting carbon assimilation benefits.

Dr. Lulie Melling, Director, Sarawak Tropical Peat Research Institute, Malaysia stated that forest for future and conservation for future need to be considered as one of the top priorities. She also flagged the following issues as deliberated during the workshop:

- Soil quality and better soil management need to be considered for success of the sustainable forest management.
- Bilateral cooperation needs to be promoted for ecosystem management
- Better technology interventions are required for better management of the natural resources for fulfilling the demands and living standards of the increasing population
- Space based tools and technologies need to be adopted for biomass prediction and mitigating climate change

Dr. Bhaskar S. Karky, Resource Economist and Carbon Finance Specialist, ICIMOD, Kathmandu stated that this workshop was very meaningful in terms of sharing of knowledge and learnings on SLEM best practices of ESIP and leanings of the other countries. This workshop has contributed a lot for south-south cooperation. He also flagged the following issues as deliberated during the workshop:

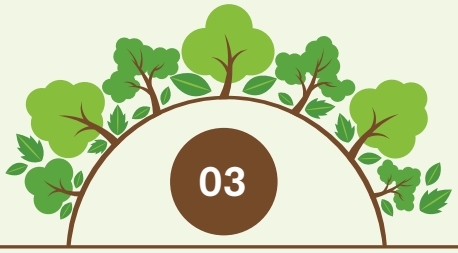
- External financial supports from the World Bank for developing innovative tools and techniques and scaling up of SLEM practices is of immense importance for enhancing ecosystem services and improving the forest health.
- India should take lead in establishment of the Domestic Forestry Carbon Market and neighbouring countries will also be benefitted from it. Policy level recommendation need to be given to the Government of India for establishment of domestic forestry carbon market.

Dr. Anupam Joshi, Senior Environmental Specialist, the World Bank thanked ICFRE for organization of the workshop and also thanked all the delegates for fruitful discussion in the workshop. He stated that ESIP will be completed by 30 July 2023 and knowledge gained under this project needs to be translated in to actions. He also flagged the following issues as deliberated during the workshop:

- India has rich history of forestry but where we are today? Need to be re-looked for addressing the challenges of climate change and meeting national targets and international commitments related to forestry sector.
- A complete package of guidance, knowledge and practices need to be developed for forestry carbon project.

- ESIP has provided the ecological and social benefits. Empowerment of the local communities done under the project could be one of the greatest achievements for sustainable management of the ecosystem.
- Skill and competency are needed for forestry extension services, and policy reforms are required for improving the forestry extension services.
- Marginal farmers are depending on the forest for their livelihoods, State Forest Departments has to provide the extension services for NTFPs, value chain and agroforestry so that contribution of the forestry sector in GDP could be enhanced.
- India has Agroforestry Policy in place since 2014 but uptake of this policy is not seen as it was expected. Ownership of the agroforestry is lacking at Ministry of Agriculture and Farmer Welfare, and Ministry of Environment, Forest and Climate Change. State Forest Departments need to take the ownership of the agroforestry.
- Potential of the agroforestry need to be explored for sequestering atmospheric carbon for mitigating climate change as well as providing the carbon credits benefits to the farmers.
- Carbon registry need to be developed in the country and the World Bank is committed to support the carbon registry under the proposed TREE-D project.
- The World Bank is also contributing in the emerging trend of OECM. Bank is discussing with other donors to setup a platform for SHARPER (South Asia Regional Platform for Ecological Resilience), and all the key ministries of the country would be brought together under this platform to build the action into conservation and bring more harmony and piece building. Country would be brought together for exchange of knowledge and sharing of the learning for management of the transboundary landscapes
- Regional trade on biological commodities is increasing and global business model is shooting up so country specific consolidated approach need to be developed for trading.
- Some of the recommendations of this workshop will be scaled up in the next phase of ESIP that is TREE-D project.

At the end, **Dr. R. S. Rawat**, Project Manager, ESIP, ICFRE proposed a formal vote of thanks to all the delegates especially session chairs, panellists, speakers, experts, national and international delegates for their lively discussions and exchange of knowledge and ideas on nursery management, plantation and restoration techniques, enhancing carbon sequestration potential of forests and assessment of forest carbon stocks and SLEM knowledge sharing for sustainable land and ecosystem management in the country. He also thanked to the World Bank and Ministry of Environment, Forest and Climate Change, Govt. of India for providing all kinds of support for organisation of the international workshop. He also thanked all the organisations and their officers and staff including personnel of ICFRE and FRI for their hard work and sincere efforts put in for the successful organisation of the international workshop on Agroforestry and Farm Forestry for Sustainable Land and Ecosystem Management under the Ecosystem Services Improvement Project.



RECOMMENDATIONS OF THE WORKSHOP

3.1. Nursery Management and Plantation Techniques for Productivity Enhancement

- Availability of Quality Planting Material to the stakeholders and quality standards of planting stock for degraded sites needs to be ensured.
- To exploit the true potential of the tree genetic resources awareness of the tree growers to retain trees for a minimum production cycle need to be developed.
- Domestic forest certification mechanism needs to be developed.
- Promoting use of short rotation crops to encourage farmers in tree planting activities with definite financial incentives.
- Promoting mosaic clone cultivation to maintain the genetic base and ensuring profitability for the grower's community and other stakeholders.
- At least one Hi-tech nursery at a Forest Range level needs to be established.

3.2. Forest Landscape Restoration Techniques for Improving Forest Quality and Productivity

- Use of pioneer tree species in restoring degraded lands, stabilizing disturbed ecosystems and ensuring better survival of climax species.
- Adoption of Integrated Farming System (IFS) including agroforestry practices in Forest Landscape Restoration approaches.
- Adopting innovative techniques like Restoration Opportunity Assessment Methodology (ROAM) to achieve Forest Landscape Restoration with a flexible and affordable framework to rapidly analyze degraded areas.
- Regional collaboration amongst collaborating government and other partners, for restoring mountain landscapes.
- Promotion of local species with proper soil and moisture conservation practices, and method of planting for restoring degraded lands.
- "Community Water Stewardship" on water use planning need to be inbuilt in land restoration projects.

3.3. Enhancing Carbon Sequestration Potential and Assessment of Forest Carbon Stocks

- Expanding use of geospatial techniques in mapping and monitoring biophysical parameters for forest and plantation management and accurate carbon stock assessment.
- Promote REDD+ activities and financial incentives in community-based forest management for the enhancement of carbon sequestration.
- Promoting climate change mitigation and adaptation practices in the AFOLU sector.
- Strengthening of the national forest monitoring system, implementation of REDD+ strategy, participation in the voluntary carbon market.
- Accessing finance from Green Climate Fund for forest sector climate change mitigation

and adaptation projects and leveraging domestic financing through green bonds.

- Forest and tree plantation programmes to be more remunerative with definite market for ecological services including mitigation/ adaptation to climate change and the market aligned with Article 6 of the Paris Agreement.
- Plantation owners should have long-term management plan certified by accredited agencies.
- Indo Flux network needs to be developed by bringing together all the institutions involved in eddy covariance-based carbon flux studies of forests in the country. Scientists/ researchers can use flux data to better understand forest ecosystem functioning, and to detect trends in climate and carbon sequestration.
- Government of India need to promote its own forest carbon market to incentivize small and marginal farmers. Carbon credits generated through these projects should be named differently for the credits generated from public and private lands.
- Government of India should include bamboos and palms in the forest definition for the purpose of market mechanism under Article 6.4 of Paris Agreement and same need to be communicated to UNFCCC. ICFRE can send an *aide-memoire* to the MoEFCC on this issue.
- Transboundary ecosystems in the South East Asia region need to be protected.

3.4. Sustainable Land and Ecosystem Management (SLEM) Knowledge Sharing and Dissemination

- Broad agrifood system-oriented approaches by integration, optimization, diversification and innovations to be included in action plans for sustainable land management.
- Integrating various technical, social and institutional approaches for landscapes restoration including traditional water harvesting structures and small land irrigation systems like "*Naulas*", for enhancing contribution in building climate resilient watershed.
- Innovative approaches in PME (Participatory Monitoring and Evaluation) with financial autonomy in Gram Panchayat and Women Aam Sabha to ensure regular flow of funds by way of income generation.
- Capacity building of the stakeholders and sharing of knowledge on SLEM best practices of local communities in sustained use of natural resources and better management of forest and land resources.
- Scaling up and adopting SLEM best practices (vermicomposting, application of biofertilizers and biopesticides for integrated farm development for sustainable land productivity, Wadi system- A tree-based farming system, lac cultivation for livelihood generation and biodiversity conservation, rain water harvesting and augmentation of water resources, system of rice intensification, and Azolla cultivation) need to be promoted for sustainable land productivity.
- Entrepreneurship interventions in agribusiness growth centres should be channelized for livelihood growth.
- Implementation of recommendations of Roadmap developed for institutional and policy mainstreaming of sustainable land and ecosystem management in India to combat land degradation and desertification.
- Documentation and dissemination of standard methodologies for the assessment of various ecosystem services among the various stockholders.
- Promotion of practices like use of nets for collection of Mahua flowers in Madhya Pradesh need to be scaled up in other parts of the country for prevention of forest fire.

AGENDA OF THE WORKSHOP

Day 1: 22 March 2023	
Session – I: Inaugural Ceremony	
1400-1430 Hrs	Registration of the Delegates:
1430-1545 Hrs	Visit to the Museums of Forest Research Institute
1545-1645 Hrs	**Opening Plenary** • Lighting of the Lamp • Welcome Address by Mr. A. S. Rawat, Director General, ICFRE • Address by Dr. Anupam Joshi, Senior Environmental Specialist, the World Bank • Address by Mr. Pravir Pandey, Additional Secretary and Financial Advisor, Ministry of Environment, Forest and Climate Change, Govt. of India • Address by Mr. B. K. Singh, Additional Director General of Forest (Forestry), Ministry of Environment, Forest and Climate Change Govt. of India • Address by Chief Guest: Mr. Ashwini Kumar Choubey, Hon'ble Minister of State for Environment, Forest and Climate Change • Vote of Thanks by Ms. Kanchan Devi, Director (IC) & Project Director, ESIP, ICFRE
1645-1715 Hrs	**Group Photo & High Tea**
1715-1730 Hrs	**Keynote Address:** Rethinking Forestry for Planet People and Profit**:** Dr. Anupam Joshi, Senior Environmental Specialist, the World Bank, New Delhi
Day 2: 23 March 2023	
Session – II: Nursery Management and Plantation Techniques for Productivity Enhancement **Chair:** Mr. Bharat Jyoti, Director, IGNFA, Dehradun **Co-chair:** Mr. Subhash Chandra, Chief Executive Officer, CAMPA, MoEFCC, Govt. of India	
0930-0955 Hrs	Nursery and plantation techniques: Dr. R.C. Dhiman, CIFOR-ICRAF
0955-1020 Hrs	Productivity enhancement of the forest plantations through planting stock improvement - ICFRE initiatives: Dr. H.S. Ginwal, Dean (Academic), Forest Research Institute Deemed to be University, Dehradun
1020-1045 Hrs	Recent advances in breeding, nursery and plantation techniques for enhancing productivity in short rotation tree species: Dr. Mohan Varghese, Senior Principal Scientist, ITC Life Sciences and Technology Centre, Bengaluru
1045-1110 Hrs	Nursery techniques for raising quality planting stock of Himalayan conifers: Dr. Sandeep Sharma, Director, ICFRE-Himalayan Forest Research Institute, Shimla
1110-1135 Hrs	**Tea Break**
1135-1200 Hrs	Conservation and Sustainable Teak Forest Management in Thailand: Prof. Yongyut Trisurat, Kasetsart University, Bangkok, Thailand
1200-1225 Hrs	Potential of *Shorea roxburghii G.* Don as forest plantation species and for rehabilitation of degraded areas: Dr. Ho Wai Mun, Forest Research Institute Malaysia
1225-1235 Hrs	*Q&A and Discussion*
Session – III: Forest Land Restoration Techniques for Improving Forest Quality and Productivity **Chair:** Dr. Dhananjay Mohan, PCCF, Uttarakhand **Co-chair:** Mr. Pankaj Agarwal, Deputy Director General of Forests, MoEFCC-IRO, Dehradun	
1235-1300 Hrs	The potential of pioneer species to the restoration programme on degraded forest: Dr. Rosdi Bin Koter, Forest Research Institute Malaysia
1300-1400 Hrs	**Lunch Break**

1400-1425 Hrs	Leveraging innovative tools and technologies for accelerating forest landscape restoration towards meeting 2030 Bonn Challenge commitment of India: Ms. Archana Chatterjee, Programme Manager, IUCN-India
1425-1450 Hrs	Innovative financing mechanisms for restoring mountain landscapes in the Hindu Kush Himalaya: Dr. Bhaskar S. Karky, ICIMOD, Kathmandu
1450-1515 Hrs	Forest restoration efforts of community forestry in Nepal: Success stories from Province-1, Nepal: Mr. Nabin Bhattarai, Hokkaido University, Japan
1515-1530 Hrs	**Tea Break**
1530-1555 Hrs	Rejuvenating landscapes - transforming lives in rural India: The Ecosystems based Adaptation: Mr. Sandeep Jadhav, Director, WOTR, Pune
1555-1620 Hrs	Sustainable Land and Ecosystem Management Opportunities in Myanmar (Case Studies on of Mangrove Ecosystem): Dr. Win Maung Aye, Assistant Director, Watershed Management Division, Forest Department, Nay Pyi Daw (Myanmar)
1620-1645 Hrs	Restoration of degraded common lands: Ms. Himani Sharma, Programme Manager, Foundation for Ecological Security, Anand
1645-1710 Hrs	Restoration of forest ecosystem services through eco-budget in Karnataka: Dr. M. Balasubramanian, Assistant Professor, Centre for Ecological Economics and Natural Resources, Institute for Social and Economic Change, Bengaluru
1710-1730 Hrs	*Q&A and Discussion*
1930 onwards	**Cultural Evening and Workshop Dinner (Venue: Seyfert Sarovar Premiere, Haridwar Bypass Road)**

Day 3: 24 March 2023	
Session – IV: Enhancing Carbon Sequestration Potential and Assessment of Forest Carbon Stocks **Chair:** Mr. Rajesh Kumar, Former DDG & NSO/FSI **Co-chair:** Dr. Nitin Kulkarni, Director, ICFRE-TFRI	
0930-0955 Hrs	Assessment of carbon stock in India's forests: Mr. Prakash Lakhchaura, Dy. Director General, Forest Survey of India, Dehradun
0955-1020 Hrs	Role of AsiaFlux Network on measurement of carbon flux from tropical peatland: Dr. Lulie Melling, Director, Sarawak Tropical Peat Research Institute, Malaysia
1020-1045 Hrs	Role of geospatial data in carbon monitoring in Cambodia, Malaysia, Philippines and India: Dr. Ram Avtar, Associate Professor, Hokkaido University, Japan
1045-1110 Hrs	Forestry, land use and ecosystem services under the Green Climate Fund: Mr. Ben Vickers, Land Use, Forests and Ecosystems Senior Specialist, Green Climate Fund, Songdo, Incheon City, Republic of Korea
1110-1125 Hrs	**Tea Break**
1125-1150 Hrs	Bhutan's initiative on forest carbon assessment: Mr. Dawa Zangpo, Deputy Chief Forestry Officer, Department of Forests and Parks Services, Ministry of Energy and Natural Resources, Bhutan
1150-1215 Hrs	Bangladesh initiatives on forest carbon assessment and ecosystem services valuation: Mr. Zaheer Iqbal, DCF, Bangladesh Forest Department
1215-1240 Hrs	Assessment of forest carbon stocks in Nepal: Mr. Thakur Subedi, Research Officer, Forest Research and Training Centre, Ministry of Environment and Forest, Nepal
1240-1305 Hrs	Ecosystem services resulting from the Khasi Hills Community REDD+ Project: Mr. Tambor Lyngdoh, Founding Chairman (Synjuk) Cum Community Conservator of Forest & Project Director, Khasi Hills Community REDD+ Project, Meghalaya
1305-1400 Hrs	**Lunch**

1400-1420 Hrs	Developing a domestic forest carbon market in India: Dr. Promode Kant, Chairman, Expert Appraisal Committee (INFRA-2), MoEFCC, Govt. of India
1420-1435 Hrs	ISRO's initiative on measurement of forest carbon exchange – status, challenges and way forward: Dr. Kiran Chand Thumaty, Scientist 'F' and Head, Forestry Resources Division, Forestry & Ecology Group, Remote Sensing Applications Area, National Remote Sensing Centre
1435-1450 Hrs	Understanding carbon exchange of western Himalayan foothill forests though Eddy Covariance measurement: Dr. Taibanganba Watham, Scientist/Engineer-SD, Indian Institute of Remote Sensing, Dehradun
1450-1500 Hrs	*Q&A and Discussion*
1500-1515 Hrs	**Tea Break**
Session - V: Sustainable Land and Ecosystem Management (SLEM) Knowledge Sharing and Dissemination **Chair:** Dr. Renu Singh, Director, ICFRE-Forest Research Institute, Dehradun **Co-chair:** Mr. Pradeep Raj Karat, CEO State CAMPA, Odisha	
1515-1530 Hrs	Advancing knowledge sharing and capacity building for restoring forests and landscapes: Dr. Illias Animon, Forestry Officer, FAO, Bangkok
1530-1545 Hrs	Enhancing ecosystem services by building climate resilient watersheds: Mrs. Neena Grewal, Project Director - Uttarakhand Decentralized Watershed Development Project-II, Uttarakhand, Dehradun
1545-1600 Hrs	Forest landscape restoration under ESIP – success stories from the state of Madhya Pradesh: Mr. S.P. Sharma, APCCF, Madhya Pradesh Forest Department, Bhopal
1600-1615 Hrs	ESIP initiatives in restoration of degraded forests in Chhattisgarh: Mr. Arun Kumar Pandey, APCCF, Chhattisgarh Forest and Climate Change Department, Raipur
1615-1630 Hrs	ESIP Learnings: Forest carbon stocks measurement and scaling up of SLEM best practices in the states of Madhya Pradesh and Chhattisgarh: Dr. R. S. Rawat, Project Manager, ESIP, ICFRE, Dehradun
1630-1640 Hrs	*Q&A and Discussion*
Concluding Session: Wrap up and way forward	
1640-1725 Hrs	**Panellist:** Mr. A.S. Rawat, Director General, ICFRE, Dehradun Dr. Anupam Joshi, Senior Environmental Specialist, the World Bank Dr. Promode Kant, Chairman, Expert Appraisal Committee (INFRA-2), MoEFCC Dr. Lulie Melling, Director, Sarawak Tropical Peat Research Institute, Malaysia Dr. Bhaskar S. Karky, ICIMOD, Kathmandu
1725-1730 Hrs	**Vote of Thanks by Dr. R. S. Rawat, Project Manager, ESIP, ICFRE**

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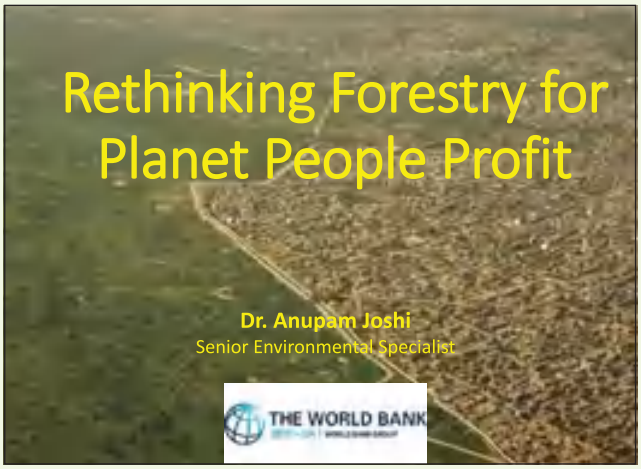
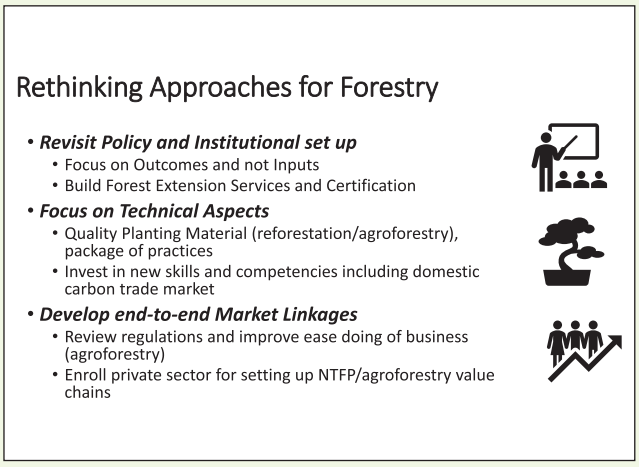
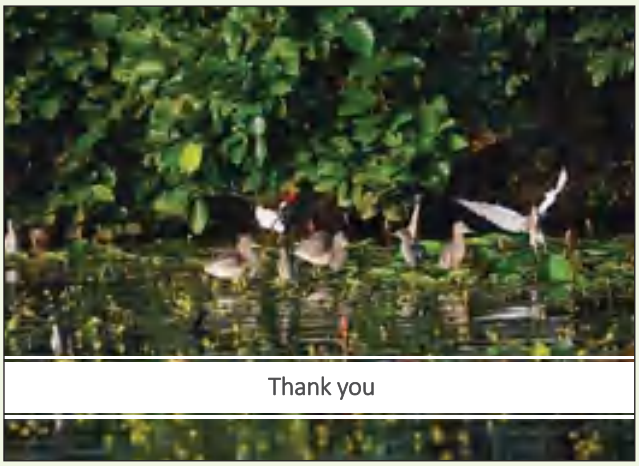
PRESENTATIONS OF THE WORKSHOP SPEAKERS

Keynote Address

Rethinking Forestry for Planet People and Profit: Dr. Anupam Joshi, Senior Environmental Specialist, the World Bank, New Delhi







1. Nursery and plantation techniques: Dr. R.C. Dhiman, CIFOR-ICRAF

Nursery and Plantation Techniques

R C Dhiman

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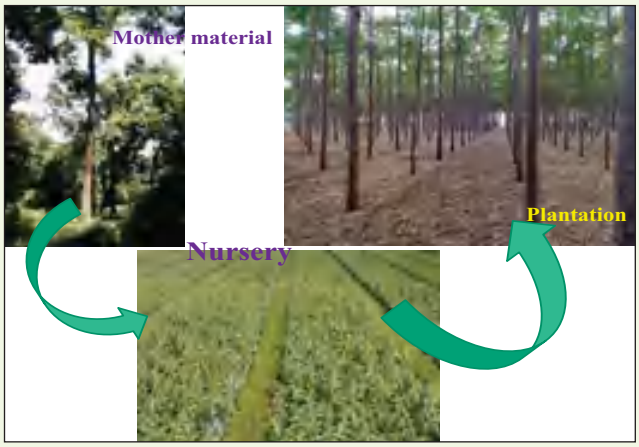
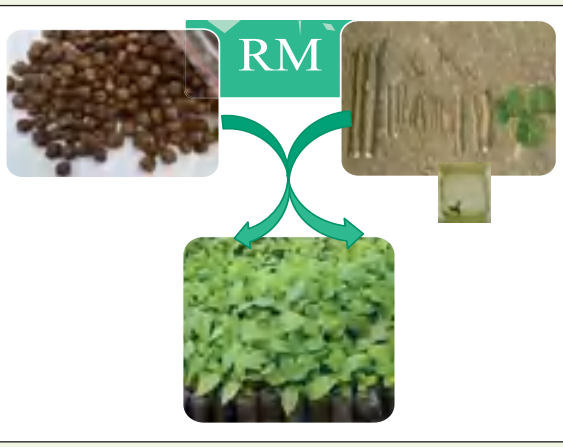
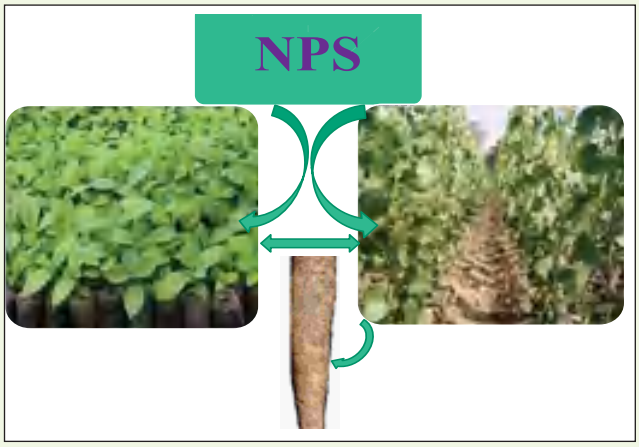
Nurseries-Introduction

- Long history of raising plantations and nurseries in India
- Tendency increasing to use improved cultivars and varieties
- Seed origin propagation is in transition to clonal propagation in QPM production
- Good progress in nursery production techniques for select species
- Improved controls on handling QPM between production and field planting



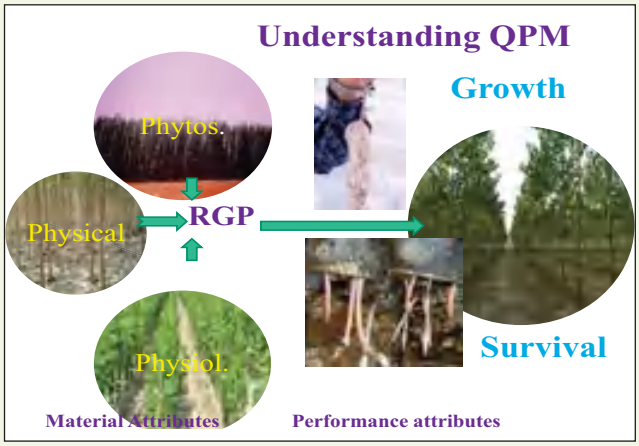




Root-shoot cutting

17-22 cm below the root collar and 2-3 cm above collar with diameter of >1 cm

RSO



QPM-Definition

- Nursery produced disease free, physically sound, and physiologically active planting stock; raised through seed or vegetative reproductive material from known mother material; with potential of high field performance

Nursery Techniques specific to

- Species and site specific
- Reproduction material
- Propagation method ?
- Propagation environment ?
- Production cost ?
- Handling
- Planting

Understanding Juvenile-mature phase through euca rooting

Plantations-introduction

- Initial plantations by forest department on forest land, currently majority on non forest land
- Rotation is gradually reducing
- Excellent progress in productive plantations for panel products, veneers, paper and pulp, etc.
- Fast growth and high productivity
- Precision agri-silviculture(Agronomy+Silv) helping in improving plantation productivity

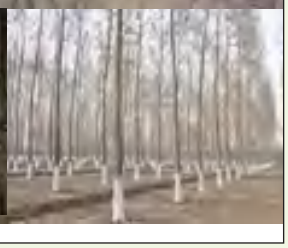
Purposes of raising forest plantations

- Initiated attempts for quality timber production, extended to restoration, firewood and fruit producing species
- Also for protection, enhancing biological diversity, other ecosystem service including socio-economic, environmental etc.

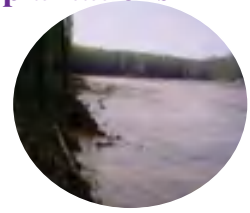
Plantation techniques

- Effective land preparation
- Planting to the final harvest density with attempts to get zero mortality
- Regular earth work
- Effective weed control
- Intercropping
- Tending operations especially pruning
- Harvesting including uprooting of the stumps
- Immediate clearing lops/tops and replanting

Plantations for wood production



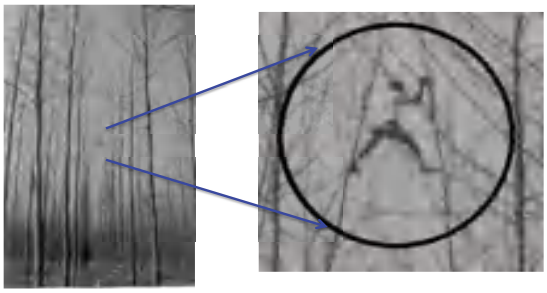
Other purposes-Forest plantations



Land preparation

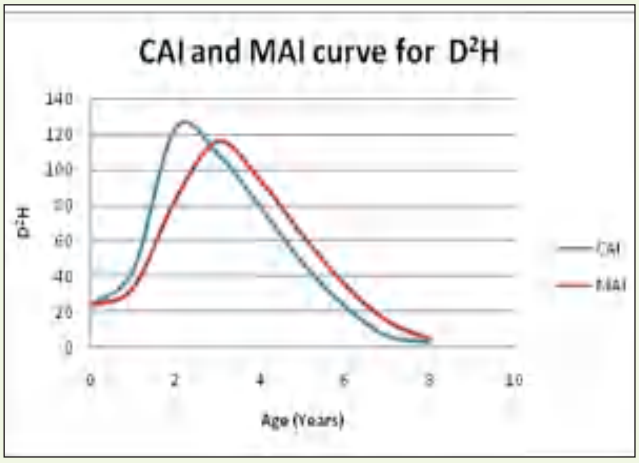
Plantation Protection

Plantation culture becoming an art



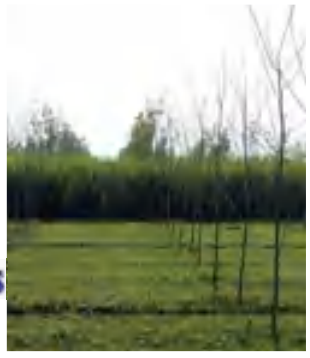
Rotation –dynamic and evolving

- **Opportunistic Rotation -is a harvesting period decided by the tree growers based on perceived opportunities and self needs.**



Conclusion: Keeping plantation in active growth

Thanks



2. Productivity enhancement of the forest plantations through planting stock improvement – ICFRE initiatives: Dr. H.S. Ginwal, Dean (Academic), Forest Research Institute Deemed to be University, Dehradun

Productivity Enhancement of the Forest Plantations through Planting Stock Improvement

ICFRE Initiatives

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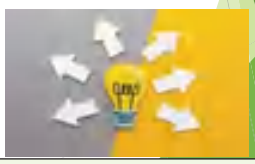
Issue and challenges

- India is a wood deficient country and a major importer of timber (with an annual import bill of around 45,000 crores (ITTO 2017))
- The societal demands on forests are becoming more diversified and rising faster than the capacity of forests to supply.



Low Productivity

- India ranks first in the extent of plantation area for Eucalypts (3 million ha), Teak (2.6 million ha) and Casuarina (0.8 million ha) and another 1-2 million ha of plantations of other tree species.
- Currently wood demand for the paper and plywood industries are almost entirely met from plantations.
- Productivity of Indian plantations is among the lowest in the world.

Commitments & responsibility

1. India has to meet the Nationally Determined Contributions (NDC) of 2.5 to 3 billion tonnes of additional carbon sinks by 2030.
2. Bonn challenge – restoration of 26 m ha
3. Considering the commitments and the domestic demand, it is essential that the **area and productivity of forestry plantations are enhanced.**

Small increment in productivity will result in substantial benefits in terms of economic gain to growers, increased raw material.

Develop and deploy plant material resilient to changing climate

Pest and disease incidence, drought, fire, salt, phenotypic plasticity

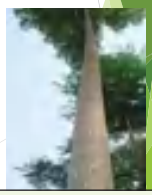
- Genetically diverse and adapted seed and planting stock provide the foundation for healthy ecosystems
- Selection and breeding program for resistance :

PLANTING STOCK QUALITY

Matters a lot !

Enhance the form/ quality/ productivity of the plantation forests

Expand the carbon sink

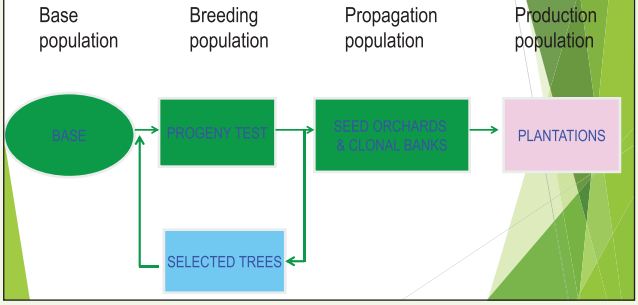


Type of planting stock

1. Clonal material
2. Quality Seeds

Planting Stock Improvement Programme

Breeding Strategy



IMPROVED CLONES – PREVALENT OPTION

Involves the following four stages:

- Selection of Candidate Clones
- Clonal Testing
- On-site Yield Trials
- Mass Multiplication and Deployment

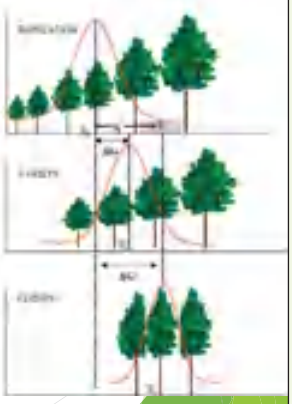


WHY CLONES ?

Because they are just the bloody same ...

But they are the best way to maximize genetic gain ...

Clonal technology capture and exploit the best recombination in a shortest possible time.

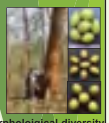


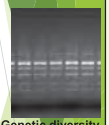
Clones can be adopted in Agro-forestry, the novel approach of combining trees with agricultural crops on the same piece of land, allows for both annual income from seasonal crops and additional income at the end of 4/5 years from sale of pulpwood


Tree Improvement - Activities in ICFRE

- Assessment of genetic diversity
- Selection of Superior genotype for increased productivity
- Establishment of Progeny trials/orchards/VMGs
- Development of Varieties /Clones

Species : Teak, *Casuarina, Eucalyptus, Gmelina, Melia,* Sandalwood, Red Sanders, *Buchanania, Ailanthus, Tamarindus,* Neem, *Dalbergia,* Poplar, Toon


Morpholoigical diversity


Genetic diversity


Genome Sequencing


Sisham clone


Poplar clone


Casuarina clones


Melia variety

Varieties/clones released

A set of guidelines were developed to systematically conduct the testing and release of new varieties and clones by ICFRE in the year 2008 and the same were approved by then MoEF, Govt. of India.

Facilitate release of new varieties and clones during the past decade.

(i) Field evaluation/inspection

(ii) Variety Testing Committees (Regional and All-India) Scrutinizes the report of Implementation Team

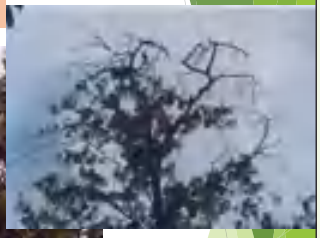
(iii)Variety Releasing Committee –approval for release of the varieties.

Release of High Yielding Clones

Species and Character	2010	2011	2014	2017	2021	Total
Eucalyptus Fast Growth, gall resistance, pulp yield	4	1	7	3	2	17
Casuarina Fast growth, wind-resistance, pulp yield	4	-	10	5	-	19
Shisham Wilt disease resistant, high yield	-	1	-	-	3	4
Melia Fast growth, good form	-	-	-	10	-	10
Rauwolfia Higher reserpine	-	-	-	2	-	2
Neem High oil and Azadirachtin content	-	-	-	-	6	6
Poplar Fast growth, good form	-	-	-	-	5	5
Callophylum Seed oil	-	-	-	-	6	6
Total Number of clones released: 69						69

Productivity loss: Heavy mortality of Shisham

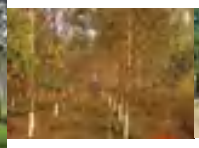
Wilt of Shisham by *Fusarium solani* & Root rot by *Ganoderma lucidum*

DEVELOPMENT AND RELEASE OF HIGH YIELDING CLONES

Shisham (1994-2012) – Wilt disease resistant high yielding clone developed (FRI-DS-14).

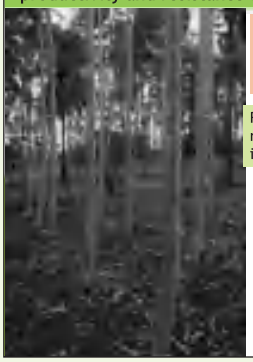
The productivity of clone estimated 12 $m^3 ha^{-1}$ compared to 5-7 $m^3 ha^{-1}$ realized from plantations raised with unimproved seed sources




In extensive use for plantations in Punjab, Haryana and Uttar Pradesh

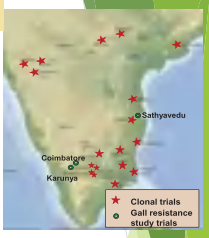
DEVELOPMENT AND RELEASE OF HIGH YIELDING CLONES

***E. camaldulensis* clones for higher productivity and resistance to Gall insect**



Following the outbreak of *Leptocybe invasa* in 2008

Released 7 clones for resistance to Gall insects - Year 2014



Clone	% improvement in growth	% improvement in gall resistance
IFGTB-EC5	26.2	80.0
IFGTB-EC6	17.1	33.3
IFGTB-EC7	14.3	72.6
IFGTB-EC8	14.3	64.2
IFGTB-EC9	9.5	75.1
IFGTB-EC10	9.5	51.2
IFGTB-EC11	4.8	81.1

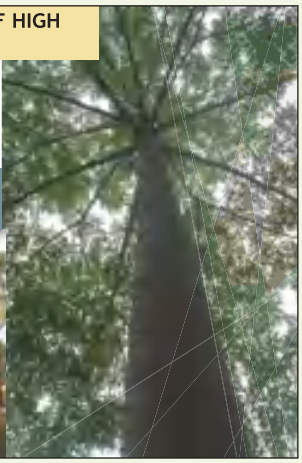
DEVELOPMENT AND RELEASE OF HIGH YIELDING CLONES

Melia (*Melia dubia*)

Ten productive varieties of *Melia dubia* were developed, field tested and released in the year 2017

6450 kg seed (6.5 million plants) + 1.5 million seedlings supplied by FRI (7000 ha planted by IFFDC, FD, farmers etc.)

Variety	Productivity ($m^3ha^{-1}yr^{-1}$)
FRI/MD/235	55.83
FRI/MD/349	40.41
FRI/MD/032	39.79
FRI/MD/232	37.11
FRI/MD/241	33.71
FRI/MD/075	33.43
FRI/MD/262	31.10
FRI/MD/231	26.73
FRI/MD/256	24.36
FRI/MD/261	23.19



DEVELOPMENT AND RELEASE OF HIGH YIELDING CLONES

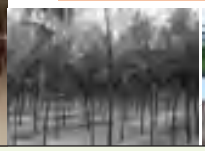
Casuarina

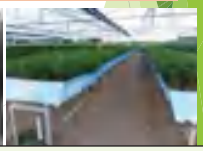
High yielding germplasm, already planted over 9,000 ha

Released 19 high-yielding clones.
(Pulp-6, Windbreak -5)

Six clones registered with PPVFRA

Casuarina junghuhniana
IFGTB-CJ-9 (PPVFRA No. REG/2015/1658)
Casuarina Hybrid Clones
IFGTB-CH-1 (PPVFRA No. REG/2017/1564)
IFGTB-CH-2 (PPVFRA No. REG/2017/1565)
IFGTB-CH-3 (PPVFRA No. REG/2017/1566)
IFGTB-CH-4 (PPVFRA No. REG/2017/1567)
IFGTB-CH-5 (PPVFRA No. REG/2017/1568)



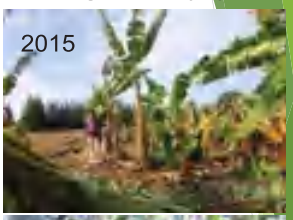


Superior Clones for Windbreak Agroforestry System

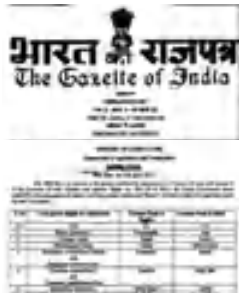
Western Zone, TN
Loss of banana crop due to wind damage:
5 crores per year

Windbreaks with selected clones protect the banana crop

Provides additional income to farmers (20 tonnes pulpwood per ha worth Rs.80,000/-)



IPR Protection for IFGTB's New Varieties



Casuarina and Eucalyptus have been notified for Registration under the Protection of Plant Varieties and Farmers' Rights Act, 2001.

Provisional IPR protection granted for seven IFGTB clones.

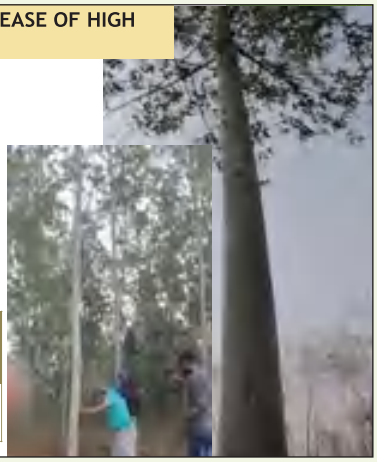
First instance for forestry crops in the country.

DEVELOPMENT AND RELEASE OF HIGH YIELDING CLONES

Eucalyptus

Three productive genotypes of *Eucalyptus tereticornis* were selected, tested in the field and have been released during the year 2017

Clone ID	Single tree volume m^3	Productivity m^3 ha^{-1}
FRI/ET/31	0.086	23.04
FRI/ET/35	0.077	20.61
FRI/ET/32	0.055	14.68



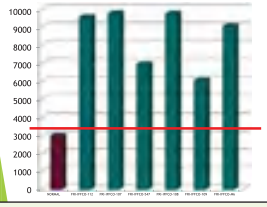
Developed six varieties of Neem

For high oil and Azadirachtin content

Released in the year 2021

Around 1.25 lakh saplings in field (IFFCO)

AZA CONTENT



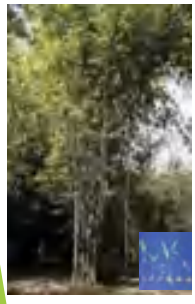
DEVELOPMENT AND RELEASE OF HIGH YIELDING CLONES

Two varieties of *R. serpentina* released during the year 2017 for higher root yield and reserpine content

(a) TFRI-RS 1 (b) TFRI- RS 2

Variety	Reserpine (%)	Total alkaloids (%)	Yield / plant	Reference
TFRI- RS 1	0.06	2.72	28.56 gm	For higher root yield
TFRI- RS 2	0.09	3.81	22.26 gm	For higher reserpine content

Improved Bamboo Clumps

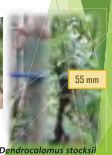


Dendrocalamus strictus

Identified 196 high yielding bamboo clumps of nine species with average potential >20% yield gain

Variations in Culm Wall Thickness

Stock of Multiplied Superior Clumps Ready for Transfer



Dendrocalamus stocksii

A total of 5161 copies of 54 superior clumps of eight species were transferred to State Bamboo Missions

All India Coordinated Research Project on Bamboo

Selection of Bamboo CPCs

Total CPCs of bamboos selected: 300

(B. balcooa, B. nutans, B. nutans, B. tulda, B. vulgaris green, B. bambos, Thyrsostachys oliveri, D. giganteus, B. multiplex, B. striata, B. jaintiana, Dendrocalamus stocksii and ***Melocanna baccifera)***

Mass multiplication of elite germplasm

Established Rhizome banks of selected clumps established at FRI, IFGTB, HFRI & IFP

Selected CPC of *B. nutans* and *B. vulgaris* at Bhasma, Odisha

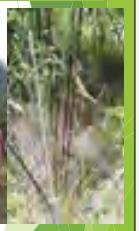
Rhizome banks of bamboo

Mass propagation of *B. nutans clumps* through cavity method

Improvement of Hill Bamboos (Ringals)

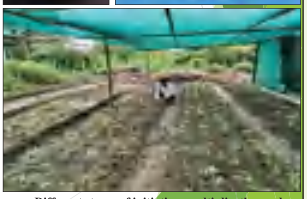
- Selection, evaluation and deployment of CPCs/clones, establishment of rhizome banks and production of Improved planting stock
- Mass multiplication of elite/promising germplasm

Extensive field survey, selection and collection carried out in Rudraprayag forest area in Uttarakhand for **Dev, GoI, Jamura and Tham ringal and collected** CPCs of Ringals



Mass multiplication and dissemination of elite germplasm

- Protocol for 8 bamboo species and CPCs (*B. balcooa, B. tulda, B. nutans, D. stocksii, D. brandisii, D. strictus D.hamiltonii,* and *G. macrostachya,)* standardised.
- *In vitro* starter cultures for 4 species (*B. tulda, D. asper, D. stocksii* and *D. brandisii*) **produced and sold (134 bottles).**
- **Produced 10,000 hardened plants of 8 species** (*B. balcooa, B. bambos, B. tulda, B. vulgaris, D. stocksii, D. brandisii, D. strictus, D.hamiltonii* and *D. asper*).



Different stages of initiation, multiplication and hardening of bamboo species

Dissemination of improved material

Improved Poplar Clones

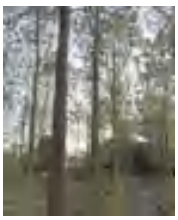
- Cultivation of poplar in agroforestry has been extended to North Bihar.
- The clonal development program of Poplar was initiated in 2013.
- Five clones of poplar released in 2021

Released Clone	Productivity (m^3/ha/year)	Productivity (Tonnes/Ha /Year)	Income Rs. (Lakh) /ha/year
IFP-BPA-38 (Arambh)	36.72	35.66	3.21
IFP-BPA-30 (Kshitij)	40.72	39.54	3.56
IFP-BPA-33 (Rohini)	40.72	39.54	3.56
IFP-BPA-34 (Khushi)	40.72	39.54	3.56
IFP-BPA-41 (Lakshmi)	43.11	41.86	3.77

Note: 1 cubic meter fresh poplar = 0.971 Tonnes, Current rate of Poplar @ Rs. 900/quintal

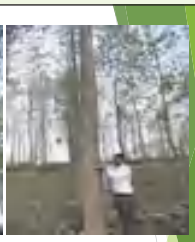
RECOMMENDED AGROCLIMATIC ZONE AND REGION FOR THE DEVELOPED POPLAR CLONES

Poplar Clones	Commercial Name	Agro-climatic Zone	Sub Zone	Districts
IFP-BPA-38	Arambh	Zone-IV (Middle Gangetic Plains Region)	Zone-I: North Alluvial Plain.	East Champaran, West Champaran, Motihari, Gopalganj, Siwan, Saran, Vaishali, Sheohar, Muzaffarpur, Samastipur, Sitamarhi, Madhubani, Darbhanga, Begusarai.
IFP-BPA-30	Kshitij			
IFP-BPA-33	Rohini			
IFP-BPA-34	Khushi			
IFP-BPA-41	Lakshmi		Zone-II: North-East Alluvial Plain.	Purnea, Katihar, Saharsa, Madhepura, Supaul, Araria, Kishanganj, Khagaria.
			Zone-III (III A & III B): South-East Alluvial Plain & South-West	Bhagalpur, Banka, Patna, Bhojpur, Buxar, Arwal, Jehanabad etc. districts of South East and South-West Bihar.

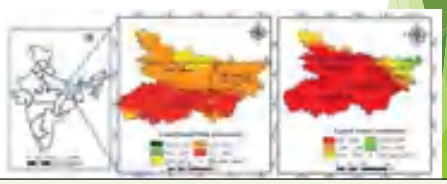


IFP-BPA-33 (ROHINI)

IFP-BPA-41 (LAKSHMI)



IFP-BPA-30 (KSHITIJ)



Dissemination of Clones/Varieties

- **Non-exclusive License Agreement signed for commercial propagation/supply / sale of planting stock:**
  - ✓ ***Melia dubia*** with ITC Limited , Bbzeini seedlings Saharanpur, Golden farm and nursery Bhatinda
  - ✓ **Eucalyptus clone with** Seshasayee Paper and Boards Ltd. TN
  - ✓ **Casuarina clones** with Andhra Paper Limited, TNPL, Santhi Clonal Nursery, Sangeetha Hitech Nursery and Makesh Nursery.
  - ✓ **Bamboos** : MP, Uttarakhand, Telangana State Bamboo Mission, Bihar Forest Department, Gujrat Forest Department, Devleela Biotech (Raipur), IFGTB (Coimbatore), IGKV Raipur, Chroma Biotech LLP, Dibrugarh,
- **Quality planting material supplied to stake holders:**
  - ✓ ***Melia dubia*** - Indian Farm Forestry Development Cooperative Ltd., Forest department, farmers and other stakeholders.
  - ✓ ***Casuarina*** – Farmers and Plantation companies etc.
  - ✓ **Teak** – F D C Maharashtra, State Forest Departments, Farmers, NGOs etc.

QPM *Melia dubia*

QPM Teak

Establishing *M. dubia* demonstration nursery

ICFRE Clones in Field

IFGTB Clone CJ 9 in Farmland - Rainfed

Tamil Nadu Forest Plantation Corporation

Clonal trial of Shisham at Bir Sanur, Patiala , Punjab

Clonal trial of Shisham at Mattiwara, Ludhiana , Punjab

Production of Genetically Improved seeds

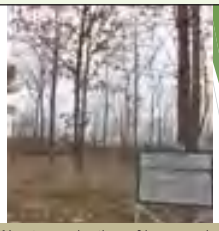
Source of quality seeds

1. Seed Production areas
2. Seed orchards

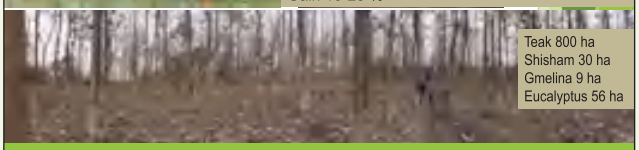
Selection of Plus Trees

Expected Genetic Gains 10-40 %

Teak 700
Simbal 62
Gmelina 119
Sandal 30
Pterocarpus 258
Sissoo 53 (>100)
Deodar 77
Populus 60
Pinus 200
Khasi Pine 33
Drek 28
M.champaca 37



Way to production of improved quality seeds
Gain 10-25 %



Teak 800 ha
Shisham 30 ha
Gmelina 9 ha
Eucalyptus 56 ha

Seed orchards

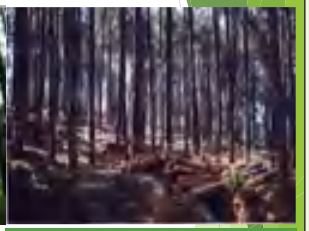
Clonal Seed Orchard (Advanced Generation) of Shisham at Pindori Mindo Mind (Hoshiarpur)

About 15-20% gain in growth in seed orchard progeny over the local seedlot

Gain from Improved Seed

Seed Production Areas

Pinus roxburghii



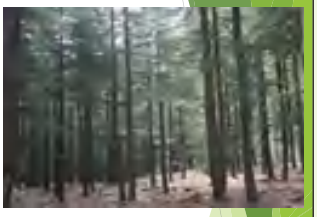
Soni, Uttarakhand

Genetic Gain from SPA (5 - 20 %)

Himachal Pradesh Area: 50 ha
Kopra Forest (Nurpur): 10.52 ha
Bairkot Forest (Sunder Nagar): 22 ha
Dibkan Forest (J. Nagar): 18.44 ha
15 ha Marghana Forest (Udhampur J&K)

Seed Production Areas

Cedrus deodara



Area: 50 ha in HP & J&K

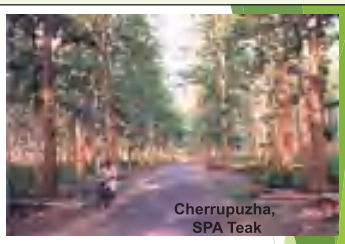
Cheog Forest (Theog Forest Division): 25.00 ha

Nankhari Forest (Rampur Forest division): 15.00 ha

Neeru Forest (Bhadrawah Forest Division J &K): 10.00 ha

Cheripuzha, 1971	20 Ha
Sankaranthode, 1961	20 Ha
Parambikulam, 1945	10 Ha
Tholpetty, 1962	20 Ha
Pandupura,1963	10 Ha
Pottikkal-1965	15.3 Ha
Total	105.3 Ha

SPA-Kerala-Teak



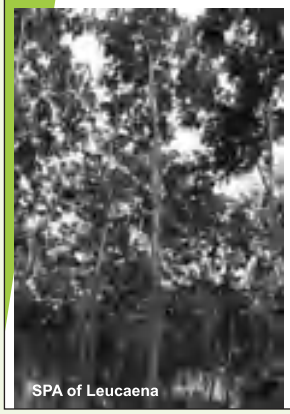
Cherrupuzha, SPA Teak

Kozhikanudhi	19 Ha
Waragaliar,	20 Ha*

SPA, Teak -Tamil Nadu

SPA, Waragaliar

Seed Production Areas



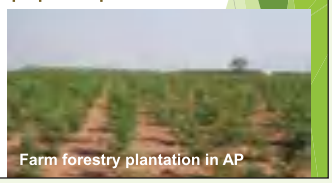
SPA of Leucaena

Leucaena (Subabul)

Seed production areas established in TN and AP

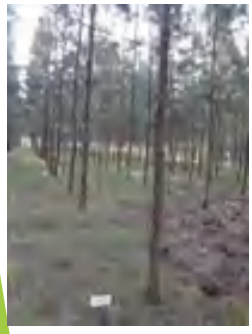
Seeds collected from SPA and supplied to farmers and industries

Genetic gain tests showed 20% gain in pulpwood production



Farm forestry plantation in AP

Second Generation SSO of *Casuarina equisetifolia*



- As part of long-term breeding programme second generation seed orchards established
- Seeds supplied to farmers, forest departments and industries
- **Genetic gain testing showed 12 to 20% more wood** production in different locations over benchmark seedlot (first gen orchard)

Dipterocarpus retusus

Progeny trial/SSO

No. of Progeny : 17

Sources : 3 locations within Assam

	Location	Area (in ha.)	Year of Establishment
SSO	• Deovan, Jorhat (Assam)	1.00	1999
	• Jeypore, Dibrugarh (Assam)	1.00	1999
	• Nahoroni, Golaghat (Assam)	0.20	2000

Magnolica champaca

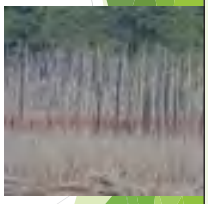
- 37 plus trees were selected from Assam, Tripura, Arunachal Pradesh &Mizoram
- Two progeny trial cum seedling seed orchard were established in Meghalaya and Assam

	location	Year of establishment
Progeny trial cum SSO	RFRI, Campus	2016
	Mayaparbot, Barapani, Meghalaya	2016

- Development & dissemination of superior quality planting stock of short rotation tree species by ICFRE institutes has nearly doubled the productivity of the plantations.

Eucalyptus Clones

Casuarina Clones



Poplar ETPs

INTEGRATING TREES IN FARMLANDS

Improve the farm productivity & profitability by integrating trees in farm land

Profitability of planting Eucalyptus under agroforestry

The farmers earn **Rs 1 .0 to 1.5 Lakh** from one acre of land planted with Euca Clonal trees, after 4 to 5 years.

INTEGRATING TREES IN FARMLANDS

Clones in Agroforestry models- 23 developed for 07 agro climatic zones.

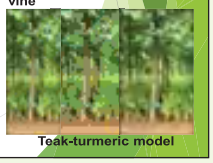
Teak, Sandalwood, Agarwood, *Casuarina*, *Melia*, *Gmelina*, Bamboo, *Salix*, *Eucalyptus*, *Flemingia*, *Acacia*

***Casuarina* with banana**

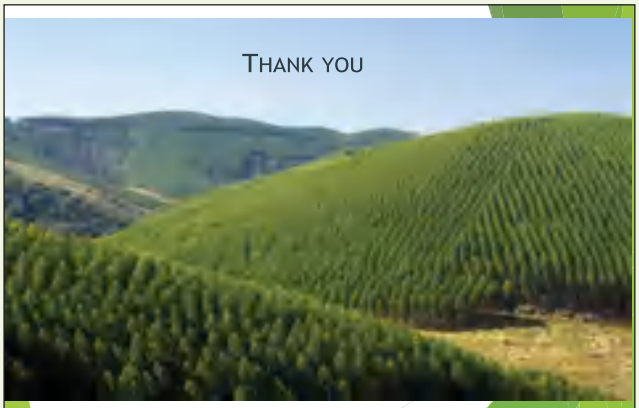
***Gmelina arborea* with Beetle vine**

Lac Cultivation on *Flemingia*

Sandalwood with Casuarina in Gujarat



Teak-turmeric model



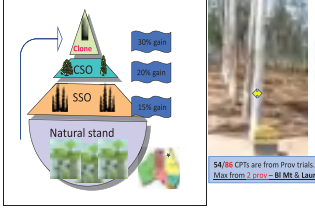
3. Recent advances in breeding, nursery and plantation techniques for enhancing productivity in short rotation tree species: Dr. Mohan Varghese, Senior Principal Scientist, ITC Life Sciences and Technology Centre, Bengaluru

Recent advances in breeding, nursery and plantation techniques for enhancing productivity of short rotation tree species

Mohan Varghese
ITC Life Sciences and Technology Centre
Bengaluru

BREEDING → NURSERY → PLANTATION → Gen 1 → Gen 2 → Gen 3

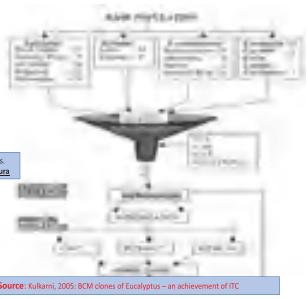
Eucalyptus Tree Portfolio



54/86 CPTs are from Prov trials.
Max from 2 prov – BI Mt & Laura

Provenance
Family
Clone

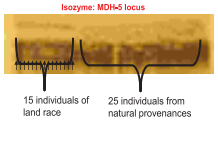
Tree Improvement: ITC (1986....)



Source: Kulkarni, 2005: 8CM clones of Eucalyptus – an achievement of ITC

Domestication of Forest trees - infancy

Provenance
Family
Land Race



Clonal forestry - Learning from short term approaches

Pulpwood plantation of WCPM

ITC Clone 10 (2003)

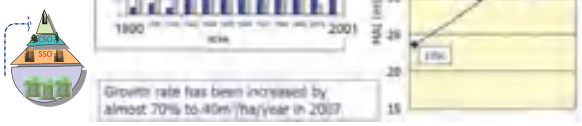
(2007)

Moving clones across locations

Cl 288: Haryana

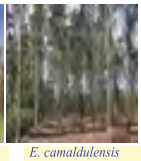
Cl 288: Telangana

Clonal planting trends in Brazil

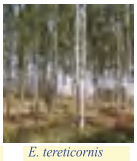


Orchards and Genetic gain trials – IFGTB (1996 – 2006)

E. camaldulensis
SSO-Panampally



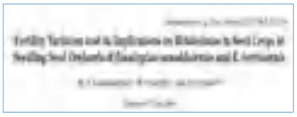
E. camaldulensis
SSO- Pudukottai



E. tereticornis
SSO- Pudukottai

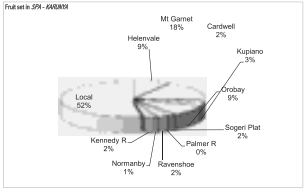
Orchard sites & Genetic trial sites

E. tereticornis
SSO- Panampally

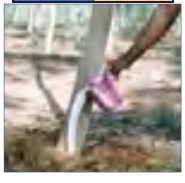


Fertility in Eucalypt orchards

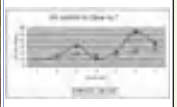
Species	Location	Fertile trees(%)
E. tereticornis	Pudukkottai	13.8
E. tereticornis	Panampally	7.5
E. tereticornis	Karunya	12.0
E. camaldulensis	**Panampally**	**71.2**
E. camaldulensis	Pudukottai	12.5
E. camaldulensis	Sathyavedu	17.7



Treatment	Flowering trees %
High N (Urea 500g)	13
High N+PK (Urea 500g + 312 g SSP + MOP 83 g)	13
Paclobutrazol	60
Control	10



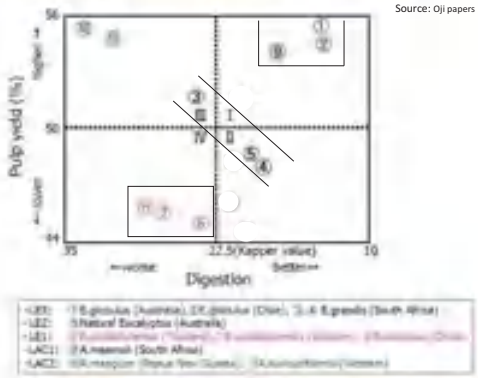
Clone development for pulp industry



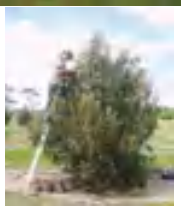
Tree selection(SSO) - Clone evaluation

Characteristics of species in digestion process

Source: Oji papers



CRC: Australia

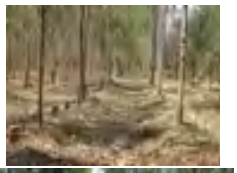


CSO: *Eucalyptus globulus*

Pedigreed Eucalyptus Hybrids

CSO - Clone deployment

Mono vs Mosaic

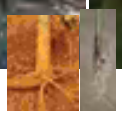


Pedigreed
Hybrid Seed
Deployment

W. Godavari

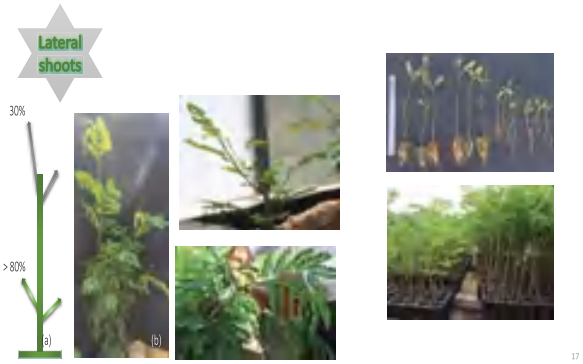
Problems in scale up of clones

Leucaena



Eucalyptus: CI 316

LEUCAENA multiplication

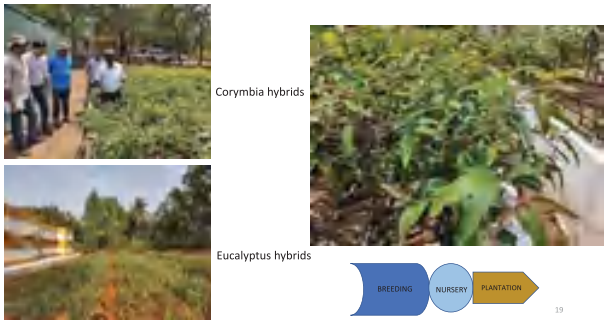


17

LEUCAENA clones: Field management

18

Evaluation of Lateral shoot production



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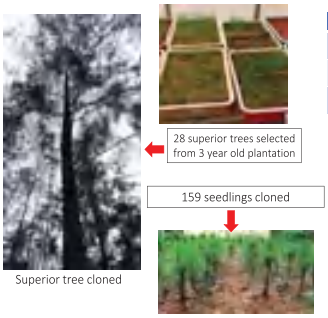
Casuarina clone evaluation

SSO - Seed



Growth and Survival

Source	Ht 48m (cm)	Dbh 48m (cm)	Survival 48m (%)
Seedling clones (SC)-All	12.25	9.59	80.1
Coppice clones (CC)-All	12.33	9.73	89.8
P_{source}	0.424^{ns}	0.308^{ns}	<0.001
P_{clones}	<0.001	<0.001	<0.001
Seedling clones - Top 10	13.31	11.39	96.7
Coppice clones - Top 10	12.94	10.54	95
Difference	3%	8%	2% ns

4. Nursery techniques for raising quality planting stock of Himalayan conifers: Dr. Sandeep Sharma, Director, ICFRE-Himalayan Forest Research Institute, Shimla

NURSERY TECHNIQUES FOR RAISING QUALITY PLANTING STOCK OF HIMALAYAN *CONIFERS*

ICFRE-HIMALAYAN FOREST RESEARCH INSTITUTE
(Indian Council of Forestry Research & Education)
CONIFER CAMPUS, PANTHAGHATI,
SHIMLA-171 013 (H.P.) INDIA

Background

- During the past century, the world's land base has been subjected to urban expansion, management practices suited for resource exploitation and ever increasing population pressure on forests causing degradation/deforestation
- As a result, tree seedling production has become a fundamental tool for afforestation, reforestation, restoration and various conservation needs
- Every year millions of seedlings are being raised in the nursery all over the world for various plantation programs focusing on increasing the forest productivity through the production of quality planting stocks
- India being the second most populous country in the world
- A large population of both the rural and tribal people (almost 300 million) are dependent on the forest wealth for fuel wood, fodder, timber, fiber, NTFPs etc.
- Productivity of India's forests is about 0.5 to 0.7 cum/ha/year, which is much below the Global average of 2.1 cum/ha/year.

Cont…

- There is a huge gap between demand and supply for both industrial & domestic wood requirement
- Gap is continuously increasing and severely affecting the very philosophy of sustainable development
- Forest nurseries thus play an important role to provide QPM for plantation to meet the national target of 1/3rd of the country's Geographical area under forest cover as well as realizing the productive potential of every individual plant to increase country's productivity
- Thus, to improve the quality of India's forests, forest nurseries can play a significant role by producing quality planting stock

Himalayan Conifers

- Conifers, the earliest extant seed plant lineages are stated to be evolved many millions of years ago
- Represent most abundant, oldest and tallest plants with 620 + species, 71 genera and 7 families
- About 11 genera and 24 species are native to India. The main forest forming genera are *Pinus*, *Abies*, *Picea* and *Cedrus*
- North-Western Himalayan region is bestowed with a unique diversity of coniferous and broad-leaved plants
- 15 species of conifers belonging to 7 genera occur naturally in the Western-Himalayan State of Himachal Pradesh
- Tree Form: 12 species *viz., Pinus roxburghii, Pinus wallichiana, Pinus gerardiana, Abies spectabilis, Abies pindrow, Picea smithiana, Taxus wallichiana, Juniperus polycarpos*, *J. excelsa, J. recurva, Cedrus deodara* and *Cupressus torulosa*
- Shrubby Form: 3 species viz, *Juniperus squamata, Juniperus communis, Juniperus indica*

- Distributed almost the entire length of the Himalaya occupying about 6.0% of the total forest area of India, 7.0% of Asia, and 0.4% of the entire World
- Distributed in different ecological niche ranging from sub-tropical to sub-alpine regions from 800m-4000m altitudinal range
- Most prominent component of the vegetation in the North-Western Himalayan region and provide valuable services to the local populace as well as to the country by providing water and elctricity through no. of perennial rivers originating from this region e.g. Jhelum, Chenab, Ravi, Beas, Sutlej, Yamuna, Ganga etc
- Important source of fuel wood, food, timber, resin, and other non-timber forest products for the people living in the vicinity of forest areas and other forest-dependent peoples since times immemorial
- Home to a variety of species of living organisms
- Play a significant role in storing carbon in its biomass and soil

Jammu and Kashmir UT

Sl. No.	Forest Type	Area in sq Km	% of Forest cover
1	Lower/Siwalik Chir Pine Forest	2725.47	10.56
2	Upper/Himalayan Chir Pine Forest	1094.20	4.24
3	Moist Deodar Forest (*Cedrus*)	1589.47	6.16
4	Mixed Coniferous Forest (Spruce, Blue Pine, Silver fir)	3217.55	12.47
5	Low-Level Blue Pine Forest (*P. wallichiana*)	2225.13	8.62
6	Riverain Blue Pine Forest	53.77	0.21
7	Low-Level Blue Pine Forest	50.80	0.20
8	Dry Broadleaved and Coniferous Forest (*Q. ilex-P. gerardiana*)	390.71	1.51
9	Dry Deodar Forest (*Cedrus*)	639.82	2.48
10	West Himalayan High-Level Dry Blue Pine Forest	1169.22	4.53
11	West Himalayan Sub-Alpine Fir Forest	358.03	1.39
12	Sub-Alpine Blue Pine Forest (*P. wallichiana*))	84.71	0.33
13	Dwarf Juniper Scrub	75.23	0.29
Total conifer forest		**13674.11**	**52.99**
Total Forest Area (excluding TOF& Grasslands)		19786.64	

Source: ISFR, 2021

Ladakh UT

Sl. No.	Forest Type	Area in sq Km	% of Forest cover
1	Dry Deodar Forest (*Cedrus*)	2.86	0.09
2	West Himalayan High-Level Dry Blue Pine Forest	32.21	1.01
3	West Himalayan Sub-Alpine Fir Forest	716.97	22.39
4	Sub-Alpine Blue Pine Forest (*P. wallichiana*)	168.81	5.27
5	Dwarf Juniper Scrub	670.15	20.92
Total conifer forest		**1591**	**49.68**
Total Forest Area (excluding TOF& Grasslands)		2744.33	

Source: ISFR, 2021

Himachal Pradesh

Sl. No.	Forest Type	Area in sq Km	% of Forest cover
1	Lower/Siwalik Chir Pine Forest	1434.74	7.01
2	Upper/Himalayan Chir Pine Forest	1324.88	6.47
3	Moist Deodar Forest (*Cedrus*)	2117.65	10.34
4	Western Mixed Coniferous Forest (Spruce, Blue Pine, Silver Fir)	2875.96	14.05
5	Low Level Blue Pine Forest	467.73	2.28
6	Cypress Forest	8.64	0.04
7	Neoza Pine Forest (*P. gerardiana*)	129.54	0.63
8	Dry Deodar Forest (*Cedrus*)	228.73	1.12
9	West Himalayan High Level Dry Blue Pine Forest	69.56	0.34
10	West Himalayan Dry Juniper Forest (*J. macropoda*)	62.56	0.30
11	West Himalayan Sub-Alpine High Level Fir Forest	119.77	0.58
12	Dwarf Juniper Scrub	187.58	0.92
	Total conifer forest	**9027.34**	**44.08**
	Total Forest Area (excluding TOF& Grasslands)	**14535.63**	

Source: ISFR, 2021

Uttarakhand

Sl. No.	Forest Type	Area in sq Km	% of Forest cover
1	Lower/Siwalik Chir Pine Forest	43.15	0.16
2	Upper/Himalayan Chir Pine Forest	7295.76	27.52
3	Moist Deodar Forest (*Cedrus*)	395.23	1.49
4	Western Mixed Coniferous Forest (Spruce, Blue Pine, Silver Fir)	1340.10	5.05
5	Low-Level Blue Pine Forest (*P. wallichiana*)	27.66	0.10
6	Low Level Blue Pine Forest	22.49	0.08
7	Dry Deodar Forest (*Cedrus*)	194.73	0.73
8	West Himalayan Dry Juniper Forest (*J. macropoda*)	4.28	0.02
9	West Himalayan Sub-Alpine Fir Forest	184.29	0.69
10	Dwarf Juniper scrub	29.92	0.11
	Total conifer forest	9527.61	35.95
	Total (excluding TOF& Grasslands)	**24199.12**	

Source: ISFR, 2021

Uses of Conifers

- Majority of the sawn timbers come from conifers
- Exploitation of this resource is still going on in many parts of the world, but there is an obvious trend especially in the developed world to phase this out and use more sustainable planted or seeded resources
- There are many species that are extremely valuable and used for fine cabinet making or expensive applications in construction
- Conifers also play a significant role in traditional medicine and in religious ceremonies
- A few conifers even have edible seeds; well known are those of certain pines e.g. Chilgoza pine

Nursery Techniques of Himalayan Conifers

Nursery techniques of important Himalayan conifers have been standardized for carrying out afforestation/reforestation in the North-Western Himalayan region

1. *Abies pindrow*
2. *Picea smithiana*
3. *Cedrus deodara*
4. *Pinus gerardiana*
5. *Juniperus polycarpos*
6. *Pinus wallichiana*
7. *Pinus roxburghii*
8. *Taxus wallichiana*

Nursery Techniques of *Abies pindrow* (Silver Fir)

Cone Collection

Best time for cone collection is the first fortnight of October from the field.

Seed Extraction

Cones after collection are spread on the ground in a shady place for drying for 15-20 days period. Once the cones open up, seeds are extracted from the cones manually.

Seed Drying

Seeds are dried in the shade after extraction from the cones and thereafter, stored in a sealed container at low temperature in a refrigerator for maintaining seed viability.

Abies pindrow

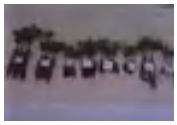
Cones and Seeds of *Abies pindrow*

Seed Sowing

- Sowing is done in 15cm raised germination beds during November-December in the nursery
- Beds are treated with formalin for controlling damping-off disease in the nursery
- Seeds are sown in line 4 - 6 cm wide strips spaced 10 cm apart at 1.5cm depth in the nursery for better germination
- There is no seed treatment required before sowing. However, winnowing of seed is required for separating the impurities
- Watering of nursery beds is done to maintain moist conditions during the dry season
- Seeds start germinating during March-April after the snow melts
- Seedlings are kept in germination beds for 1½ years for proper growth of seedlings and shifted in transplant beds at a spacing 15cm X 8 cm during August for further growth of seedlings

- **Agro-shade net that provides 50% shade is required for Silver fir nursery stock**
- **The shade is required from April to October to protect the seedlings from scorching Sun during entire nursery period of the stock. The shade should be removed during last 1-2 months of nursery period i.e. just before out planting**
- **Plants are ready for outplanting when 4 ½ years of age with average height of around 20cm**

Abies pindrow seedlings in the Nursery



Nursery Techniques of *Picea smithiana* (Spruce)

Cone Collection

Best time for cone collection is the first fortnight of October from the field.

Seed Extraction

Cones after collection are spread on the ground in a shady place for drying for 15-20 days period. Once the cones open up, seeds are extracted from the cones manually.

Seed Drying

Seeds are dried in the shade for some time after extraction from the cones and thereafter, stored in a sealed container at low temperature in a refrigerator

Picea smithiana

Cone and Seeds of *Picea smithiana*

Seed Sowing

- Spruce sowing is done in 15cm raised germination beds in the nursery during November-December
- Beds are treated with formalin for controlling damping-off disease in the nursery
- Pre-sowing treatment of Spruce seeds with tap water for 24 to 48 hours is required that would also help in elimination of empty floating seeds for obtaining better germination percentage
- Seeds are sown in line 2-4 cm wide strips spaced 10 cm at 1cm depth in the nursery for better germination
- Seeds start germinating during March-April after the snow melts
- Seedlings are kept in germination beds for 1½ years and shifted in transplant beds at a spacing of 15cm x 8 cm during August for further growth of seedlings
- Watering of nursery beds is done to maintain moist conditions during the dry season
- Seedlings are kept in the nursery for 3½ years for proper growth of seedlings

- **Agro-shade net that provides 50% shade is required for Spruce nursery stock.**
- **The shade is required from April to October to protect the seedlings from scorching Sun during entire nursery period of the root-trainer grown stock. The shade should be removed during last 1-2 months of nursery period i.e. just before out planting**
- **Plants are ready for outplanting when 3 ½ years of age with average height of around 20cm**

Picea smithiana seedlings in the Nursery

Nursery Techniques of *Cedrus deodara*

Cone Collection

- Best time for cone collection is the Second fortnight of Sept to first fortnight of October from the field.

Seed Extraction

- Cones after collection are spread in a shady place for drying for 10-15 days period. Once the cones open up, seeds are extracted from the cones manually.

Seed Drying

- Seeds are dried in the shade after extraction from the cones and thereafter, stored in a sealed container at low temperature in a refrigerator for maintaining seed viability.

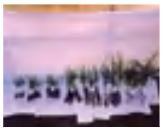
Cedrus deodara

Cones and seeds of *Cedrus deodara*

Seed sowing

- Seeds are sown in polybags of size 9"x5" filled with potting media (Soil 2: Sand1: FYM1) during November-December in the nursery
- Watering of polybags is done to maintain moist conditions necessary for seed germination
- Seeds start germinating during March-April after the snow melts
- Polybags containing seedlings are kept in the nursery for 2½ years for proper growth of seedlings

Cedrus deodara seedlings in the Nursery



The Seedling Quality of Nursery Stock of Deodar

- It was found in the studies conducted at HFRI that polybag raised stock survived better in the field as compared with bare root stock in Deodar
- Even naked root Deodar stock performed differently in different year of planting on same site owing to local weather conditions controlling field survival to a great extent
- However, bare root stock performed comparably well in higher limits of occurrence of this species viz. a viz. Polybag raised stock
- In good sites, stock height >9" was found to be good indicator of field performance in case of Deodar
- In stress sites, stock height >15" was found as better parameter related to survival. Site conditions had direct correlation with type of planting stock based on their morphological grading and subsequent success rate in the field

Producing tall plant in the nursery

- Firstly the Deodar stock should be raised as bare root stock for 2.5 years in nursery beds
- Subsequently transplanted in gunny bags during rainy season
- The plants should be kept in shade house (50% shade) and also moderately pruned (50% of lower branches) at the time of transplanting for better survival
- Application of 20 ml/ plant Vermiwash during March to May at 15 days interval will further enhance the growth of Deodar plants in the nursery
- In out planting experiment the pit size of 75cm^3 found to be better for survival and growth of gunny bag raised stock in the field
- Further, the rainy season was found to be the most appropriate season for planting gunny bag raised stock
- However, the plantation success in winter and spring seasons was also found to be encouraging in the present study

Production of Deodar Tall Plants

Nursery Technique of *Juniperus polycarpos*

Cone Collection

Best time for the collection of berries is the second fortnight of November from the field.

Seed Extraction

Berries after soaked in lukewarm water for a 3 days period and thereafter seeds are extracted from the berries manually.

Seed Drying

Seeds are dried in the shade for 7-10 days period after extraction from the berries and thereafter, stored in an air-tight sealed container at low temperature in a refrigerator.

Juniperus polycarpos

Berries and Seeds of *Juniperus polycarpos*

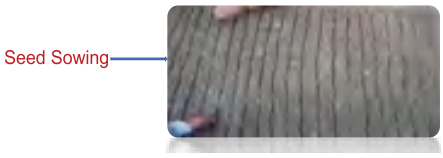
Pre-sowing Treatment

- Best pre-sowing treatment for overcoming seed dormancy is cold moist stratification in cow dung for 60 days duration during winter.
- Seeds mixed with cow dung and placed in pits for 60 days duration during winter recorded around 70% germination in the nursery.

Cold Moist Stratification

Seed Sowing

- Sow seeds in line at 2cm x 4cm spacing in sand beds at 1.5cm depth for better germination in poly house.
- Watering should be done once in three days to keep the germination beds moist.
- Avoid seed dehydration during the germination stage in the nursery as it induces secondary dormancy.



Seed Germination

- Germination starts after 10 months of seed sowing in the nursery and completes within a months period
- Keep the germinated seedlings in sand beds for one growing season f

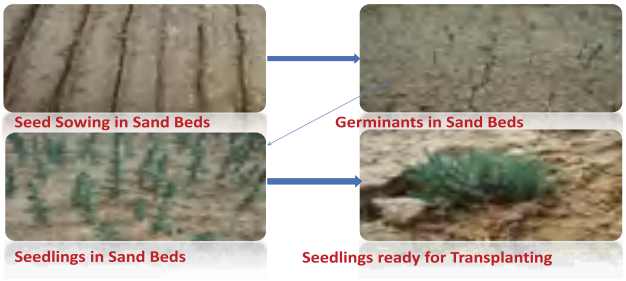
Germinants in Sand Beds

Transplanting from Germination beds to Polybags

- After one year, transplant germinated seedlings in polybags filled with potting media (soil 1: sand1: FYM 1) and kept in a shade house for 3 months for hardening.
- Shift the seedlings to open nursery beds after three months for further development of seedlings.
- Seedlings attain 5-6cm shoot length after 2 years, 10-12cm after three years, and 20-25cm after five years of seed sowing in the nursery.

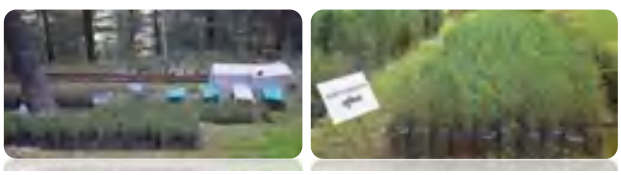
Seedlings in Shade House

Propagation Technique of Juniper Seedlings in Nursery



- Growth of Polybags (25x15cm)raised seedlings is better as compared to nursery beds and root trainers raised seedlings.
- Among root trainers, 500cc single-cell bullet-type root trainer is best.
- Seedlings raised in potting media soil + sand + FYM (1: 1:1) show better growth performance compared to other potting media.
- Root-pruned seedlings (5cm root retained) exhibit better shoot growth compared to non-pruned seedlings.
- Application of urea @ 3.5g/plant enhances shoot growth compared to untreated seedlings in the nursery.

- Seedlings raised under polyhut and agro shade net white 50% shows better growth performance as compared to other shading materials.
- Watering once in three days period is best for over all development of seedlings in the nursery.
- Seedlings given 5g vermicompost/seedling or 2.5g organic plant growth booster shows better growth as compared to other treatments.



Plantation Techniques

- 5Year old polybags raised nursery stock can be planted in the field.
- Seedlings planted in 45cm^3 pits performs better in the field and show better growth of shoot length and collar diameter.
- Seedling having sizes 30-40 cm performs better in the field and shows better growth of shoot length and collar diameter.
- Field planting of *Juniperous polycarpos* under 3mx3m spacing.
- Summer, as well as the pre-winter season is equally good for carrying out plantation in the field.
- NPK in a combination of 2g Urea: 1g SSP: 2.5g MOP exhibits better shoot length growth and collar diameter compared to un fertigated seedlings in the field.

Demonstration Plantation of *Juniperus polycarpos*, Tabo (Spiti Valley, H. P.)

Taxus wallichiana Zucc.

Taxus wallichiana Tree

Main Source of

Taxol® (Paclitaxel)

Part used- Leaves

Use- Chemotherapy

- Family Taxaceae
- Evergreen Tree
- Distribution (Altitude)
- 1800-3300 m

Fruit of *Taxus wallichiana*

Taxus wallichiana Forest

Dry Trees of *Taxus wallichiana*

Nursery Technique of *Taxus wallichiana*

Seed Collection

- Best time for the collection of berries is September from the field.

Seed Extraction

- Seeds are extracted from the berries manually.

Seed Drying

- Seeds are dried after extraction from the berries and thereafter, stored in a sealed container at low temperature in a refrigerator for maintaining seed viability.

Taxus wallichiana

Seeds of *Taxus wallichiana*

Nursery raising through seeds

- Seeds are sown in polybags of size 9''x5'' filled with potting media during November-December in the nursery.
- Seeds start germinating during March-April.
- Germination is very low due to seed dormancy
- Polybags containing seedlings are kept in the nursery for 3 years for proper growth of seedlings.

Nursery raising through shoot cuttings

(Technique standardized by Himalayan Research Group, Shimla)

- Shoot cuttings (4'' Size) are taken from the mother tree during February-March just before bud break
- Shoot cuttings are treated with IBA 1000ppm through the quick dip method in Talcum powder or in solution form.
- Treated cuttings are planted in sand beds in poly house or in polybags (9''x 5'') for rooting of cuttings.
- 80-85% rooting occurs in Himalayan Yew.

Planting of *Taxus wallichiana* Cuttings

Stacking of Nursery Bags

Taxus wallichiana Cuttings in bags

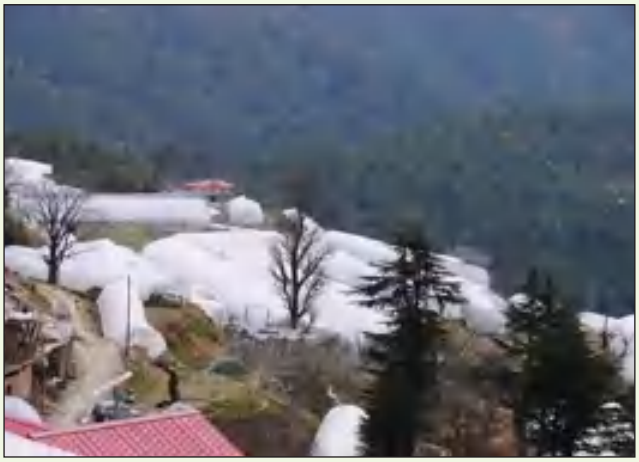
- Propagation technique Rooting of Cuttings
- Season of planting cutting February – March
- Age of cutting for rooting 1 year
- Cutting dimensions 10 cm with apical bud
- Rooting Hormone Commercial rooting hormone
- Planting Nursery/ Poly-bags

Rooting of Cuttings in Nursery

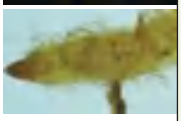
Polyhouse sheet

- UV stabilized
- > 300 gauge

300 gauge = 75 micron = 0.075mm

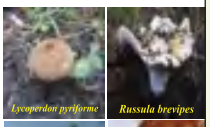


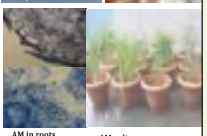
- Mycorrhizae are the integral component in the root system of conifers
- More than 90% of worlds plant establish mycorrhizal association with plants
- The roots of all conifer are mycorrhizal
  - Forest department is using forest soil (humus) to meet the mycorrhizal requirement of seedlings in nursery
  - Labour intensive and possibility of introduction of unknown microbes including pathogens to nursery
  - **Artificial inoculation with suitable fungi seems to be better option**
- Mycorrhizal inoculum can be produced in laboratory and can be transported to nursery for artificial inoculation of seedlings
- Ectomycorrhizal (ECM) fungi can uptake and provide a host with a wide range of macronutrients and micronutrients
- Majority of phosphorus and nitrogen to some extent become available to plant through mycorrhizal roots



Application of mycorrhizae in nursery

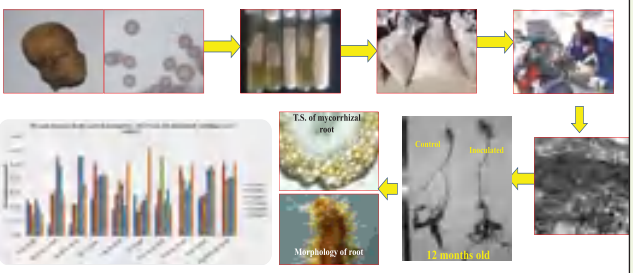
- **Ectomycorrhizal fungi**
  - Identified EcM associates of conifers of NW Himalaya
  - Isolated pure cultures and mass multiplied
  - Artificial inoculation in nursery
    - *Pinus gerardiana*
    - *Cedrus deodara*
    - *Abies pindrow*
    - *Picea smithiana*
- **Endomycorrhizal (AM) fungi**
  - Seasonal population dynamics of AMF with temperate Medicinal plants
    - *Angelica glauca*
    - *Valeriana jatamansi*
  - Multiplied with living host in pots on wheat plants Foxtail millet Kangni (*Setaria italica*) and Barnyard millet Shaunk (*Echinochloa esculenta*)
  - Development of AMF biofertilizer containing indigenous strains (Him Midra Sanjeevani 1)





Pinus gerardiana – Mycorrhizal Inoculations

Seedlings of *P. gerardiana* were inoculated with one of its mycorrhizal associate -*Scleroderma polyrhizum*. The results revealed 44-94% increase in different growth parameters of artificially inoculated seedlings. It will help in reducing retention period of the seedlings in nurseries and better chances of their survival in field conditions. The outcome will help the HPSFD for production and subsequent plantation of tall and healthy seedling in the field.



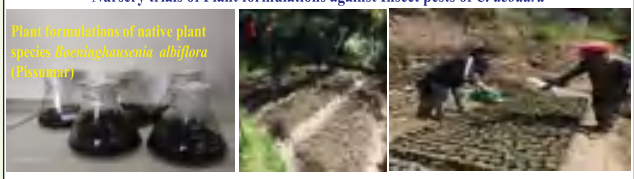
Application of EcM in forest nurseries

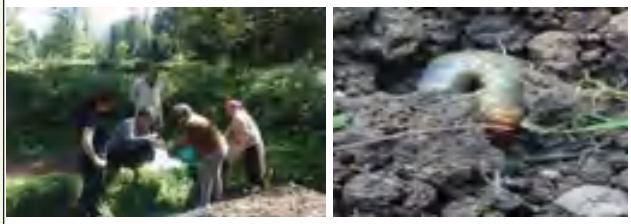
- Planting stock production by artificial inoculation with EcM fungi in the nurseries Forest Department
- Evaluate performance of artificially inoculated seedlings
- Capacity building of field functionaries Forest Department on mycorrhizal biotechnology

Insect pests of Conifers nurseries with emphasis on Deodar Pests and their Management

- Conifers are the major forest timber tree species in NW Himalaya
- In Himalayan region, the preferred planting material *i.e.* seedlings of conifers are grown in the nursery bed. The productivity of these nursery stock in forest nurseries is often affected by incidences of 'cutworms' and 'white grubs' inhabiting soil of nursery beds
- Cut worms (*Agrotis* spp.) and White grubs (immature larval stages of Scarabaeid) are potential pests (adults known commonly as chafer beetles), capable of causing heavy mortality in nursery stock
- It has been observed that the frontline forest nursery staffs are not adequately aware of life cycle of these pests, however, absence of proper guide-lines specific to the management of nursery pests has been one of the major reasons for the lack of awareness
- Larvae of several genera of May or June beetles, commonly known as white grubs, feed on the roots of many herbaceous and woody plants. All coniferous are susceptible to attack. Some common genera that cause losses in nurseries include *Phyllophaga*, *Diplotaxis*, *Dichelonyx*, *Serica*, *Cotalpa*, and *Anomala*. *Phyllophaga*, with more than 100 species, is the most important genus.

Nursery trials of Plant formulations against Insect pests of *C. deodara*





Control of Deodar nursery insect pests

Chemical control

Fumigate seedbeds with a Methyl bromide-chloropicrin formulation before sowing to eliminate white grubs. Applications of granular insecticides to beds of established seedlings and root dipping of transplants have also been effective in reducing damage.

Efficacy of Biopesticides/Plant formulations

- **Recent studies conducted by the institute to check the efficacy of native plant extracts revealed that these formulations are very effective (causing up to 78% mortality) in containing the nursery pests of Deodar.**
- **The study further indicated that the mortality rate of larva differed significantly ($p \leq 0.05$) among the treatments.**
- **Keeping in view the toxic effects of chemical insecticides these plant formulations are suitable eco-friendly alternate to chemical insecticides.**

Plant formulations of native plant species *Boeninghausenia albiflora* (Pissumar) developed by HFRI in different solvents (Acetone & Ethyl acetate)

Nursery Technique of *Pinus gerardiana*

Cone Collection

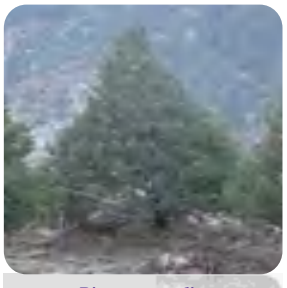
Best time for cone collection is the first week of October from the field.

Seed Extraction

Cones after collection from the forest are spread in a shady place for drying for 15-20 days period. Once the cones open up, seeds are extracted from the cones manually.

Seed Drying

Seeds are dried in a sunny area after extraction from the cones and thereafter, stored in cotton bags under ambient room temperature or an air-tight sealed container at low temperature in a refrigerator.



Pinus gerardiana

Cones and Seeds of *Pinus gerardiana*

Seed Sowing

- Seeds are sown in polybags of size 18"x5" filled with potting media (Soil 2: Sand1: FYM1) during November-December in sunken beds in the nursery.
- Polybags are covered with pine needles or wire mesh after seed sowing for retaining moisture and protection from birds and rodents.
- Watering of polybags is done to maintain moist conditions during dry periods.
- Seeds start germinating during March-April after the snow melts.
- Polybags containing seedlings are kept in the nursery for 2½ to 3 years for proper growth of seedlings.

***Pinus gerardiana* seedlings in the Nursery**

Threats to the Western Himalayan Conifers

- Coniferous forests of this eco-region are threatened by illicit felling, encroachment of forest land for agriculture, horticulture etc.
- Diversion of forest land for non-forestry purposes especially hydroelectric projects for which large numbers of trees are being cut down by the project authorities
- Incidence of forest fires which causes tremendous damage to conifer forests every year
- Construction of roads in the interior areas for the benefit of local communities
- Expansion of tourism activities in the Himalayan region has resulted in the construction of ill-planned roads, trails, and hotels
- Trampling by domestic /stray animals in the natural forest still poses a serious threat to the successful regeneration of conifers

Gaps in production of quality planting stock of conifers

- **Lack of availability of genetically superior seeds, vegetative propagules etc.**
- **Species and site specific SOPs for nursery production of important conifer species**
- **Lack of nutritional management of nursery soils and potting mixture**
- **Lack of modern infrastructure for raising quality planting stock**
- **Gap in application of mycorrhizae and other microbes in the nursery**
- **Gap in fixing of species specific morphological quality parameters *viz-a-viz* age of the stock**

Strategies to fill gaps in production of quality planting stock

- **Lack of availability of genetically superior seeds, vegetative propagules etc.**
  - * Identification and finalization of seed stands, seed production areas, plus tree selection, progeny testing, establishment of seed orchards of etc.
- **Species and site specific SOPs for nursery production**
  - * Standard operating procedures for nursery production of important conifer species need to be refined frequently under variable site conditions as well climate change scenario and adopted in the field for better stock production

Strategies to fill gaps in production of quality planting stock

- **Lack of nutritional management of nursery soils and potting mixture**

  Testing of nursery soils for various physical and chemical parameters e.g. preparation of nursery soil health cards and accordingly planning & implementing correction measures for realizing full productive potential of individual plant in the nursery

- **Lack of modern infrastructure for raising quality planting stock**

  Establishment of modern nurseries at least at range level with modern infrastructure e.g. Poly house, Shade house, Composting/ Vermi-composting Unit, Water storage facility, Sprinkler system, Potting mixture shed, Drying platform, Small laboratory, etc. for raising quality stock

Strategies to fill gaps in production of quality planting stock

- **Gap in application of mycorrhizae and other microbes in the nursery**

  For the production of quality planting stock in addition to standard practices application of mycorrhizae and other beneficial microbes need to be included in SOPs not only for enhanced growth, enriches soil with nutrients but also protects plants from diseases

- **Gap in fixing of species specific morphological quality parameters *viz-a-viz* age of the stock**

  For important species interim morphological quality parameters may be fixed immediately and efforts need to be initiated for fixing the species specific morphological parameters relevant under changing climatic conditions in coming years for grading the nursery stock

Strategies to fill gaps in production of quality planting stock

- **Non adoption of culling practices in the nursery**

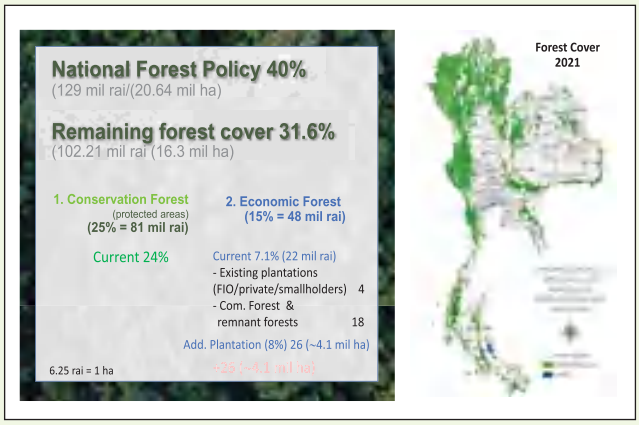
  Culling of inferior stock is an important operation in the nursery for better survival and initial establishment. Revised species specific culling guidelines need to be finalized, approved by competent authority and religiously adopted in the field for better survival and initial growth after out planting in the field.

- **Allotment of nursery stock**

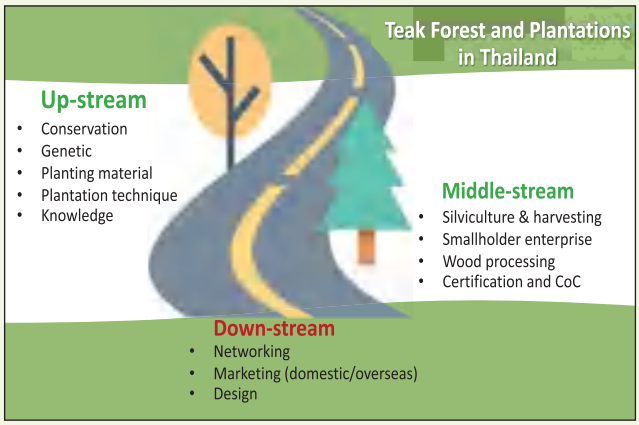
  It should be well planned and sturdy stock need to be allotted to degraded or poor sites and lower grade stock need to be allotted to better sites or in higher limits of occurrence of conifer species in Himalayan region for overall success of plantation programmes.

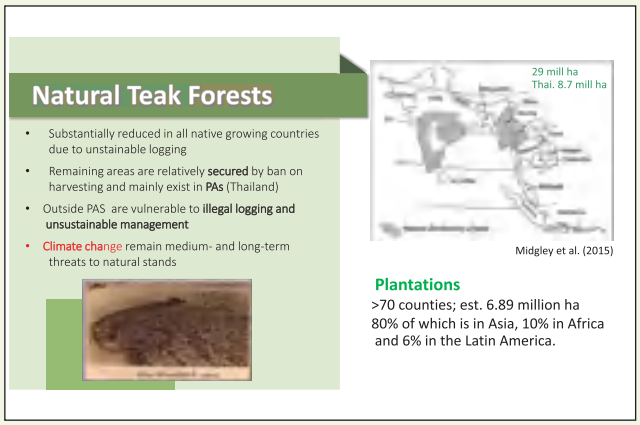
THANK YOU

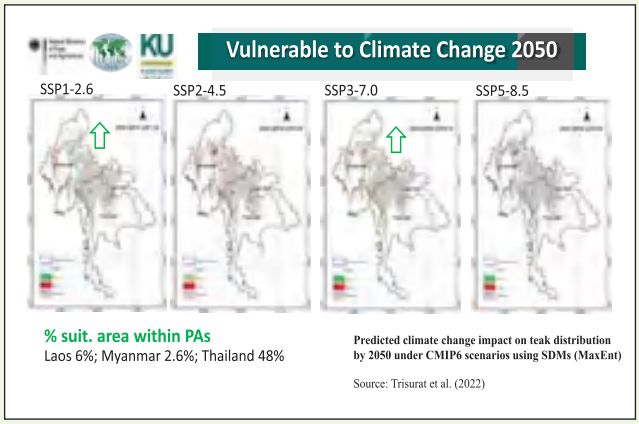
5. Conservation and Sustainable Teak Forest Management in Thailand : Prof. Yongyut Trisurat, Kasetsart University, Bangkok, Thailand



Source: KUFF (2018)





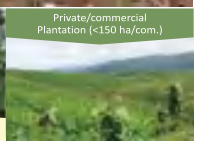


Teak Genetic Improvement

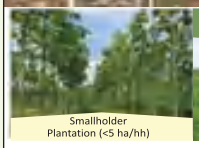
- Thailand/DANIDA teak genetic improvement (seed orchard since 1965)
- Mother tree collection (>6,000 trees)
- Clonal tests (3 trails) for all mother trees
- Seed production from seed orchard and seed production areas ~2-3 ton/year, eq. 2.5-3k ha (+ unknow)
- Growth of improved clones ~MAI 8 m3/ha/yr

Investigate genetic Variations & plus tree selection

FIO: Rotation 30 yrs
Thinning: 5, 10, 20
Stock 2.3 mill cum
>30 yrs 1.7 mill cum



Private/commercial Plantation (<150 ha/com.)



Smallholder Plantation (<5 ha/hh)

Teak Plantations by FIO = 80k ha (118 st.)

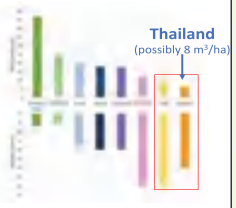
Improvement the Silvicultural Practices

- New intensive method for teak plantations shortens the rotation length to **6 years** from the traditional **20 years**
- Irrigation management; rapid-growth Teak plantations (MAIs of **20-35 m³/ha** were extrapolated.

TEAK FARM

Cambodia

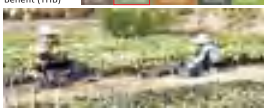
Innovation afforestation
Fertigation



Why teak is preferred species for smallholders and private sectors?

- A native species
- High value timber
- High demand for furniture
- Possible for intercropping
- No exact no. (being register)

Smallholder teak Enterprise (Co-op)



Estimated cost and benefit (THB)

6.25 rai = 1 ha

	Eucal.	Teak	Mahog.	Neem.	Acacia
Rotation (yr)					
Vol per tree					
Value (THB) p m³					
Value p tree					
Value p rai					
No tree p rai					
Invest. (THB)					
Benefit (THB)					

Capacity Building & Training for Trainers

1) seed production/nursery techniques
2) silvicultural practices and improved stand management,
3) **Community-based (enterprise) and smallholders teak forest management**
4) minimizing harvesting loss, efficient transport and processing of teak roundwood
5) supply chains and marketing
6) Legal wood certification

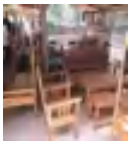
Wood Processing

Teak value Chains in Mekong

Tree growers

Middle men

Sawmill owners/ furniture finishers

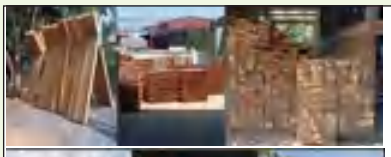


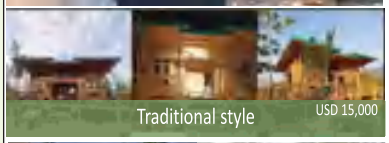
Retailers & consumers

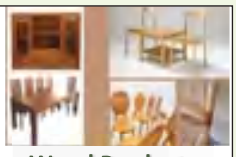
- Teak industry was **well-established** in the region.
- Profits margin among the VC actors are relatively fairly distributed in Vietnam (not Laos).
- Selling teak products (furniture) by design is valued-added.

Vietnam
- Price of standing tree: USD130 (DBH 25-30 cm
- Profit of middleman 10%
- **Simple** regulation
- Transportation cost is cheap.

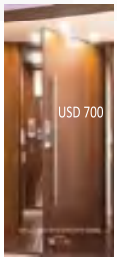
Laos
- Price of standing tree: USD10-25
- Profit of middleman 39%
- **Complex** regulation
- Transportation is costly.







Wood Products



Policy, Legality and Certification

costly

Article 7 of new **Forest Act of 2019**

- Change teak status from a restricted sp. to a regular **economic** sp.

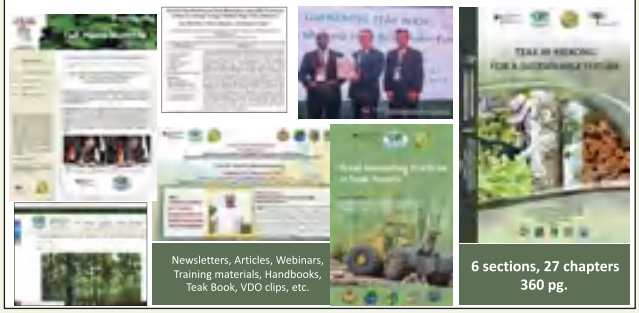
International SFM & certification

- FIO teak plantations: 43,000 ha (50%)

Thailand Nat. Standard

- TIS 14061: The **Sustainable** Forest Plantation Management (2016)
- TIS 2861: **Chain of Custody** Standard Forest-based Products (2018)
- ITTO **C&I** Forest Plantations and Community Forests (2019)
- On-going Thai-**EU FLEGT** license

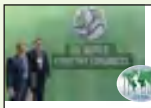
Project Outputs



Newsletters, Articles, Webinars, Training materials, Handbooks, Teak Book, VDO clips, etc.

6 sections, 27 chapters
360 pg.

Partnerships and Networking



MAFF

"ITTO Promotion of sustainable domestic consumption of wood products in Thailand" PD 926/22 Rev.1 (I)

Specific Objective : To promote sustainable domestic consumption of wood and wood products in Thailand

Development objective

To contribute to sustainable and efficient use of domestic wood resources

Challenges and Opportunities for SFM

Future of Teak trade **lies in teak plantations**, not natural teak forests; **Smallholder teak planting** with the involvement holds the key.

Challenges

- **poor quality of seedling materials** and silvicultural techniques
- Lack of access to **supportive financial** schemes for smallholders (harvested too early before the plantations reach their optimum age with respect to **timber quality and value**)
- Complicated legal system and expensive **wood certification**
- **Limited knowledge** sharing and cooperation

Needs (opportunities)

- Provide and propagate good quality materials
- Innovation to use thinning wood & value-added design
- Access to financial schemes to promote longer rotation > enhancing carbon storage in plantation forests, which can also generate additional incomes from carbon credits
- National certificate

RFD Strategy (2018 – 2036)

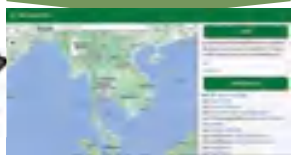
Goals (ambitious)

- additional **forest plantations of 4.1 mil ha**
- [redacted] of tree farmer 420,000 THB per person (current- 232,000; agr. 60,300 THB)
- Contribute at least [redacted] in GDP (current - 350,000 mill THB)

Strategies

- Improve law and regulations
- Identify suit areas for plantation
- Provide economic incentive and marketing
- Increase capacity of smallholders and wood processing
- R&D and innovation
- Strengthen logistic and admin/permission
- Improve/develop legal wood certification

Online site matching tool to identify tree species (25 spp). in suitable areas
https://site-matching.forest.go.th



Supporting policies and initiatives

Policies

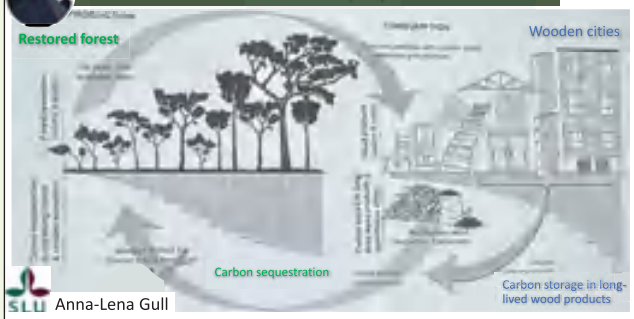
- Thailand **BCG Model**
- **Carbon neutrality** by 2050; **GBF** (30x30)
- TGO: Thailand **Voluntary Emission Reduction** Program (T-VER) – no cutting in 10 yrs, >10 rai (~2 ha)
- **Illegal land occupation**: Government encourages farmers to **grow trees in degraded forests**

Financial incentives

- **Revoke/reduce export tax** of wood products (0%) and lumber from 40% to 10%
- **Waive land tax** if plant tress > 187 trees/ha)
- Agr. Bank initiated **tree bank project** (5,621 communities) as asset to get loan.
- BOI **waives investment tax** (0%) for economic tree plantation and renewable energy crops

T-VER

Wood Solution in a Changing Environment



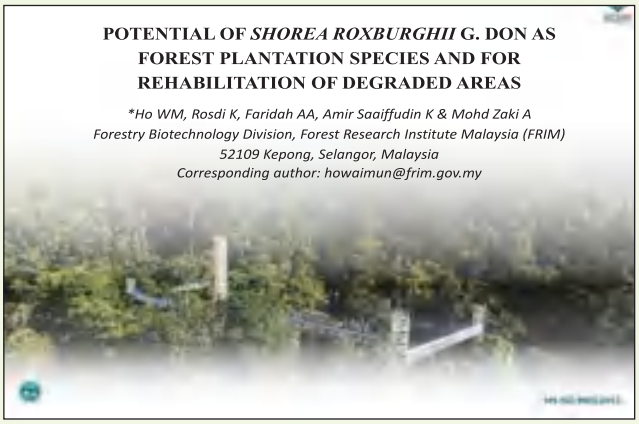
SLU Anna-Lena Gull

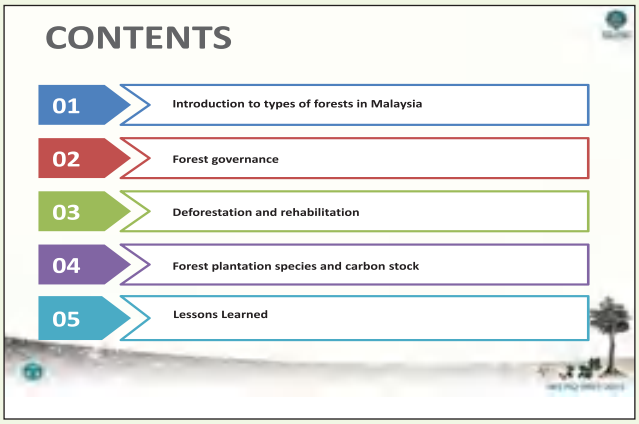
QUESTIONS AND ANSWERS

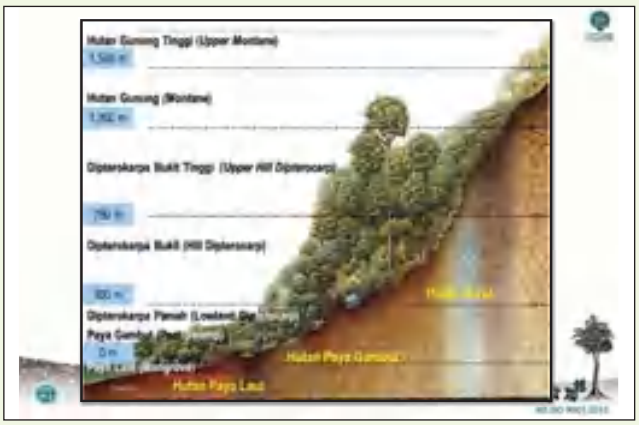
ITTO-TEAK IN MEKONG

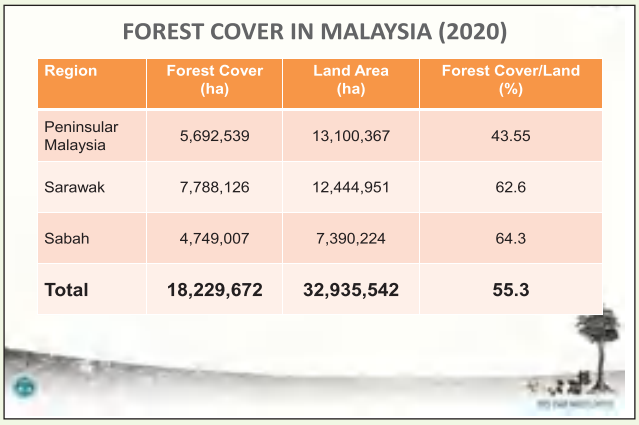
Special thanks to BMEL, ITTO and All project staff and consultants

6. Potential of *Shorea roxburghii* G. Don as forest plantation species and for rehabilitation of degraded areas: Dr. Ho Wai Mun, Forest Research Institute Malaysia



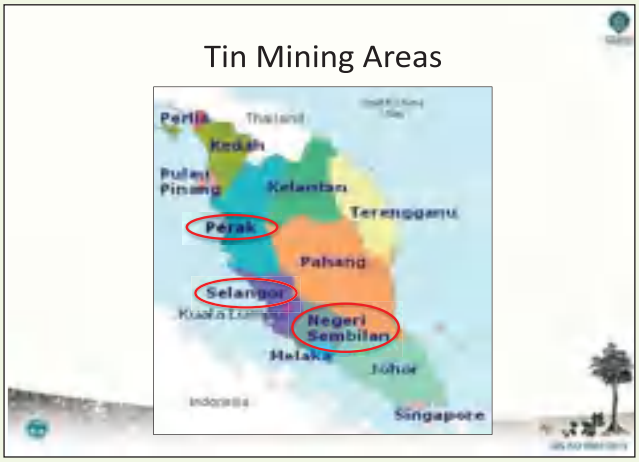


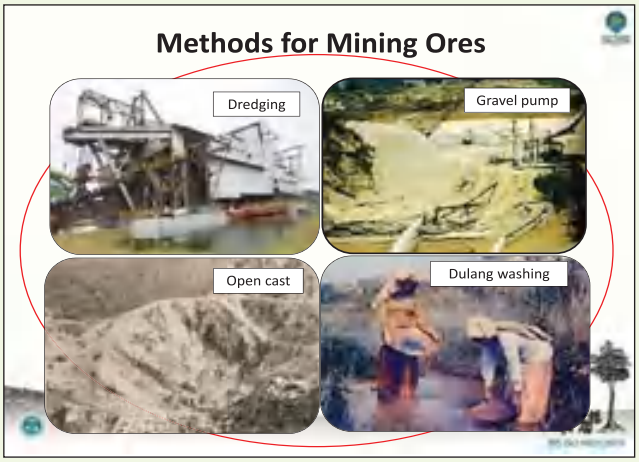


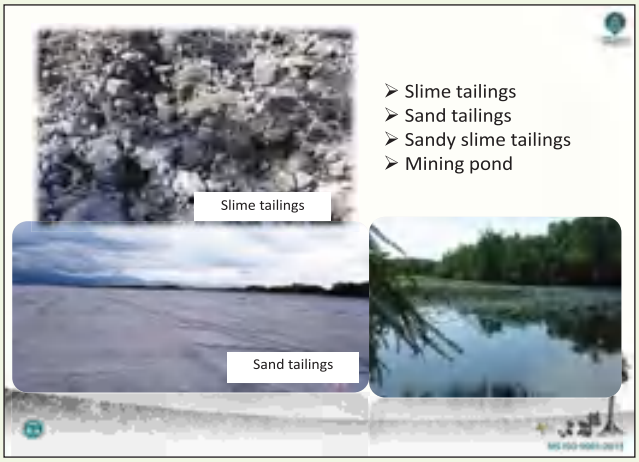

FOREST COVER IN MALAYSIA (2020)

Region	Forest Cover (ha)	Land Area (ha)	Forest Cover/Land (%)
Peninsular Malaysia	5,692,539	13,100,367	43.55
Sarawak	7,788,126	12,444,951	62.6
Sabah	4,749,007	7,390,224	64.3
Total	**18,229,672**	**32,935,542**	**55.3**


Deforestation


Tin Mining Areas
Perlis
Thailand
Kedah
Pulau Pinang
Kelantan
Terengganu
Perak
Pahang
Selangor
Negeri Sembilan
Melaka
Johor
Singapore


Methods for Mining Ores
Dredging
Gravel pump
Open cast
Dulang washing


Slime tailings
Sand tailings
Sandy slime tailings
Mining pond
Slime tailings
Sand tailings

Conversion of ex-tin mining sites

- Agriculture – fruit and vegetable farms, grazing grounds
- Housing estates
- Recreation areas – shopping mall, theme park, garden
- Idle land

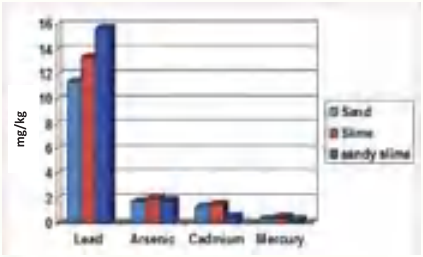
Mines Wonderland

Taiping Lake Gardens

Mohd Najib et al , 2015

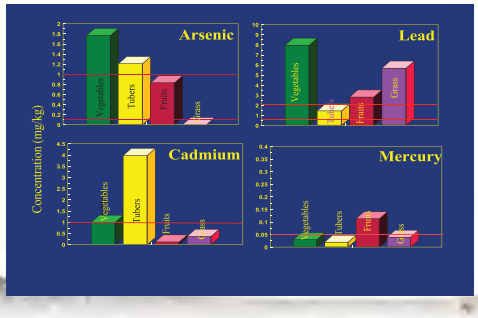
INTRODUCTION

Occurrence of potentially toxic elements (PTEs)

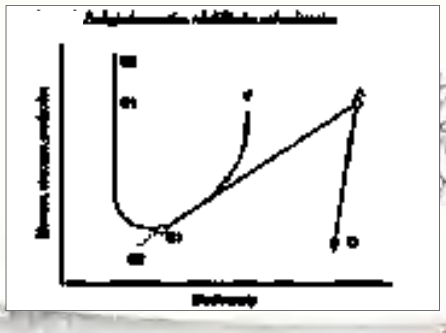


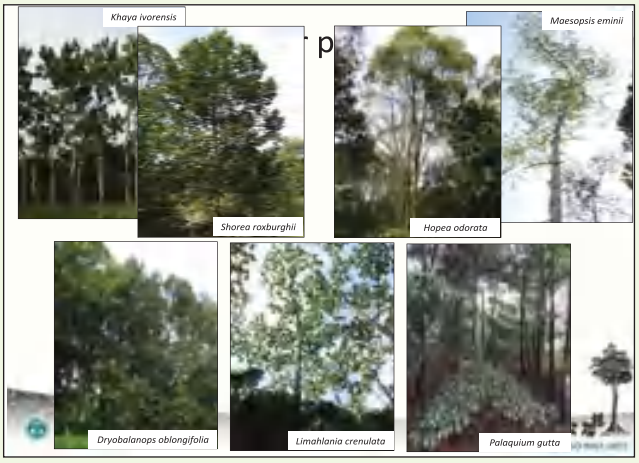
INTRODUCTION

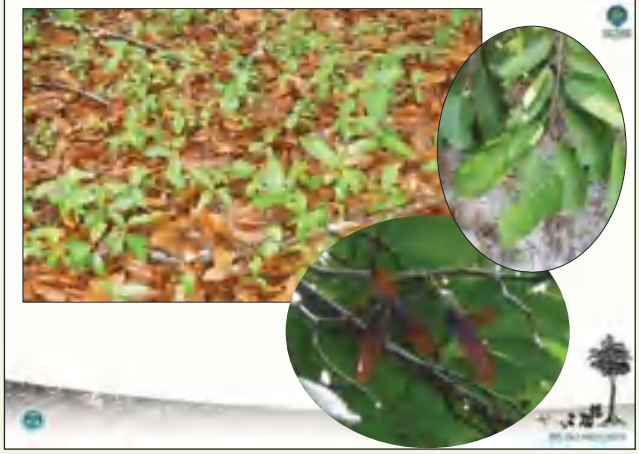
Permissible limits of PTEs in selected food crops
Potential health risk through contamination of food

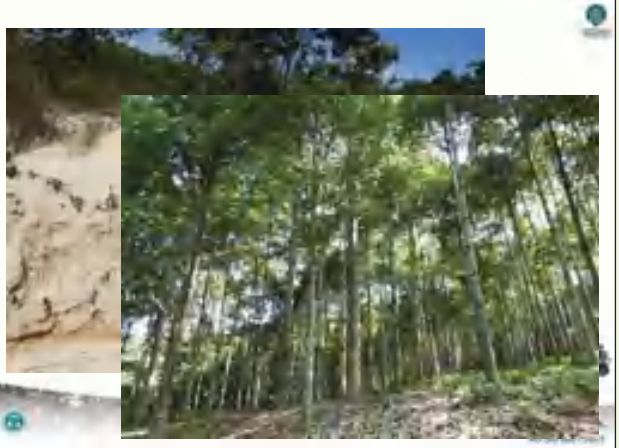


Rehabilitation





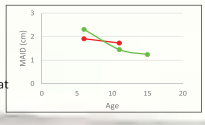




Growth of *Shorea roxburghii* at different ages and sites

Site	Age	N	Average DBH (cm)	Average Height (m)	MAID (cm)	MAIH (m)
BTGT	5	82	7.58 ± 2.28	5.24 ± 1.52	1.52 ± 0.46	1.05 ± 0.30
SBDR	6	62	11.43 ± 4.38	10.29 ± 3.26	1.91 ± 0.73	1.71 ± 0.54
SBDR	**11**	**65**	**19.08 ± 7.15**	**14.61 ± 4.29**	**1.73 ± 0.65**	**1.33 ± 0.39**
SGMT	6	400	13.86 ± 3.79	12.22 ± 2.31	2.31 ± 0.63	2.04 ± 0.39
SGMT	**12**	**390**	**17.41 ± 5.35**	**17.38 ± 3.47**	**1.45 ± 0.45**	**1.45 ± 0.29**
SGMT	15	385	18.63 ± 6.01	18.52 ± 3.82	1.24 ± 0.40	1.23 ± 0.25

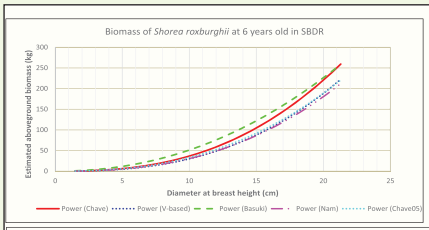
Note:
BTGT – Bukit Gantang
SBDR – FRIM Research Station Bidor
SGMT – FRIM Research Station Segamat

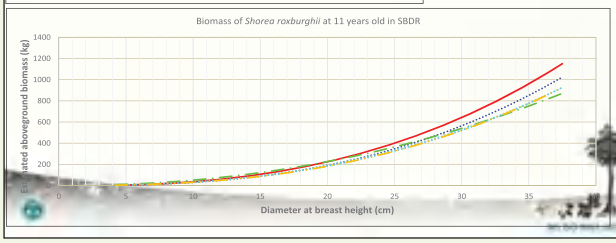


Aboveground biomass (Mg/ha) of *Shorea roxburghii*

Site	Age	N	Basuki et al (2009)	Chave et al (2005)	Chave et al (2014)	Nam et al (2016)	Kaoru et al (2010)
BTGT	5	82	25.68	11.18	11.95	10.03	42.19
SBDR	6	62	45.19	33.61	38.08	31.43	9.22
SBDR	11	65	141.31	125.94	149.79	121.97	36.26
SGMT	6	400	87.93	69.87	80.04	65.86	18.88
SGMT	12	390	146.25	152.29	179.98	146.81	35.21
SGMT	15	385	168.76	184.73	220.28	179.24	17.48

Note: Wood density = 0.67 g/cm^3 (Khoo et al., 1998)





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SGMT	15	385	168.76	184.73	220.28	179.24

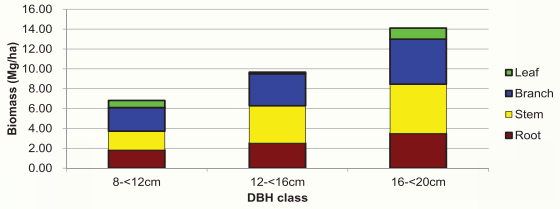
Note: Wood density = 0.67 g/cm^3 (Khoo et al., 1998)

Total biomass (Mg/ha) of *Shorea roxburghii*

Site	Age	N	AGB Chave et al (2005)	BGB Kaoru et al (2010)	Total Biomass (Mg/ha)	Carbon Stock (Mg/ha)
BTGT	5	82	11.18	4.24	**53.37**	**25.08**
SBDR	6	62	33.61	9.22	**42.83**	**20.13**
SBDR	11	65	125.94	36.26	**162.20**	**76.23**
SGMT	6	400	69.87	18.88	**88.75**	**41.71**
SGMT	12	390	152.29	35.21	**187.50**	**88.13**
SGMT	15	385	184.73	17.48	**202.21**	**95.04**

Tree Biomass - Bidor

Biomass Distribution of *Hopea odorata* in Bidor



Aboveground / Belowground biomass: 2.33, 2.65, 3.00

Carbon Pool - Bidor

Forest Floor = 1.92 Mg/ha

Soil (45 cm) = 16.31 Mg/ha

Tree Stand 45.05 Mg/ha

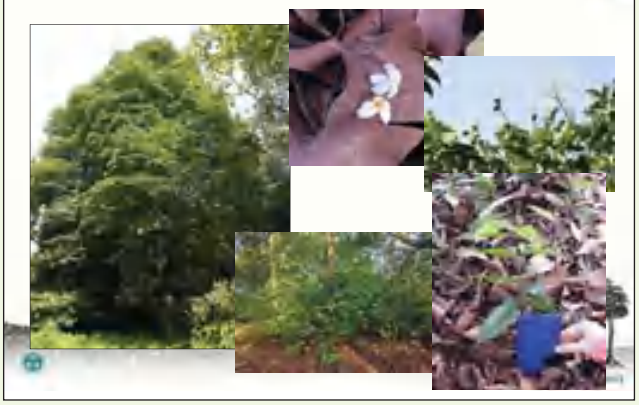
Tree only 59.53%

Soil 36.20%

Lessons learnt

Khaya senegalensis

Dryobanalops oblongifolia



Acknowledgements

- Indian Council of Forestry Research and Education (ICFRE)
- Ministry of Agriculture (MoA), Malaysia
- Ministry of Natural Resources, Environment and Climate Change, Malaysia (NREEC)
- Forest Research Institute Malaysia (FRIM)

7. The potential of pioneer species to the restoration programme on degraded forest: Dr. Rosdi Bin Koter, Forest Research Institute Malaysia

THE POTENTIAL OF PIONEER SPECIES TO THE RESTORATION PROGRAMME ON DEGRADED FOREST

Rosdi K, Ho WM, Patahayah M & Mohamad Fakhri I
Forestry Biotechnology Division,
Forest Research Institute Malaysia (FRIM)
52109 Kepong, Selangor, Malaysia
FOREST RESEARCH INSTITUTE MALAYSIA (FRIM)

International Workshop: Enhancing Ecosystem Services by Improving Forest Quality and Productivity, and SLEM Knowledge Dissemination at ICFRE, Dehradun on 22 to 24 March 2023

INTRODUCTION

What is pioneer species?

Duram (2010) defines pioneer species as hardy species which are the first to colonize previously disrupted or damaged ecosystems, beginning a chain of ecological succession that ultimately leads to a more biodiverse steady-state ecosystem

Pioneer species plays a vital role in the restoration of deforested lands. Pioneer species usually have good growth characteristics, are readily available, free from pests and diseases, have conservation value, and adapt well to problematic areas (Whitmore 1975; 1978).

The Role of Pioneer

Could act as nurse tree, protecting dipterocarps from intense radiation (Hardiwinoto *et. al.* , 1998; Ashton *et al* ., 1997). Can be used in rehabilitation programme for deforested or denuded area (CIFOR, 2000)

The importance of provenance trial is to identify the most suitable provenance(s) for introduction to plantation programme.

Among the critical characteristics to be considered in the selection of the best provenance are growth performances, tolerance to pests and diseases, physiological adaptation to the site (Barros *et al.*, 2002), and phytochemical contents

The Macaranga

- Macaranga tanarius is a plant found in South East Asia, Thailand, Papua New Guinea, South China, Taiwan, and eastern Australia. It is commonly seen as a pioneer species in disturbed rainforest areas. Easily recognised for the round veiny leaves.
- *Macaranga* is one of the well-known genus of pioneer tree grown in disturbed area and widely distributed in Malaysia.
- There are 27 different *Macaranga* species in Malaysia (Whitmore, 2008), and 257 species worldwide (CABI, 2018).
- *Macaranga gigantea* and *M. tanarius* being the two top performing species regarding growth and biomass production (Susanto *et. al.*, 2016)

Macaranga tanarius

Description	
Family	Euphorbiaceae
Genus	*Macaranga*
Species	*Macaranga tanarius*
Distribution	Can be found South East Asia, Papua New Guinea, Eastern Australia Tropical /sub tropical climate
Habitat	A very fast growing pioneer species. Secondary forest, disturbed sites, thickets, forest fringe, roadsides
Leaves	Round and veiny, peltate. Leaves look like parasols
Features	Shrub or bushy tree, up to 20m tall, can reach 40cm stem diam., short trunk , crooked, bark grey brown Flower: small spray yellow/green form on panicles Fruit: spiny-like, globose/sub-globose Seed: black, germination from fresh w/o difficulty,
Uses	Good firewood, general utility-matchboxes, toys; general landscaping, wood for house construction, animal feed in the zoo, nurse tree to promote natural regeneration

DISTRIBUTION OF *M. tanarius* IN PENINSULAR MALAYSIA

- *M.tanarius* can be found from Perlis to Johor
- Along the highway and roadsides – single individuals or mono-stand
- Growing together with other pioneer species
- Concentrated in the northern part, scarcely in eastern region and southern part of Johor
- Found in various altitudes and soil types – except peat soil and BRIS

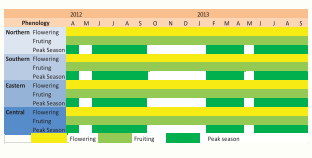
A cluster of *M. tanarius* forms a mono-stand along the roadside to the Cameron Highland

M. tanarius population observed in highlands and hill sites in Peninsular Malaysia

M. tanarius associated with *Musa* sp. in an open area

M. tanarius near the second station, Penang Hill

PHENOLOGICAL OBSERVATION AND GERMINATION OF *M.tanarius*



Observed flowering and fruiting patterns of *M. tanarius* in four regions in Peninsular Malaysia from April 2012 to September 2013

- ✓ Flowering and fruiting occur all year round
- ✓ Two peak flowering – Feb to Apr, June to Sept

FLOWER MORPHOLOGY

- ✓ Dioecious tree
- ✓ Male : Female tree ratio – 1: 27
- ✓ Flower borne in cluster among the leaves
- ✓ Staminate & pistillate on different tree
- ✓ Flowers yellowish- brighter in staminate
- ✓ Pistillate transform into fruit

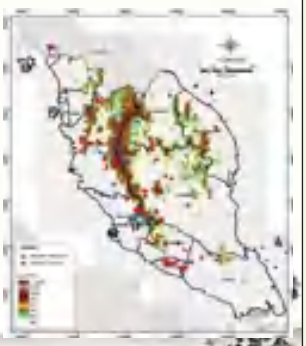
(A) fresh shoot; (B) overview of flower inflorescences; (C) sample of abscised flower; (D) structure of flower

The Use of Pioneer Species in Restoration Programme

- 3RSM Project - restoration, reclamation, and rehabilitation of degraded areas. A programme funded by the federal government and managed by the Forestry Department Peninsular Malaysia (JPSM).
- The programme includes a study on *M. tanarius* as a pilot species in a landslide restoration project in Cameron Highlands.
- *M. tanarius* was chosen as a pilot plant due to the availability of seeds throughout the year, a high percentage of seed germination, and readily available seedlings (Rosdi, 2019).

Furthermore, *M. tanarius* grows naturally at an altitude of 1000 m above sea level in Cameron Highlands.

Its high-altitude tolerance is expected to contribute to the suitability of *M. tanarius* as nurse trees for seedlings of quality forest species planted at the Bukit Jerut and Kuala Terla project sites, located at an altitude of around 1600–1800 m above sea level



Cameron Highland, Malaysia

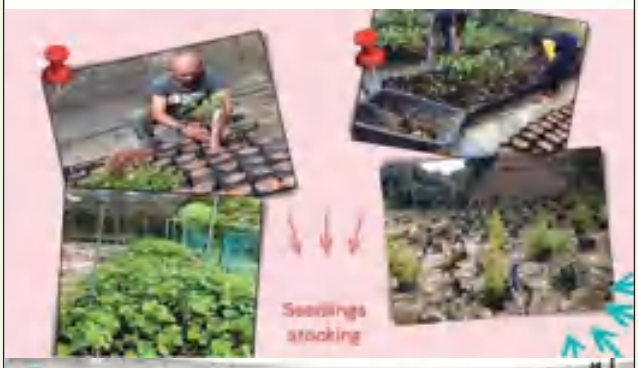
Landslide damage

3RSM Programme

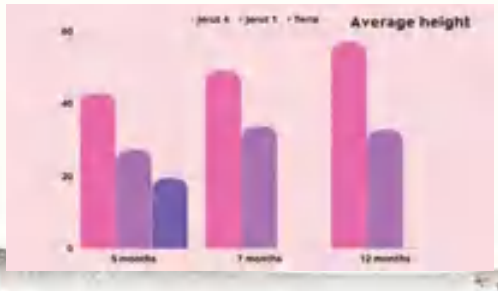
1300 to Janda Baik

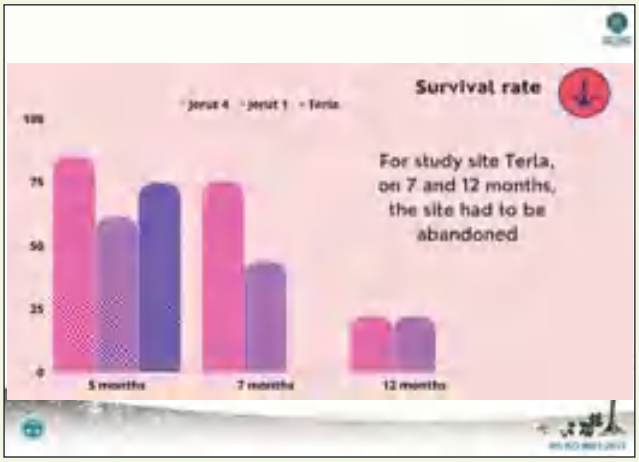
3200 to Cameron Highland

4500 wild seedlings



		Average height (cm)	Average height (cm)	Average height (cm)
	Elevation / m	Dec-19	Feb-20	Jul-20
Jerut 4	1,680	42.7	48.9	56.8
Jerut 1	1,540	27.3	33.6	32.6
Terla	1,004	-	-	-





Conclusion

- M. tanarius were smaller in size and failed to fulfill their purpose
- Overall, the seedlings planted in Jerut 4 showed increase in average height
- Mortality rate relatively high and data from Terla had to be excluded

Conclusion

Restoration of degraded land in Cameron Highland and Sungai Bela through planting multipurpose pioneer species mahang partially delivered the initial objectives

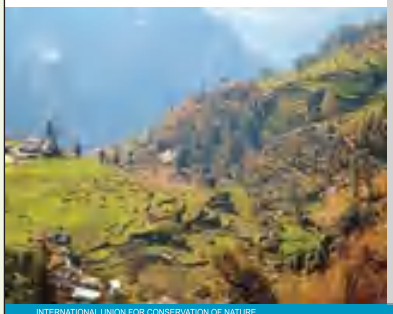
Way forward

- Selection of bigger and older wild M. tanarius seedlings than dipterocarp seedlings would achieve the study objective by providing shade

ACKNOWLEDGEMENTS

- INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION
- MINISTRY OF NATURAL RESOURCES, ENVIRONMENT AND CLIMATE CHANGE, MALAYSIA,
- FOREST RESEARCH INSTITUTE MALAYSIA (FRIM)
- FORESTRY DEPARTMENT PENINSULAR MALAYSIA

8. Leveraging innovative tools and technologies for accelerating forest landscape restoration towards meeting 2030 Bonn Challenge commitment of India: Ms. Archana Chatterjee, Programme Manager, IUCN-India



Leveraging innovative tools and technologies for accelerating Forest Landscape Restoration towards meeting 2030 Bonn Challenge commitment of India

INTERNATIONAL UNION FOR CONSERVATION OF NATURE

About IUCN

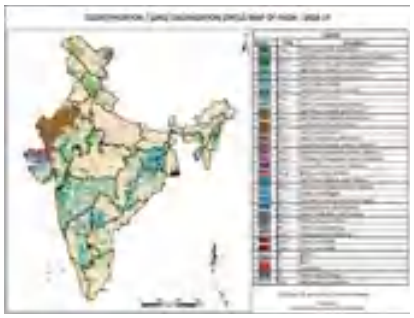
- Membership Union of government and civil society organisations. Set up in 1948.
- Headquartered at Gland, Switzerland
- More than 1,400 Member organisations and the input of more than 17,000 experts.
- **Seven IUCN Commissions:** CEC | CEM | CEESP | SSC | WCEL | WCPA | CCC
- Observer and consultative status at the UN. It plays a role in the implementation of several international conventions on nature conservation and biodiversity
- The GoI is a State member of IUCN and is represented by the Ministry of Environment, Forest and Climate Change
- India became a State Member of IUCN in 1969
- The IUCN India Country Office was established in 2007 in New Delhi under an MoU with GoI in 2004
- Currently, there are 40 IUCN members and 1003 commission members in India.

Status of Land Degradation in India

Land degradation: **97.9 mha** (30%) undergoing process of land degradation during 2018-19.

Processes of Desertification/ Land Degradation

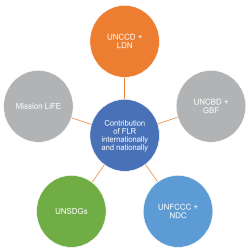
- Vegetation degradation
- Water erosion
- Wind erosion
- Water logging
- Salinity / Alkalinity
- Mass Movement
- Frost Heaving
- Frost shattering
- Man Made
- Barren / Rocky area



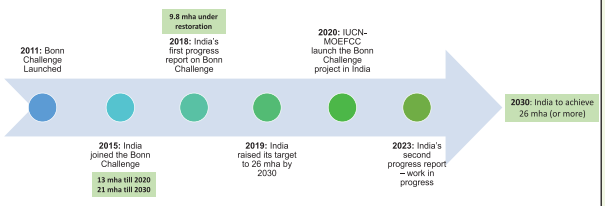
Source: Space Application Centre, ISRO. 2021. Desertification and Land Degradation Atlas of India.

Bonn Challenge

- Global goal to bring into restoration **150 million hectares (mha)** of degraded and deforested lands by 2020 and **350 mha by 2030**
- Launched in 2011 by the Government of Germany and IUCN
- IUCN – Global Secretariat for Bonn Challenge
- India Bonn Challenge pledge is to bring under restoration **13 mha** of degraded land by 2020, and **26 mha** by 2030.
- Forest Landscape Restoration (FLR) is the underlying approach.
- FLR is the long-term process to regain ecological functionality and enhance human well-being in deforested or degraded landscapes



Timeline: Bonn Challenge



Linkages of FLR with international commitments

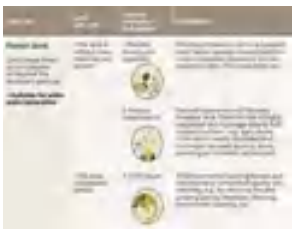
- FLR can contribute to the **Rio conventions** (UNFCCC, UNCCD, and CBD) as well as its implementation can be accelerated by these conventions.
- FLR has strong linkages with Targets 1-4, 6, 8, 10, 11, 14, and 18-22 of the **Kunming-Montreal global biodiversity framework** under the **CBD**.
- FLR has strong linkages with Objectives 1, 3, and 4 of the **UNCCD**.
- FLR can stimulate action for reducing emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests and enhancement of forest carbon stocks, i.e. **REDD+**, as well as the **Nationally Determined Contributions (NDC)** target of creating an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.
- FLR can also cater to some of the suggested actions under the **Mission LiFE** (Lifestyle for Environment), such as: starting biodiversity conservation at community level, planting trees, planting medicinal plants, etc.
- FLR can also contribute significantly to the restoration of forest fire affected areas and mining affected areas – key focus of the Environment and Climate Sustainability Working Group (ECSWG) of the G20.

Forest Landscape Restoration principles

Long-term process to regain ecological functionality and enhance human well-being in deforested or degraded landscapes within biomes with the natural potential to support trees

FLR harnesses the power of nature to provide benefits to people's livelihoods, improve access to essential resources, create and restore habitats for countless species, and store vast amounts of carbon to help mitigate climate change.

Types of FLR interventions



It is not just about planting trees

FLR prioritises both biodiversity conservation and human livelihoods. It is about using land sustainably in a variety of ways, such as new tree plantings, protected wildlife reserves, regenerated forests, ecological corridors, agroforestry, riverside plantings to protect waterways, managed plantations, and agriculture.

Multiple benefits of FLR

Restoration Opportunities Assessment Methodology (ROAM)

- Before FLR can be undertaken, prioritization of potential sites and restoration options is important
- ROAM methodology developed by IUCN and WRI in 2014
- Robust framework to guide the processes for developing restoration interventions at the landscape level

Implement ROAM to identify degraded landscapes & recommend FLR interventions

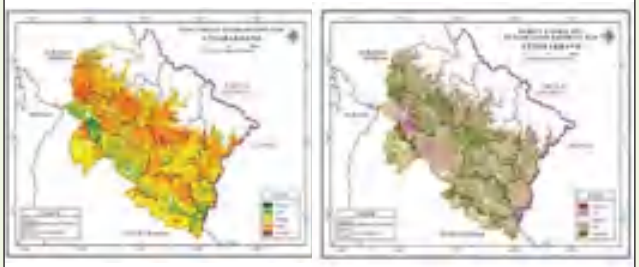
Identify Drivers of Degradation	**Identify** priority areas for restoration	**Develop** shortlist of FLR interventions	**Quantify** costs & benefits of interventions	**Estimate** values of carbon sequestered	**Analyse** finance & resourcing options	Final Report & **Recommend ations**

Phase 1 Planning & Preparation | Phase 2 Data Collection & Analysis | Phase 3 Results to Recommendations

ROAM Results from Uttarakhand

- ROAM analysis carried out for Uttarakhand, with detailed stakeholders consultations in Pithoragarh and Garhwal
- The pilot study was carried out by IUCN, with the G.B. Pant National Institute of Himalayan Environment & Sustainable Development (GBPNIHESD) as the implementing partner in the state.
- Major drivers of landscape degradation identified: forest fires, invasion by unwanted species (especially chir pine), free livestock grazing, landslides, increasing anthropogenic pressure and growing community apathy towards agriculture and forest management
- Functional degradation map (FDM) developed that presents deterioration in quality and standard of performance of a functional unit/area due to degradation drivers
- FDM used as a layer to develop FLR priority map.
- FLR priority map prepared using multi-criteria spatial analysis, with a combination of ecological, social and biophysical factors such as forest density, forest type, population, poverty, elevation, slope and aspect, etc.
- The detailed report identified restoration interventions as per altitudinal zones in the state

ROAM Results from Uttarakhand



Nearly 69% of the state of Uttarakhand is experiencing some form of functional degradation, with 21% of the geographical area under high levels of degradation and 8.8% under very high levels of degradation

Restoration Opportunities Optimization Tool (ROOT)

Restoration Opportunities Optimization Tool (ROOT)		
Product of a two-phase partnership between International Union for Conservation of Nature and The Natural Capital Project	**Software tool:** optimises trade-offs among different ecosystem services to help decision-makers visualise where investments in restoration could be made that would optimise benefits	Applies an integrated linear programming algorithm which optimises and displays the location of the expected ecosystem services generated through restoration

- ROOT is a decision-support tool that demonstrates ecosystem service trade-offs among a number of ecosystem services
- It allows a multi-stakeholder process to define which ecosystem services are important across many sectors, where and how landscapes are degraded, and who should benefit from the augmentation of ecosystem services.
- It provides decision makers with concise and clear figures, maps, and baseline data to make landscape restoration decisions that will optimise human and economic investments in restoration. It provides actionable information on where restoration could benefit multiple ecosystem services and beneficiaries.
- Among other countries, ROOT was used in Colombia to optimise the locations of four types of interventions (agricultural best management practices, forest restoration, riparian restoration, and protection of native vegetation) in the watersheds of six of the largest cities in the country to reach targeted changes in ecosystem services, including sediment retention, nitrogen retention and carbon storage.

Using Blockchain for FLR

- Current distribution systems depend mainly on opaque cash transfers that are inefficient, slow, and vulnerable to fraud – and marginalised people may not actually receive the benefits.
- Hence investors are hesitant to invest, and farmers, for example, have minimal incentive to act.
- A key challenge to FLR implementation is establishing efficient, transparent and sustainable systems to monitor FLR implementation and to distribute financial incentives to those who are actually restoring landscapes, such as smallholder farmers.
- FLRchain is a blockchain-based application to follow FLR implementation through a verifiable ledger system that traces transactions from funding source to farmer
- Being developed by IUCN and Gaiachain

Who could use it and Why?

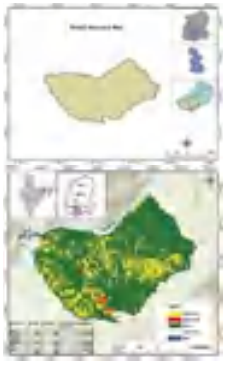
Investor	Facilitator	Steward
• Private companies, government donors, or philanthropist foundations that provide FLR funds • Investors can easily invest in FLR, track fund distribution, & access proof-of-impact data	• NGO, farmer association, or other entity that coordinates FLR implementation • Facilitator can attract more investors, maximise incentives for stewards, and streamline reporting	• Local farmer, landowner, community level institutions, etc. that implement FLR activities • Stewards can diversify income, reduce risk to climate change, and increase land productivity

Nature-positive carbon finance planning in Uttarakhand

- Under IUCN's initiative in Indian Himalayas "Himalayas for Future" project supported by the TATA Group of Companies, a Project Idea Note has been developed.
- The project aims to protect forest from degradation, enhance forest cover, reduce loss of forest through the community-led management of Van Panchayats areas, improve socioeconomic condition of local communities and enhance environmental services including restoring and preserving watershed.
- Results-based payment can be secured through developing a REDD+ project for this PIN
- Project proposed in 38 villages in 2 blocks (Narainbagar, and Dhasoli) of Chamoli district. Total project area is 4125 hectares.

Nature-positive carbon finance planning in Sikkim

- Under IUCN's *"Coping with Uncertainties: Building Community Resilience and Ecosystem Based Adaptation to Climate Change in the Indian Himalayan Region (CWU),"* a Project Idea Note has been developed.
- The project seeks to enhance forest cover and reduce loss of forest through the community-led management of private community land and forests in 25 villages, covering a total of 898.5 hectares of a watershed.
- Results-based payment can be secured through developing a REDD+ project for this PIN
- The project area is located in the 37th Mamley Kamrang Gram Panchayat Unit (GPU) of Mamley Watershed in Namchi, capital of South District of Sikkim.



Private sector engagement in the Extractives sector

Private Sector Engagement

Operational impacts
- Biodiversity and Land degradation
- Habitat fragmentation and soil erosion
- Contamination of natural resources like soil, water bodies and ground water
- Hindrance to traditional livelihood

Knowledge Gaps
- Understanding the ecology and biodiversity of the area
- Restoration often identified as plantation
- Application and implementation of land restoration

IUCN Value Add
- Development of site-specific Management Plans integrated with Mine closure Plans
- Guidance on land and habitat restoration backed up with scientific measures
- Capacity Building through Leaders for Nature Programme
- Improvement in Biodiversity measures
- Increase in local species - native biodiversity and ecology

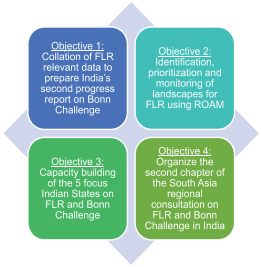
IUCN-MoEFCC Project

Title
Enhanced Capacity Building of Stakeholders and State Governments on Forest Landscape Restoration (FLR) and Reporting Mechanism on Bonn Challenge

Nodal agency
National Afforestation and Eco-Development Board (NAEB)

Duration
3.5 years (January 2020 - July 2023)

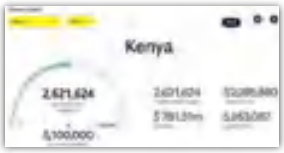
Focus States
Haryana, Karnataka, Madhya Pradesh, Maharashtra, and Nagaland



Measuring progress on Bonn Challenge: Bonn Challenge Barometer

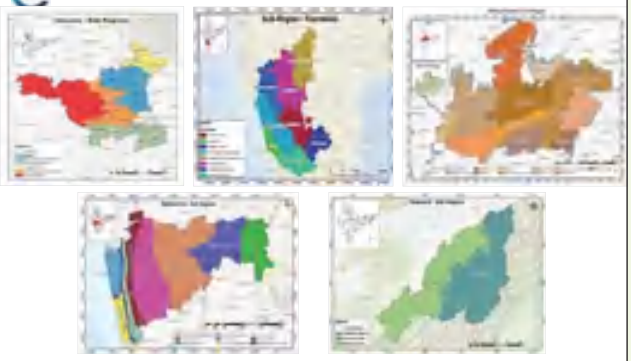
- The global restoration tracker tool developed by IUCN with support from International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)
- Universally applicable, systematic framework for identifying, assessing and tracking action on global restoration commitments

COMPONENTS OF BAROMETER
- Land brought under restoration
- Climate impacts
- Biodiversity benefits
- Socio-economic impacts
- Policies and institutional arrangements
- Financial flows
- Technical planning
- Monitoring systems

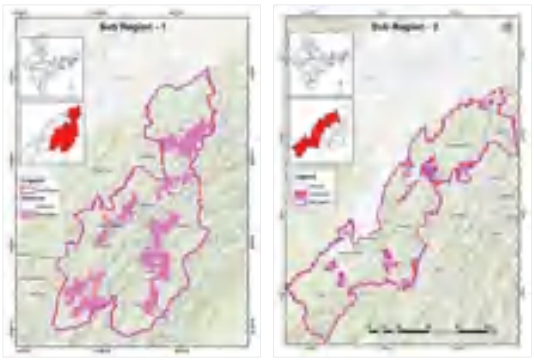


Sample snapshot | *Source: https://restorationbarometer.org/dashboard/countryResults/#tab-area-of-land*

Sub-regional maps generated as ROAM Results for focus states



Sample prioritized degradation landscape maps for Nagaland



Capacity building on FLR and Bonn Challenge

- Capacity building workshops planned in the five focus States (Haryana, Karnataka, Madhya Pradesh, Maharashtra, and Nagaland)
  - 2 days interactive training
  - 1 day field visit to the FLR site suggested by the respective State Forest Department
  - Participants to include from the State Forest Department, Agriculture Department, Watershed department, other line departments
  - Resource persons from IUCN Global FLR team, National Experts, State-level Experts, Practitioners
- An FLR Primer has been prepared
- Modules on Understanding land degradation; Fundamentals of FLR and ROAM, Planning and preparing for an FLR assessment; FLR implementation; Financing approaches; Monitoring and reporting of FLR interventions.

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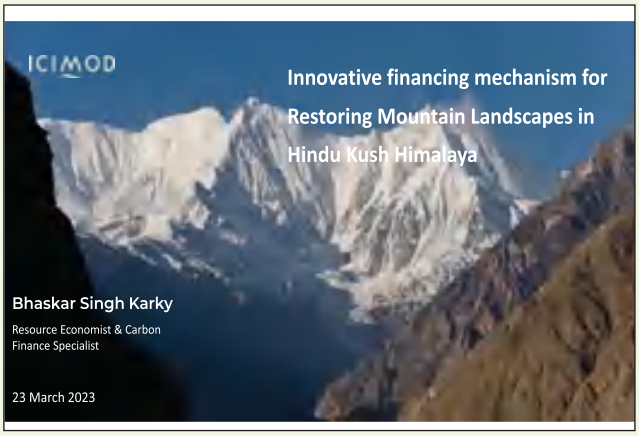
- https://www.niti.gov.in/sites/default/files/2022-10/Brochure-10-pages-op-2-print-file-20102022.pdf
- https://portals.iucn.org/library/sites/library/files/documents/2018-031-En.pdf

Thank You for Listening!

INTERNATIONAL UNION FOR CONSERVATION OF NATURE

9. Innovative financing mechanisms for restoring mountain landscapes in the Hindu Kush Himalaya: Dr. Bhaskar S. Karky, ICIMOD, Kathmandu



2021-2030 UN Decade of Ecosystem Restoration

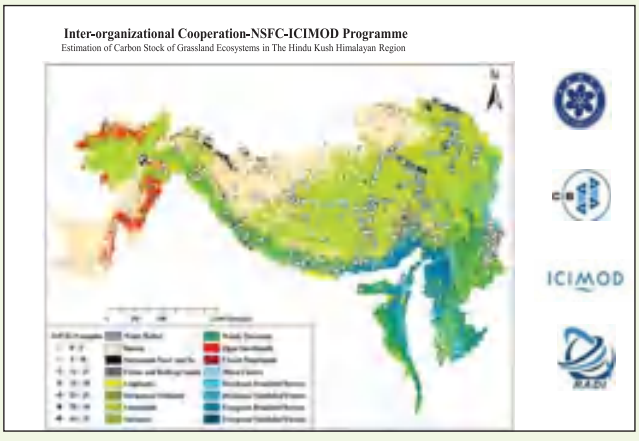
- The UN Decade on Ecosystem Restoration aims to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean. It can help to end poverty, combat climate change and prevent a mass extinction. It will only succeed if everyone plays a part.
- In HKH governments and partners must collaborate to forge a concerted effort for restoring the mountain landscape (regional scale to local level action)

Theory: Innovative instruments in financing landscape restoration

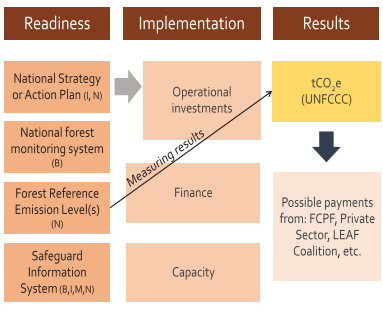
- Why finance landscapes?
  - Recognizing importance of Natural Capital.
  - Realizing disasters and ecosystems services are interdependent (degradation of biodiversity, wildfire, soil nutrient loss, flood, famine, etc.)
  - In HKH: Abundance of natural capital and human-nature failures, including market failures
  - Applications of landscape restoration: SD, DRR, CC Adaptation, CC Mitigation, PES, Green Infrastructure, Forestry, Conservation, Regenerative Agriculture
  - What is additional now compared to BAU: NbS Global Standards (Align with 8 standards)
- In theory, financing landscapes = Scaling for positive outcome for climate, nature (ecosystems), people (economy for resilience) (Green Economy). An incentive must be felt to change behaviour of BAU.
- Financing source:
  - Regulatory instruments and taxes
  - Most crucial aspect for sustainability. GCF and GEF in short run to address immediate concern. Public and private sources of finance plus revolving fund, Green Bonds, carbon finance, etc.,
  - Blended finance: commercial capital to support climate actions creating a win-win situation for those that need to take climate action, but public funds are not available or insufficient, and for those private companies that seek to make profit from such investment.

Practice: the problem and example of solutions

Practice: Need to customize solutions with financial incentives



REDD+ Initiative supporting HKH governments to make transition for implementing Paris Agreement



CLIMATE FINANCE

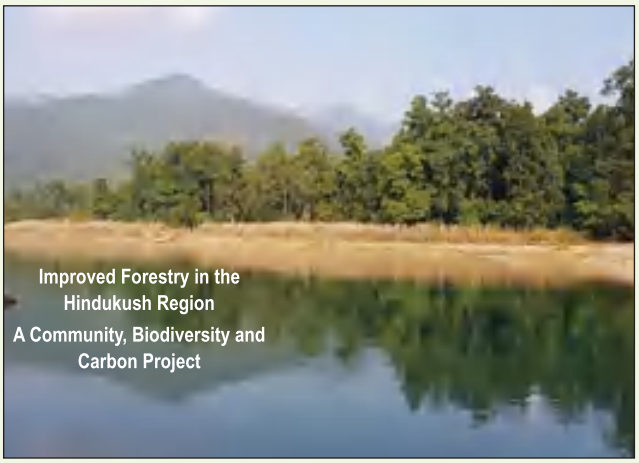
The 2015 Paris Agreement has led to the development of different kinds of climate finance instruments.

PUBLIC SECTOR-BASED CLIMATE FINANCE

Traditional public sector based climate finance has been difficult to access because of scarcity of public finance allocated for climate change. Also certain cumbersome processes.

PRIVATE SECTOR-BASED CLIMATE FINANCE

This instrument is essentially based on Net-Zero Targets that are set by companies and traces the path of how their residual emissions need to be accounted for.
Private sector finance tries to fill the financing gap to ensure continuity in the adaptation & mitigation programmes.
Due to its result-based nature, private sector finance is also a consistent revenue achieved to specifically address climate action and invest in climate resilient solutions over a long duration.



Potential for: Transformative change in the region

An endeavor such as this one, which may establish a symbol of collective restoration action undertaken by countries along the Himalayan landscape, linking multi-national and local communities, has not yet been attempted, and hence could be an exemplary case for future regional initiatives.

BIODIVERSITY COMMUNITY AND CARBON PROJECT

President Churе-Terai Madhesh Conservation Area Program is one of the National Pride Projects initiated by the Government of Nepal, will lead this programme.

The project provides financial incentive for afforestation, reforestation and re-vegetation to community forest user groups, farmers and land-owners that develop and manage forest and to re-vegetate private and state -owned barren lands.

The private sector financing this project is entitled to the carbon credits generated from this investment project.

A true regional-scale program intended to bring transformative change in the forestry sector of the HKH landscape.

This project will also be first of its kind in terms of Climate Change and Biodiversity Action where multi-national companies collaborate directly with community institutions taking actions for landscape restoration and biodiversity conservation.

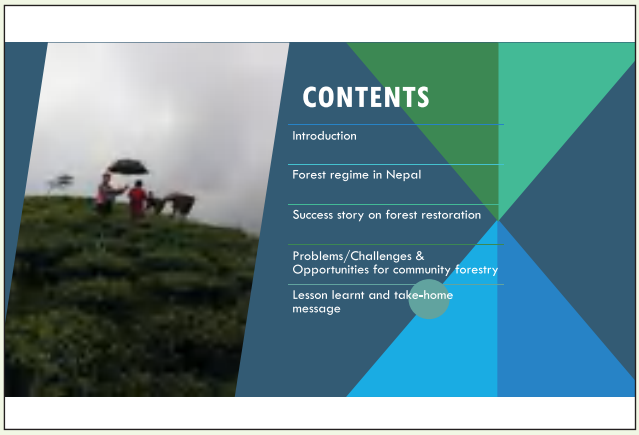
Ten-year Funding Cycle HKH Regional Scale Landscape Programme

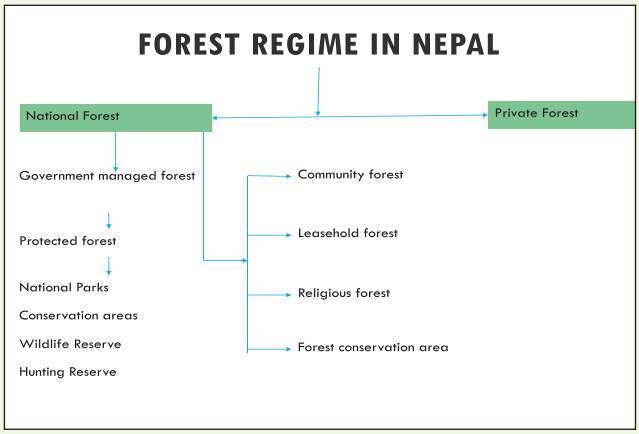
- Phase 1: Nepal (through MoFE)
  - 2.3mtCO_2 sequestered over 10 year
- Phase 2: Nepal (through MoFE)
  - Additional area to sequester 7 mtCO_2 over 10 year
- Phase 3: India, Myanmar, Bhutan, Pakistan
- After 10 years: there will be renegotiation for next project period.

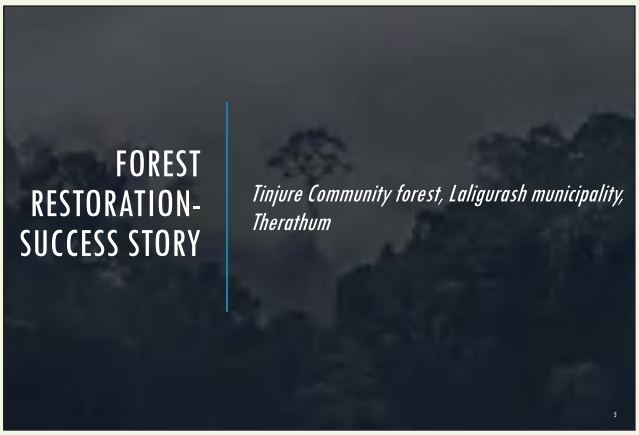
Programme beneficiaries

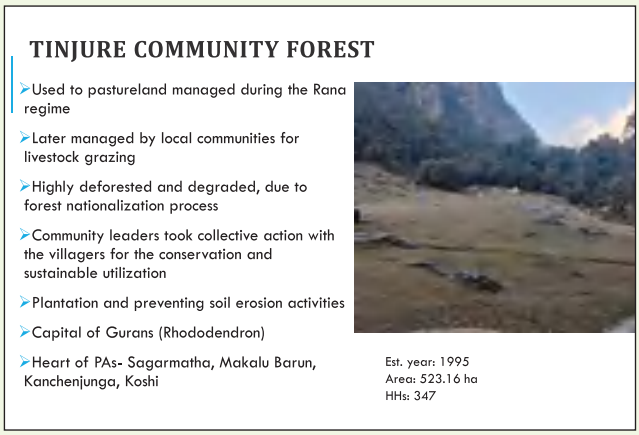
- Community managed forest groups (community, collaborative, leasehold, buffer zone, and religious forest),
- Private forest owners
- Forest-dependent marginalized groups & women
- Capacity building will be done at the institutional level which is also a direct co-benefit achieved via this program

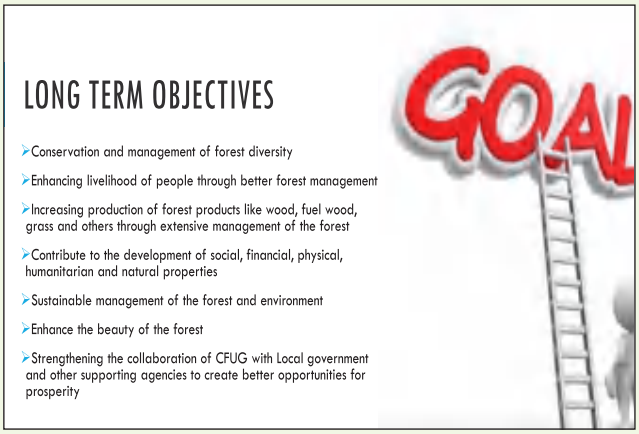
10. Forest restoration efforts of community forestry in Nepal: Success stories from Province-1, Nepal: Mr. Nabin Bhattarai, Hokkaido University, Japan

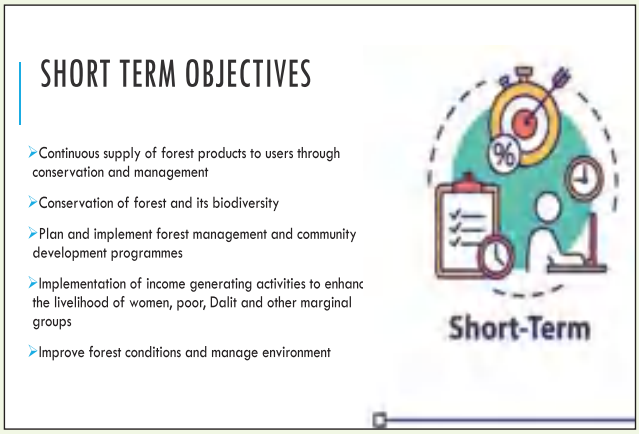












GOOD PRACTICES IN CFUG

- Alternative arrangement of forest products
- Availability of forest products to the community
- Resource mobilization and Increase in income
- Poverty reduction
- Combating climate change
- Inclusive governance
- Increasing adoption of clean energy (reduce dependency on fuelwood for HH energy by using ECS)

CURRENT FOREST STATUS

- Forest condition improved within two decades due to collective efforts of UG.
- Rhododendron, Pinus spp., Alnus nepalensis, Quercus spp., Chiraito, Lokta, Argeli, Satuwa, and many more
- Pangolin, Red Panda, Bear, Leopard cat, etc
- Lophophorus, Dove, Myna, etc
- 28 species of Rhododendron out of 31 species.

PROBLEM AND CHALLENGES

- Limited resources lead to higher demand than supply
- Spread of new invasive species leading to decrease in grass availability and reduction in reproduction
- Three tier tax system under new federal system
- Drying of existing water sources and their impact on wildlife and forest health
- Developmental activities
- Climate change- Season forest fire, drying of water sources
- Limited knowledge of silviculture and gradually dependency on forest for livelihood purpose

OPPORTUNITIES

- TIMBER-BASED FOREST INITIATIVES
- PROMOTION OF NATURE-BASED TOURISM
- PROMOTION AND COMMERCIALIZATION OF NTFPS
- ADOPTION AND PROMOTION OF ALTERNATIVE ENERGY SOURCES
- PROMOTE AGROFORESTRY
- LEVERAGING CARBON FINANCE FOR COMMUNITY FORESTS

LESSON LEARNT

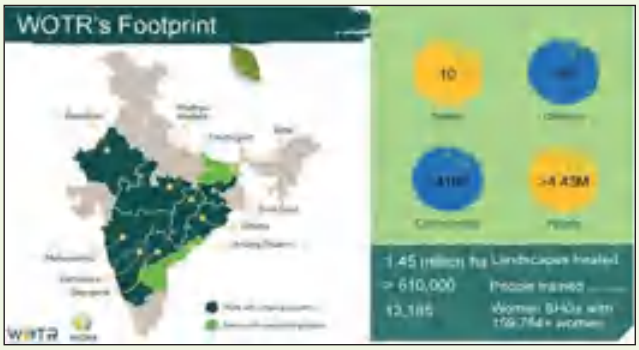
- Restoration will only succeed with local participation, leadership.
- Massive contribution in restoring the degraded forest areas and minimizing the disasters
- CF committee members- elected local bodies –which helped in leadership
- Inclusive-recognition of the poor, disadvantage groups, single women, minorities, enhance livelihoods.
- Community development works-improve education, rural road constructions, sports, rural electrification, improvement in water supply, rehabilitation/reconstruction of disaster affected areas, leadership trainings

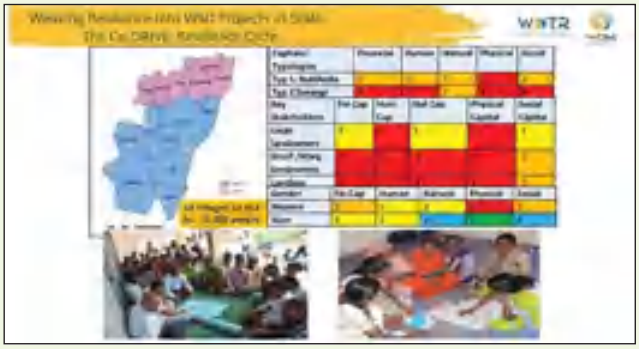
TAKE HOME MESSAGE

- For effective and successful FRL incentive is the key
- Lot to learn on OECM policy from India and other countries can adopt
- Effective governance is prerequisite

13

11. Rejuvenating landscapes – transforming lives in rural India: The Ecosystems based Adaptation: Mr. Sandeep Jadhav, Director, WOTR, Pune

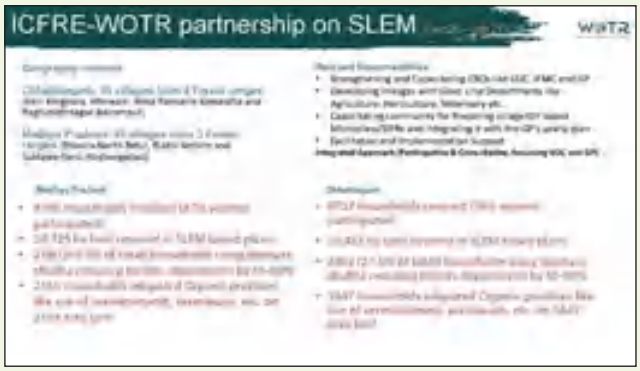




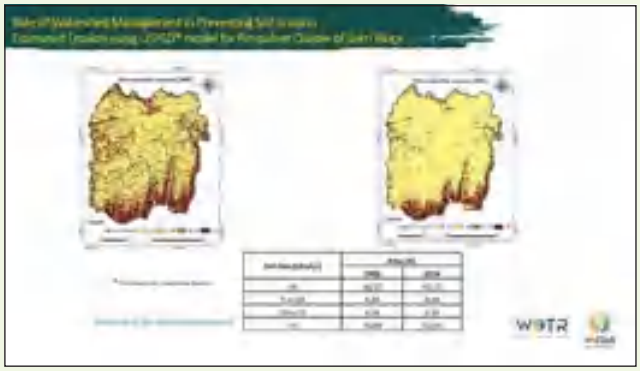

Community Water Stewardship & Water Use Planning
OUTREACH (Maharashtra)
212
63,732
IMPACT
100 villages (3 districts) in 2 years:

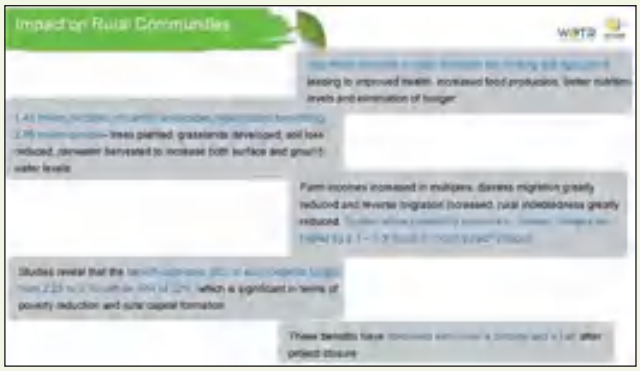

Climate Resilient Agricultural Practices


FARM and Non-Farm Livelihoods


ICFRE-WOTR partnership on SLEM


Ecosystem-based adaptation (EbA) enhances overall resilience of people and ecosystems




Impact on Rural Communities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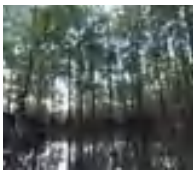
12. Sustainable Land and Ecosystem Management Opportunities in Myanmar (Case Studies on of Mangrove Ecosystem): Dr. Win Maung Aye, Assistant Director, Watershed Management Division, Forest Department, Nay Pyi Daw (Myanmar)

International Workshop
Enhancing Ecosystem Services by improving Forest Quality and Productivity and SLEM knowledge Dissemination

Sustainable Land and Ecosystem Management Opportunities in Myanmar (Case Studies on of Mangrove Ecosystem)



Dr. Win Maung Aye
Assistant Director
Watershed Management Division
Forest Department

22-24 March 2023

Dehradum, India

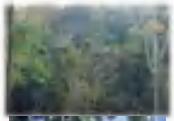
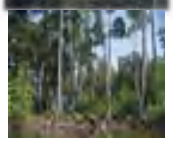
Content

- Forest Resources in Myanmar
- SLEM Opportunities
- Mangroves and Moken Community
- Mangroves and Karen Community
- Mangroves and Mon Community
- Thinking Points for SLEM

Forest Resources of Myanmar

Country Profile

- **Mainland Southeast Asia.**
- **Total land Area : 676578 sq.km**
- **Coastal lines: 2300 km**
- **Population: 51.4 millions (2014)**
- **70% in rural areas**

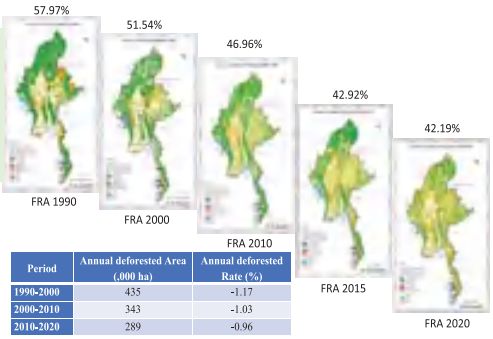

Myanmar's Forest Cover = 42.19 % of the country area (FRA 2020)

Category	Area (,000ha)	% of total country area
Closed Forest	11811.8	17.46
Open Forest	16283.61	24.07
Mangrove	448.4804	0.66
Total forest	28543.89	42.19
Other Wooded lands	18756.05	27.72
Others	18386.8	27.18
Water	1971.14	2.91
Total	67657.88	100

Forest Cover Change

Major Forest Types

1. Mixed Deciduous Forest (39%)
2. Hill and Temperate Evergreen forests (26%)
3. Evergreen forest (16%)
4. Dry Forests (10%)
5. Deciduous Dipterocarp/ Indaing Forest (5%)
6. Tidal Forest
7. Beach and Dune Forest
8. Swamp Forest



Period	Annual deforested Area (,000 ha)	Annual deforested Rate (%)
1990-2000	435	-1.17
2000-2010	343	-1.03
2010-2020	289	-0.96

SUSTAINABLE DEVELOPMENT GOALS

SDG goal 15 – Protect, Restore and Promote Sustainable Use of Terrestrial Ecosystems, Sustainably Manage Forests, Combat Desertification, and Halt and Reverse Land Degradation and Halt Biodiversity Loss

Conventional Forest Management

- Forest Management Unit is at District level
- 69 forest districts in the country
- Implements 10 year district management plan with the mid-term review (and revision)
- It includes SEVEN working circles;
  - Production Working Circle
  - Watershed Working Circle
  - Mangrove Working Circle
  - Plantation Working Circle
  - Local Supply Working Circle
  - Protection Working Circle
  - Non-timber Forest Products Working Circle

Ecosystem-based Forest Management

Piloting in Three Districts (One is in Mangroves)

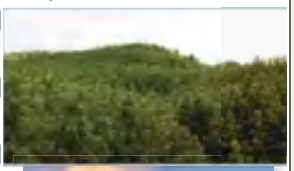
3 Major Focus of Forest Management

- Protection and extension of existing Reserved Forests and Protected Public Forests (RF/PPFs)
- Designating the Protected Areas (PAs) and establishing PA Networks across the country
- Restoration of natural habitats and forest ecosystems

SLEM Opportunities in Myanmar

Development of Permanent Forest Estate and Protected Areas

National Target = **30% of PFE** and **10% of PAs** of the total land area
PFE= 25.88% and PAs= 6.44% (as of December 2022)

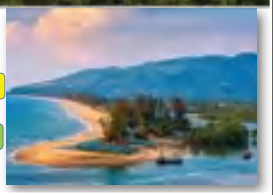


Establishment of Forest Plantation

State Owned Forest Plantation = 930,566 ha (1981 to 2020)
Private Forest Plantation= 273,738 ha (2006 to 2020)

Development of Community Forestry

National Target = 920,000 ha (5% of total forest Area)
CF Development = 354,516 ha (as of August 2021)
Agroforestry is promoting by permitting CF in long-term encroached Ya land in PFE.



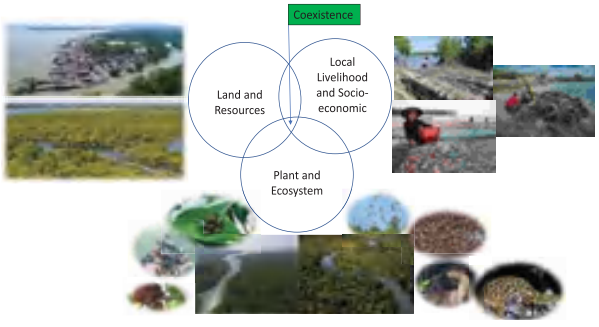
Myanmar Reforestation and Rehabilitation Programme (2017 to 2026)

69 Forest Districts with 500 million USD of state budget

Myanmar Re-establshing Natural Habitats (2019 to 2028)

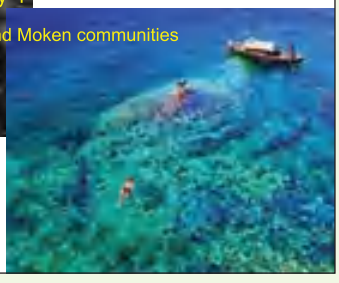
Habitat Restoration Plan development of 19 PAs

SLEM Opportunities via Coexistence Approach



Case Study-1

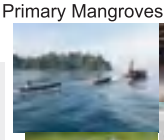
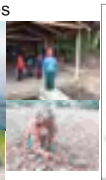
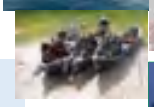
Primary Mangroves and Moken communities



Moken and Primary Mangroves

Moken (Sea gypsy) in Myeik Archipelago

- 800 islands along Andaman Sea
- Moken reside in 3 islands-Myeik District and 7 islands-Kawthaung District
- Moken: 6000 in 1976 & 3438 in 2012


- Live in sea at *Kabang*, boat(8 months)
- Temporary stay on land (4 months)
- Life relation to coastal and marine environments
- Coexistence of Moken and Mangrove?
- Lampi, a mother island of *Labi*, a Moken group

Sociopolitical and Environmental Timeline of Moken (*Labi* group)

Socialist Government (1962-1988)	Military Government (1989-2010)	Democratic Government (2010-2015)	Democratic Government (2015- to date)
• Stay in *Kabang*, boat • Receive rice ration • Sell marine products to the Government	• Dynamite fishing & logging • 1996- Relocation (Marine National Park) • Moken village (2004-*tsunami*)	• Access to formal Education • Squid fishing • 42 households of Moken+ 32 HHs of Moken-Burma	• Tourism and economic development projects • Mobile phone, daily transport • Ya Ba (Amphetamine tablet)

Living in Sea (Temporary Stay on land) — 2003 — Permanent Resident on land & Connected to Modern Society

Animists

- *Tuda* (Good Spirit), *Katoi* (Bad Spirit) and *Awmanlupone* (Ancestors)
- Two times of major worship and every times of bad events

Mangrove Poles and Thatch

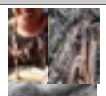
Rarely cut at the time of temporary resident on land

Resting Site

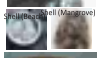
During squid fishing at full moon nights, rest at day time (camping)

3 Kinds of Foods from Mangroves

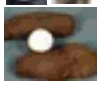
Ship worms
At least 3 times a year for ancestor worships



Shells
Food for Daily life



Water yams
Rice substitute food in 1990s



Biomass comparable to **Asia's Primary mangroves**

Not for Code

Site Location	Forest Type	Dominated Species	Diameter Range (cm)	Height (m)	Basal Area (m^2/ha)	AGB (t/ha)	BGB (t/ha)	References
Myanmar (Lampi Island)	Primary	***R. apiculata***	8.6-60.6	16.0	**31.8**	**466.8**	**159.6**	**Current Study**
Indonesia (Halmahera) *	Primary	*R. apiculata*	5.7-47.7	21.2	25.1	356.8	196.1	Komiyama *et al.*, 1988
Indonesia (Halmahera) **	Primary	*R. apiculata*	5.7-47.7	15.5	22.8	299.1	177.2	Komiyama *et al.*, 1988
Indonesia (Halmahera) ***	Primary	*R. apiculata*	5.7-47.7	-	18.7	216.8	98.8	Komiyama *et al.*, 1988
Malaysia (Matang)	>80 years	*R. apiculata*	-	-	-	460.0	-	Putz and Chan 1986
Malaysia (Matang)	>80 years	*R. apiculata*	-	-	-	270.0	-	Putz and Chan 1986
Myanmar (Lampi Island)	Primary	***Rhizophora***	4.6-60.6		**27.0**	**382.2**	**132.9**	**Current Study**
Thailand (Ranong Southern)	Primary	*Rhizophora*	5.3-39.7	6.15-31.2	31.3	298.5	272.9	Komiyama *et al.*, 1988
Thailand (Ranong Southern)	Primary	*Rhizophora*	5.7-40.7	10.6	24.0	281.2	117.6	Tami *et al.*, 1986
India (Andaman Island)	Primary	*Rhizophora*	-	22.5	15.7	214.0	-	Mall *et al.*, 1988
Myanmar (Lampi Island)	Primary	***R.mucronata***	4.6-57.6	13.9	**23.2**	**314.6**	**111.6**	**Current Study**
Japan (Okinawa)	Primary	*R. mucronata*	-	5.5	31.0	108.1	-	Suzuki and Tagawa 1983

Note. Indonesia (Halmahera) * is the site never inundated by tide, ** is the site inundated by spring high tide and *** is the site inundated by neap tide. Myanmar sites are inundated by neap tide.


Coexistence Opportunities

- No contradict interest of Moken for **Mangrove Conservation**
- Lampi's mangrove is connected to a unique cultural and natural landscapes--> **Opportunities for Ecotourism & Community Based Tourism**
- With the developing contexts, the cultural sustainability of Moken is under worrying condition
- Disturbing the coexistence of Moken and mangroves--> **Higher impacts on Mangrove Sustainability**
- **Develop Policy and Management Planning** to be inline with the sustainability of mangroves and Moken's culture

Locally managed Mangroves and Karen Community

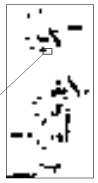
Mangroves uses by Karen Community (KC)

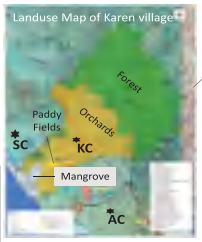
- 8 species for post, 9 species for pole, 4 species for lumber, 1 for roof/wall
- 6 species for fuel-wood
- 1 species for medicine

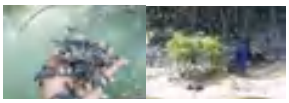
No high demand of mangrove plant resources (97.7% of village hhs owned orchards)

- Fish, crab, shell and Krill (ecosystem related products)
- Commercial purpose two crab species
  - Mud crab (*Scylla cf. serrata*)
  - *Thit-tat* crab (*Episesarma cf. lafondii*)
- Alternate crab production system (9 months for mud crab and 3 month thit-tat crab)
- 27 times of fishing/month
- Moon bathing and hiding place

Typical Land use condition of Dawei District







Sociopolitical Conditions of KC village

ca.1820	1895 (123 years)	1948	1952- 2013 (60 years of Insecurity)	2013- Current
Village Establishment	Church Establishment	Karen-Burma Conflict	Conflict between Karen National Union(KNU) and Myanmar Military	Democracy
4 households along the Kanyin Creek	Christian Religious & Education	KC village was fired under Pyu Saw Htee Conflict	(1952) KNU Development & KC village was a major supporter	Cease fire & Peace Talks

Elephant trampling was used on Thatch covered flood plains to prepare land and establish coconut orchards.

(1975) Became a Battle Ground (1 villager died) & 1979 (babies were died because of land mine (military action)

(1990-91) KC village Relocation (Military action & must leave existing houses and must centered in the main village portion) (Day Pass for Orchard Work)

(1993) KC village Relocation (Porters must provided to Myanmar Military) 10 peoples passed during war and 3 were arrested (5 years of imprisonment)

(2003-04) Rebuilding of Village

(2012) Peace Building (No Military Action)

- Villagers migrated to Thailand as refugee
- 1990-2000, Middle School passed students migrated to Thailand as refugee for education
- Nowadays, some family members of villagers settled in the Developed Countries

Mangrove Management in KC village

Politics	1952-1997 Insurgent Period (Serious insecurity)	Improved Security (Cease fire between government and KNU in 2012), Transportation and Communication		
Period	ca.1978-	1995 - 2000	2001-2015	2016- Current
Concept	Village level Protection by leading of *Phado* *Village Owned Concept*		Transition to Community Forestry with State Admission	
Mngt. activities	• Protect mangrove cutting by outsiders • Establish notification signboard (Karen National Union supports) • Allow cutting for household use and village use	• 4 times of fuel-wood cuttings allowed for commercial purpose	• Protect mangrove cutting by outsiders • Allow cutting only for landless households and fishing pole • Aware the good status of their mangroves by WCS • Apply Community forestry	• Protect cutting fishing pole by the villagers • Manage crab fishing • Protect fish spawning ground • Certified community forestry • Community based tourism
Regulations	• Posts, Poles, fuel-wood and Nipa for household and village uses (fishing poles, fuelwood selling for village income) • Fish, crab, shell catching for subsistence use • Moon bathing and Breath taking place • Hiding place from War (especially for porter arresting by Myanmar military)		• Cutting 20 posts/year, poles and Nipa for household uses • Fish, crab, shell catching for subsistence use and commercial crab catching under management control (alternate production) • Moon bathing and Breath taking place • Initiate community based tourism with the assistances of Forest Department and Wildlife Conservation Society (WCS)	
Aids	Receive advice from village respected technician for potentials of mangrove conservation for village development in future		Receive technical and financial assistances from WCS and official supports form Forest Department of the Region from 2015	

➢ From mangrove products for subsistence use and village development to services used oriented mangrove conservation

Biological Outcomes

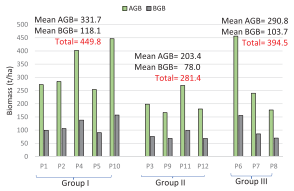
➢ Species Composition

- 14 mangrove species
- 12 tree life forms and 2 shrub forms

➢ Stand Structure

Parameter	Group I	Group II	Group III
Density (/ha)	789[a]	683[a]	648[a]
Diameter (cm)	17.3 ± 0.6[b]	17.0 ± 0.5[b]	18.5 ± 0.8[b]
Height (m)	12.6 ± 0.2[cd]	14.8 ± 0.3[e]	13.0 ± 0.4[cd]
Basal area (m2/ha)	26.2[f]	19.3[f]	23.6[f]

➢ Biomass



Group I: conserved forest (high ground level)
Group II: harvested forest (low ground level)
Group III: medium harvested forest (medium ground level)

Biological Outcomes

➢ **Biomass** comparable to **Asia's mangroves**

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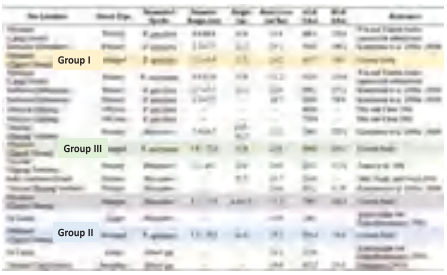


Coexistence Opportunities

➢ **Karen community management from collective management view (Ostrom 1990)**

Necessity & Scarcity
- Forest product use
- Daily subsistence
- Moon bathing
- Hiding place
- Scarcity in the area

Local Autonomy
- *Phado* (KNU)
- Well defined mngt
- Use rights
- CF user groups

Defined Boundary
- Use rights
- Clear regulations
- Protected areas

Social Capital
- Social Cohesion
- Village own
- Protect outsider cuttings (SC case)

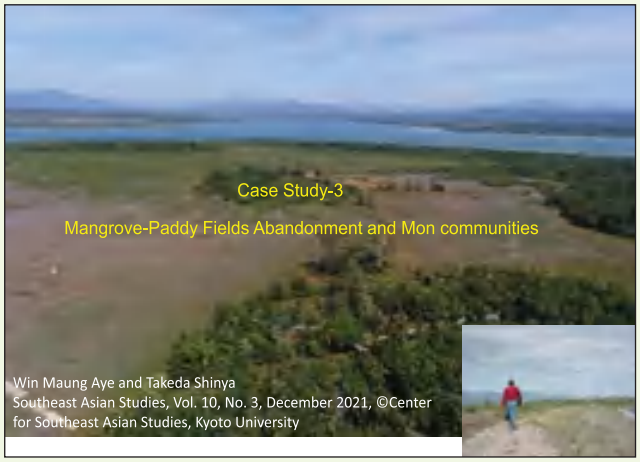
Monitoring
Daily fishing
Local knowledges

Local leadership
Phado & elders
Involve young leader

External Aids
WCS and FD
Technicians

➢ **Biological Outcomes (Local Managed and Utilized over 40 years)**

- **Minimum impacted mangroves** (Basal Area- 26.2 and 23.6 m^2/ha of Group I and III) and **medium impacted mangroves** (19.3 m^2/ha of Group II) (Komiyama et al. 2008)
- According to management condition, biomass comparable to primary conditions (Group I), to old conserved mangroves or >80 years plantation (Group III) and to secondary forest (Group II) of Asia region
- Under **40 years of mangrove utilization** without land conversion, the considerably good status of mangrove could be conserved through **local management practices of Karen Community**



Coexistence of Mangrove Paddy fields and Mon Community (Abandonment Issue)

- Rapid expansion of **mangrove paddy cultivation** in Myanmar (Giri et al. 2008; R. Richards and Friess 2015; Estoque et al. 2018)
- **Rice trauma** of the socialist and military governments
- **Unsustainable farming practice** due to abandonment (Than et al., 2006; Aung et al., 2011; Thant et.al, 2012 in Ayeyarwady Delta, Saw and Kanzaki 2015 in Rakhine, and Yadanar CSR newsletter 2017 in Taninthayi)

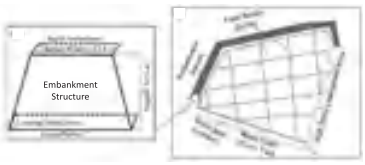
95,266 ha of paddy field (2017)
42% Dawei, 53% Myeik and 5% Kawthaung
12,366 ha under fallow/abandoned
71.6% of abandonment in Dawei

Three Local practices of Mangrove Paddy Field Development

1. Embankment Building

Water Salinity | Tide

- Collectively built with Manpower
- At Neat Tide Days (Oct- May)
- Mangroves killed by water logging



2. Mangrove Cutting & Land Clearing

Mangrove Cutting & EMP Broadcasting → Firing at the open Season → Soil preparation & EMP Broadcasting

- Mangrove Cutting (Oct-March/April)
- Early Mature Paddy (EMP) broadcasting (June-July)
- Firing tree parts & unharvested paddy (Dec-Mar/April)
- Cattle trampling, EMP broadcasting (June-July)

3. Permanent Field Development

- Plowable Condition
- Inner dyke (*Kazin*) building
  water control, paddy varieties, ownership
- Rice Growing (June/July -Oct/Dec)
  Early maturing , *Kauk Yin* (140-150 days)
  Medium maturing, *Kauk Latt* (150-170)
  Late maturing, *Kauk Kyi* (170-200)

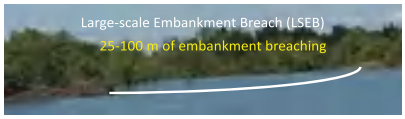
Conditions for Mangrove Paddy Field Development

TC village tract

- Distinct Development of Mangrove paddy fields (1990s)
- Destruction of extensive mangrove cover (*Nipa frutican* mad flats)
- Reduce natural floodplains of existing creeks
- Local authority supported the field development.

Field-A: local geographical setting, minimum destruction on water action
Field-B: Government program, blocked seven creeks, destroyed extensive mangroves
Field-C: Nearest to low water line with less mangrove protection cover

Causes of Field Abandonment and Responses of Local Farmers



C field- 2 times of LSEB within a year (1992)

B field- LSEB at 3 places (1996-97)
LSEB at 2 places (1998)- **lost production**
LSEB on 1999- **yield decrease** due to frequent embankment breaches
LSEB on 2002 and then **abandoned**.
2003- government **rebuit** a portion of embankment (**still breaching**)

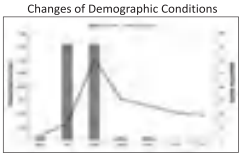
A-Field- 2 times of LSEB within a year (Mar & Sept,2011)

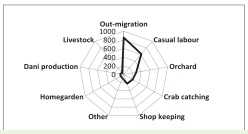
Rebuilding the embankment – Reducing the individual field area of Field-B

Frequent Repairing and Reconstruction of Embankment of Field-B by Government

Demographic and Livelihoods Changes

Changes of Demographic Conditions



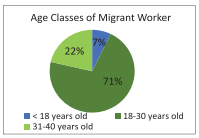


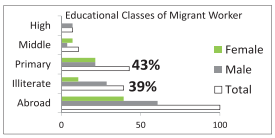
- 9 income sources of the village (2513 USD/year)
- Remittances from out-migrants (67% of income)

Outmigration after 2004
22% of total population (44% interviewees)

3D works in Thailand
39% illiterate and 43% primary education

Age Limitation for wage labour (sustaining livelihoods?)





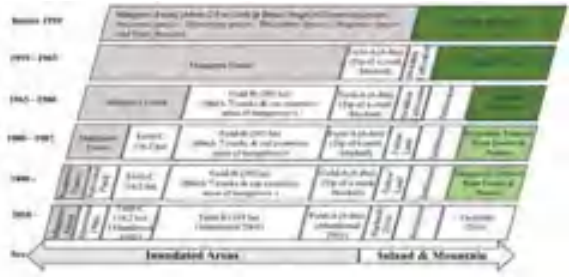
Orchard Establishment to Safeguard Livelihood

- 26.95 ha of the higher ground lands (2002-2017)
- 32% swidden fallows and 68% degraded forest lands
- 72 % of households owned orchard (min- 0.8 ha to max- 5.7 ha).
- 87% of paddy field owners had established orchards

Orchard Cropping Pattern and Area of Orchard Development in K village

Orchard Crop	Area (ha)	% of total cropping area	Original land Condition	
			Degraded Forest	Swidden Fallow
Rubber	4.05	15.1	1.62	2.43
Betel Nut	3.24	12.0	3.24	-
Rubber & Betel Nut	13.19	48.9	8.74	4.45
Rubber & Cashew Nut	0.40	1.5	0.4	-
Betel Nut & Cashew Nut	4.45	16.5	4.45	-
Betel Nut, Cashew Nut & Coconut	1.62	6.0	-	1.62
Total	26.95	100	18.45	8.5

Changes in agroecology of K village (1950-2018)



- 300 ha of paddy field expansion to mangroves (1959-1987) with **no emphasis on coexistence of mangrove and agriculture**
- Within 2-3 decades, lost all productions from paddy fields (**no alternative products**)
- 26.95 ha of orchard developed on degraded tropical forests and old swidden fallows around the village (**without legal recognition**)

Human-environmental Timeline

- Commercial paddy cultivation to **subsistence use** in the study area
- Options for two alternative livelihoods- **Shrimp farming** (no interest) and **Mangrove planting** (fairly interest- no show case)
- 100% of farmers willing to **revitalize** the fields (area decrease after embankment reconstruction)
- **Integrated farming**: manageable area of paddy field with reasonable mangrove cover (open-space fishing and livestock breeding)

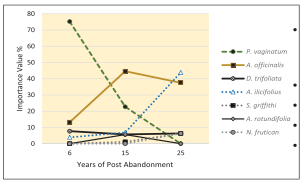
28

Natural Recovery and Stand Structures of Mangroves on Abandoned Paddy Fields

Secondary succession is **site specific** and **complex multifunctional process** (Lee and Robinson 2002)

Natural recovery in Ayayarwady Delta (Aung, 2012 and Win and Takeda, 2020)

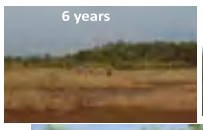
Natural Recovery at understory layer

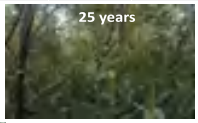


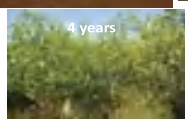
- **14 species** including 9 true mangrove species
  6 spps tree life form, 3 shrubs, 2 grasses, 1 herb, 1 palm and 1climber
- **Decreasing** domination trend of *P. vaginatum* (**grass**)
- **Increasing** domination trends of *A. ilicifolius* (**herb**)
- Since **6 years**, *A. officinalis* (**tree** life form) recover
- On **25 years**, mixed *A. ilicifolius* and *A. officinalis* domination

Productivity Compare to *A. officinalis* Plantation

Parameter	Natural Recovery on abandoned mangrove paddy Field		Plantation on Abandoned mangrove paddy field (Win and Takeda 2000)		
Period/ Age	15 year	25 year	4 year	8 year	> 10 year
Mean DBH (cm)	2.7 ± 0.1	3.8 ± 0.1	3.2 ± 0.1	6.1 ± 0.3	6.7 ± 0.2
Mean Height (m)	3.2 ± 0.1	4.5 ± 0.1	4.3 ± 0.4	6.4 ± 0.1	7.3 ± 0.1
Stand Density (/ha)	130	5200	2666	3166	4066
Basal Area (m2/ha)	0.076	7.031	2.320	11.010	15.600

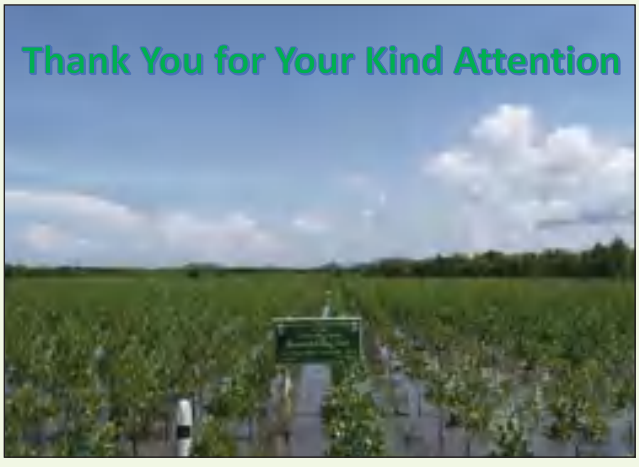






Thinking Points for SLEM via Coexistence Approach

Local management and utilization	Mangrove Status	Mangrove and people coexistence
Moken Sea gypsies • Mother Island • Shipworms of Rhizophora tree for ancestor worship • Mangroves shells for daily subsistence • Ecosystem services	Primary Mangrove Forest	Protection integrated with local's cultural usufruct
Karen Village • Well defined local management • Village owned and development concept • 40 years of product and services uses • Without land conversion	Old Conserved Mangrove Forest	Conservation of mangroves under community-based management in line with Local's daily needs and livelihoods
Mon Village • Mangrove Paddy cultivation • Government intervention for paddy field expansion • Paddy field abandonment and consequences of on set out migration and orchards farming	Mangrove Paddy Fields	Coexistence strategy of mangrove and agriculture through integrated farming



13. Restoration of degraded common lands: Ms. Himani Sharma, Programme Manager, Foundation for Ecological Security, Anand

CORE MODEL

Secure community land rights + Collective action for inclusive management & governance + Access to resources & finance for restoration = Ecological health + Resilient livelihoods

Ecological Restoration: understanding landscape

We take advantage of working on natural features, we start eco-restoration processes by identifying contiguous stretch of land – may be catchment of a small river, micro watersheds, range of hills or a social cohesive unit.

- Facilitating institutional arrangements at landscape level- to enable transaction and negotiation between resource rich and resource poor institution, upstream and downstream habitation on issues like boundary, open grazing, forest fire, sharing of resource, conflict management etc.
- Providing platform for communities, civil society organizations, informed individuals, academia, government functionaries for collective analysis of problems, search for appropriate solutions and influencing development agenda of a region

Understanding ecosystems

(on the lay of the land - what lie above and what lie beneath)

- Ecological succession trends of the area
- Forest type, Fauna and flora (biodiversity)
- Geo hydrology
- Local agriculture
- Human – Nature interaction.
- Detailed ecological profile

Computerized Landscape Assessment & Restoration Tool (CLART)

Decision support tool which provides ***location specific*** information in a ***user friendly*** manner to ***enable village communities*** to ***plan*** and ***develop estimates*** of the soil and water conservation interventions ***without help of Engineers and Internet at field***

Planning tool that aids in area-based soil and water conservation interventions

- Scientific recommendations are translated through colour-coded maps that depict recharge potentiality by overlaying layers of lithology, drainage, slope, landuse and landcover.

Forest Management Tool

- Working in partnership with Forest Plus
- Enabling development of Forest Working Plans based on Working Plan Code, 2014
- Being scaled in collaboration with Government of India and with State Governments
- Enabling better decision making at the Forest Division Level

- Training of the forest division officials undertaken across 73 divisions
- Implemented in 4 states – saturation in Rajasthan planned in 6 months
- Plans for scaling of the tool to across states and districts through Van App

Nurturing Systems Thinking – through community-based system dynamics

Regeneration plan

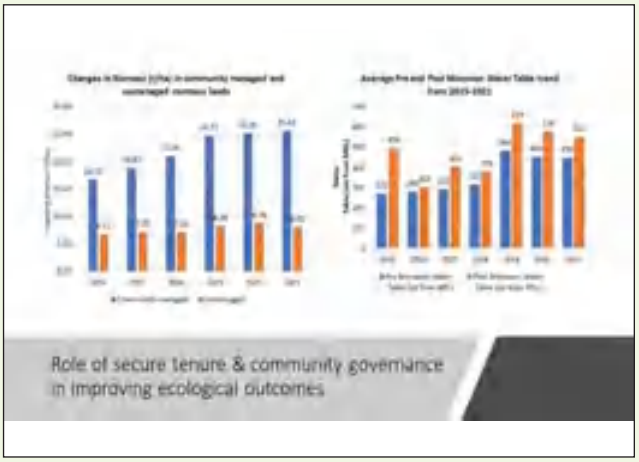
- Discussion with community members (men and women)
- Mapping of bio-physical factors using manual/GIS.
- Species selection based on:
  - Species survey of site
  - Ecological concerns
  - Community preference
  - Past learning
- Treatment plan including SWC work: CLART
- Discussion in village institution : implementation and protection
- Approval of plan in gram-sabha and panchyat (after technical section)
- Planting and after care
- Time budgeting
- Implementation
- Monitoring
- Learning

Zonation and Species selection method

Regeneration of indigenous grass species

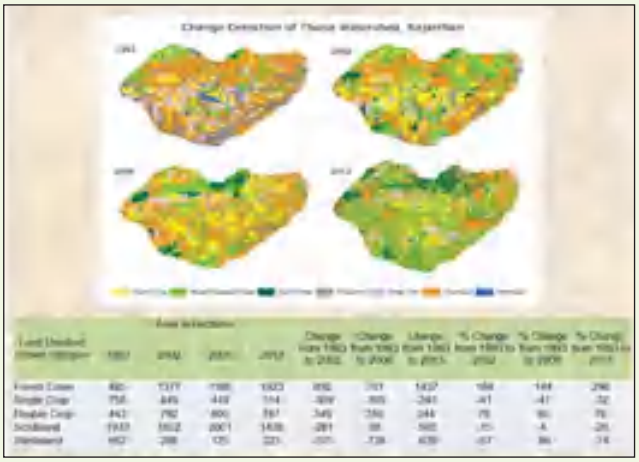
Grass Seed Pellets:
Dried seed balls used for sowing into the soil

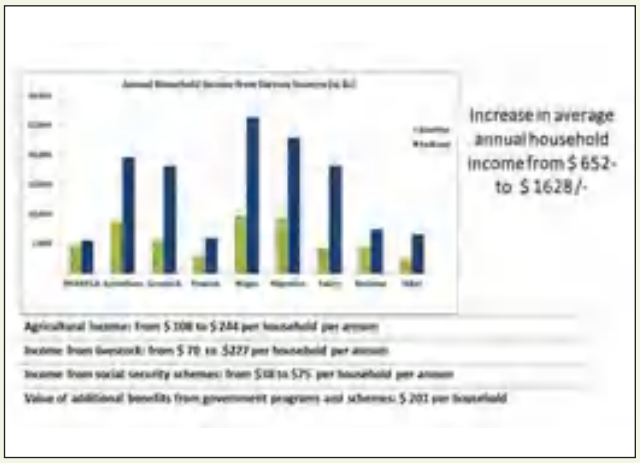
Grass slip planting:
Plucking grass clump from the soil (carefully with the roots) and splitting it in slips for planting in soil and trenches.



Changes in faunal diversity of Kalyanpura Watershed

S.No.	No. of species	2009-10	2018-19	Remarks/ new records
1	Birds	86	113	River Lapwing
2	Reptiles	8	15	6 new records
3	Amphibians	3	7	Short Headed Burrowing frog
4	Butterflies	13	22	11 species newly recorded
5	Mammals	14	18	Small bat species




Increase in average annual household income from $ 652- to $ 1628/-
Agricultural Income: from $ 108 to $ 244 per household per annum
Income from livestock: from $ 70 to $227 per household per annum
Income from social security schemes: from $38 to $75 per household per annum
Value of additional benefits from government programs and schemes: $ 203 per household


Rajasthan
AP & Karnataka
HP & Odisha

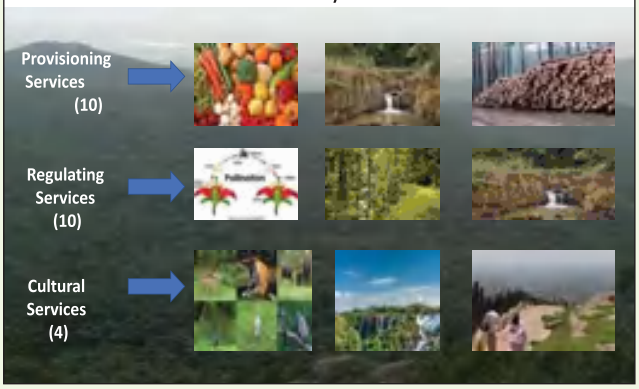

Thankyou

14. Restoration of forest ecosystem services through eco-budget in Karnataka: Dr. M. Balasubramanian, Assistant Professor, Centre for Ecological Economics and Natural Resources, Institute for Social and Economic Change, Bengaluru

Restoration of forest ecosystem services through eco-budget in Karnataka

Dr M Balasubramanian Ph.D
Assistant Professor
Institute for Social and Economic Change
Bangalore – 560 072

What is Forest Ecosystem Services?



Why Valuing Ecosystem Services?

- Missing markets
- Imperfect markets and market failures
- Uncertainty involving demand and supply of natural resources, especially in the future.
- Government may like to use the valuation as against the restricted, administered or operating market prices for designing biodiversity/ecosystem conservation programs.
- Natural resource accounting.
- Natural resource allocation and full social cost and benefits
- Decision making
- Damage assessment
- Internalising externalities and price setting

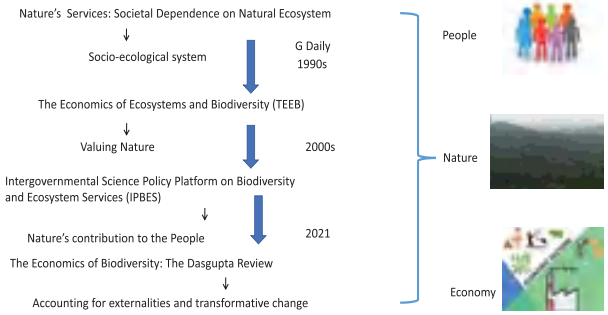
Source: (Pascual and Muradian, 2010; Pieter et al .,2015)

How Valuing Ecosystem Services?

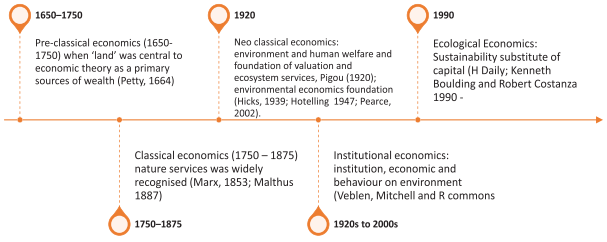
Approach	Method	Value
1. Direct Market Valuation Method		
Price based method	Market prices	Direct and indirect use
Cost based method	Avoided cost	Direct and indirect use
	Replacement cost method	Direct and indirect use
	Mitigation/restoration cost method	Direct and indirect use
Production based method	Production function approach	Indirect use
	Factor income	Indirect use
2. Revealed Preference approach	Travel cost method	Direct (indirect) use
	Hedonic pricing method	Direct and indirect use
3. Stated Preference approach	Contingent valuation	Use and non-use
	Choice modelling/conjoint analysis	Use and non-use
	Contingent ranking	Use and non-use
	Deliberative group valuation	Use and non-use

Source: Pascual and Muradian, 2010

Value of Natural Capital



Economics Idea of Natural Capital (Forest ES)



Loss and Degradation of Forest Ecosystem Services

- Food and Agriculture Organisation (2003) defined forest degradation as "the long-term reduction of the overall potential supply of benefits from the forests, which include carbon, wood, biodiversity and others goods and services".
- Loss and degradation of forest ecosystem services have reduced their ability to provide sustainable essential services to human beings as well as nature.
- In addition, loss and degradation of forest ecosystem also challenges biodiversity, livelihood for local communities, climate mitigation and adaptation loss of natural habitat (Leadley et al., 2010; IUCN, 2021).
- Forests provide important services such as clean air, water, climate regulation and health soil for agriculture production etc.,

Negative Externality: a view of forest ecosystem services

- Markandya et al., (2001) defined externalities is " arise when the actions of an individual, firm or community affects the welfare other individuals, firms or communities [and the agent responsible for the action does not take fully account of the effects" (UN et al 2021:2).
- Further, how externality have valued, how the values are useful for policy marking. For example, negative externalities affect both the flow of ecosystem services, by reducing the wellbeing of the society can drive from them and possibly also the stock value of the ecosystems, by reducing the flow of services and wellbeing they can contribute to the future.
- Therefore, the negative externality measured in monetary terms. Negative externalities are included in the SEEA-EA in the aspects of flow and asset account

System of Environmental Economic Accounting: Loss and Degradation of Ecosystem

- SEEA-EA (UN et al., 2021) discussed the definition of ecosystem degradation must include into the current national accounting framework with the measurement of consumption of fixed capital (CFC) or depreciation of produced assets as described in the system of national accounts.
- Ecosystem services degradation in the physical terms, is the decrease in the quantity of the stock of natural asset over an accounting period that is because the extraction of ecosystem asset by economic units occurring at al level greater than that of regeneration.
- Ecosystem degradation considers changes in the capacity of environmental assets to deliver a broad range of contributions – known as ecosystem services (e.g. air filtration services forests) and the extent to which this capacity may be reduced through the action of economic units, including households.

Why Forest Ecosystem Services loss important for Karnataka?

- India has committed itself to creation of an additional carbon sink of 2.5 to 3.0 billion tonnes which can be achieved through additional forest and tree cover by 2030.
- In this regard, Karnataka has been identified as the second potential state for additional carbon sink of 112.95 million tonnes CO_2 eq by 2030.
- Economic loss assessment of forest ecosystem services can help in understanding contribution of forest to the state economy and societal welfare, as well as better understanding of how anthropogenic activities affect forest ecosystem and its services.
- A standard environmental economic framework, called System of Environmental Economic Accounting –Ecosystem Accounting (SEEA-EA) has been developed by United Nations and accepted by all member countries, including India, which needs to be used strictly for assessment of ecosystem losses.

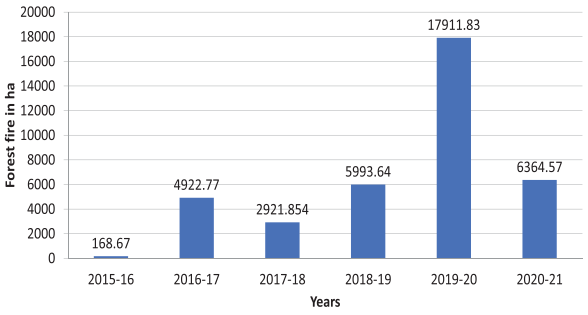
Materials and Methods

- This study has used different data for valuing of forest timber as explained under forest land conversion for other purposes such as irrigation, hydel and wind power, mining and quarrying, road, railway, transmission line and other categories, such as a pipeline to provide drinking water supply with data taken from the Annual Report of the Forest Department for various years.
- Forest fire data obtained from the statistical division, Aranya Bhavan, Government of Karnataka.
- Remote Sensing Application Centre in Bangalore
- Study Period 2015-16 to 2020-21
- Provisioning Services: (Non-timber forest products, timber production, household income)
- Regulating Services: (carbon sequestration e.g vegetation, soil organic carbon, soil erosion prevention, air purification SO_2, NO_2), Pollination services)

Forest land converted for non-forest purpose in Karnataka (area in ha)

Category	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Irrigation	0.17	2.62	110.37	4.8	0.12	100.12
Hydel and wind power	0	18.36	9.82	30	0	0
Mining and Quarrying	0.51	145.04	29.9	101.675	10.04	0.19
Road	1.35	74	37.14	0.808	0.96	168.95
Railway	0.16	0	0	0	18.11	10.37
Transmission Line	2.37	24.83	11.2	0	3.01	0
Others	103.8	33.53	132.75	0	4.07	161.92
Total	108.34	298.38	331.17	137.28	36.31	442.27

Forest Fires in Karnataka (Division wise)(area in ha)



Loss of carbon in vegetation in Karnataka

Year	Forest Conversion (A)	Forest Fire (B)	Total (A+B)	carbon stored in vegetation	Social cost of carbon (Rs)
2015-16	108.34	168.67	277.01	33.41	5313
2016-17	298.38	4922.77	5221.15	33.41	5777
2017-18	331.17	2921.854	3253.024	34.11	5598
2018-19	137.283	5993.64	6130.698	34.11	5883
2019-20	36.31	17911.83	17947.54	33.41	6054
2020-21	442.27	6364.57	6806.84	31.69	6375

Social Cost of Carbon

The social cost of carbon (SCC) represents the economic cost associated with climate damage that results from the emission of an additional tonne of carbon dioxide (tCO_2). The SSC captures the amount of marginal damage (if negative) expected to occur in an individual country because of additional CO_2 emission (Ricke et al 2018: 895).

$$G_{i,t} = G_{i,t-1}\,(1+n_{i,t} +\delta(T_{i,t})$$

Where is the growth rate coming from the data in which no climate change occurs and δ(Ti,t) is a response function of the temperature increase at year t. ,

They have used both exogenous and endogenous discounting.

For conventional exogenous discounting, two discount rates were used 3% and 5% - and the results under endogenous discounting were calculated using two rates of pure time preferences (ρ=1,2%) and two values of elasticity of marginal utility of consumption (μ=0.5,1.5) for four endogenous discounting parameterizations.

Loss of soil organic carbon

Year	Forest Conversion (A)	Forest Fire (B)	Total (A+B)	Soil organic carbon	Social cost of carbon
2015-16	108.34	168.67	277.01	53.2	5313
2016-17	298.38	4922.77	5221.15	53.2	5777
2017-18	331.17	2921.854	3253.024	77.14	5598
2018-19	137.283	5993.64	6130.698	77.14	5883
2019-20	36.31	17911.83	17947.54	53.2	6054
2020-21	442.27	6364.57	6806.84	53.6	6375

Loss of soil protection function

Vsc = Csr.G ∑ Si .D [here, D=(di - do)

where Vsc indicates the economic value of soil conservation (US$);

Csr denotes the cost per tonne of sediment deletion (US$);

Si stands for the area of the respective type of forest in hectare;

D is erosion reduction in forest land (t ha-1);

G indicates the ratio of the amount of sediments present in rivers or reservoirs to the total soil lost; di designates the rate of erosion of broad-leaved forest (t ha-1)

Loss of soil protection function

Year	Forest Conversion (A)	Forest Fire (B)	Total (A+B)	Economic value of soil production function
2015-16	108.34	168.67	277.01	126019
2016-17	298.38	4922.77	5221.15	126019
2017-18	331.17	2921.854	3253.024	126019
2018-19	137.283	5993.64	6130.698	126019
2019-20	36.31	17911.83	17947.54	126019
2020-21	442.27	6364.57	6806.84	126019

Air quality regulation

Forest purification include the following functions SO_2 and NO_2 the method commonly adopted involves area absorption (Xi, 2009); Ninan Kontoleon (2016); Balasubramanian (2021)

$$V_{aq} \Sigma n\ i=1\ S.Qi.Ci$$

- V Where value of air quality improvements (US$),
- S area of the forest loss (ha);
- Q absorption the pollutant per unit area (kg-1 ha-1);
- C treatment cost of the ith pollutant (US$/kg);
- value of air purification by forest (US$ yr-1

Air quality regulation SO_2

Year	Forest Conversion (A)	Forest Fire (B)	Total (A+B)	Sulfur dioxide annual absorption rate (SO_2)/kg/ha	Quantity of SO_2 (tones)/ha	Abatement cost of SO_2 (Rs)
2015-16	108.34	168.67	277.01	10.8	299	40305
2016-17	298.38	4922.77	5221.15	10.8	563	40305
2017-18	331.17	2921.854	3253.024	10.8	351	40305
2018-19	137.283	5993.64	6130.698	10.8	662	40305
2019-20	36.31	17911.83	17947.54	10.8	1938	40305
2020-21	442.27	6364.57	6806.84	10.8	735	40305

Air quality regulation (NO_2)

Year	Forest Conversion (A)	Forest Fire (B)	Total (A+B)	Nitrogen dioxide annual absorption rate (SO_2)/kg/ha	Quantity of SO2 (tones)/ha	Abatement cost of SO2 (Rs)
2015-16	108.34	168.67	277.01	15.6	432	88580
2016-17	298.38	4922.77	5221.15	15.6	814	88580
2017-18	331.17	2921.854	3253.024	15.6	507	88580
2018-19	137.283	5993.64	6130.698	15.6	956	88580
2019-20	36.31	17911.83	17947.54	15.6	2799	88580
2020-21	442.27	6364.57	6806.84	15.6	1061	88580

Loss of Pollination Services

Year	Forest Conversion (A)	Forest Fire (B)	Total (A+B)	25% of degraded area	Pollination Services (Rs)
2015-16	108.34	168.67	277.01	67.5	23377.42
2016-17	298.38	4922.77	5221.15	1305	23377.42
2017-18	331.17	2921.854	3253.024	812	23377.42
2018-19	137.283	5993.64	6130.698	1532	23377.42
2019-20	36.31	17911.83	17947.54	4485	23377.42
2020-21	442.27	6364.57	6806.84	1700	23377.42

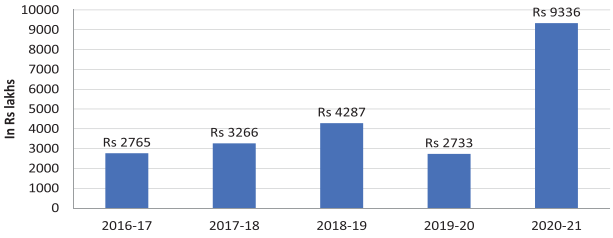
Revenue Loss from NTFPs

Year	Forest Conversion (A)	Forest Fire (B)	Total (A+B)	Production of NTFPs (tonnes)	Value of NTFPs
2015-16	108.34	168.67	277.01	0.2	1671.54
2016-17	298.38	4922.77	5221.15	0.12	1671.54
2017-18	331.17	2921.854	3253.024	4.52	1671.54
2018-19	137.283	5993.64	6130.698	5.72	1671.54
2019-20	36.31	17911.83	17947.54	0.036	1671.54
2020-21	442.27	6364.57	6806.84	2.09	1671.54

NTFPs and Household income loss

Year	Forest Conversion (A)	Forest Fire (B)	Total (A+B)	value of non-timber forest products
2015-16	108.34	168.67	277.01	12000
2016-17	298.38	4922.77	5221.15	12000
2017-18	331.17	2921.854	3253.024	12000
2018-19	137.283	5993.64	6130.698	12000
2019-20	36.31	17911.83	17947.54	12000
2020-21	442.27	6364.57	6806.84	12000

Economic Loss of Timber (in Rs lakhs)



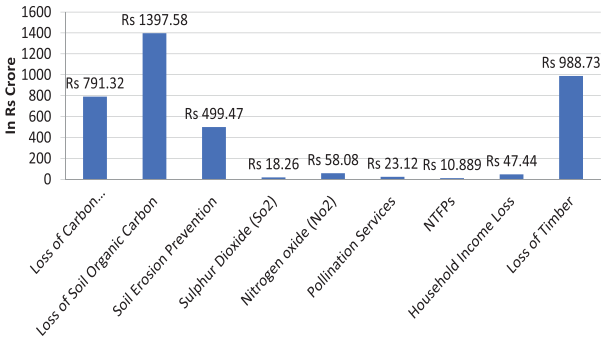
Physical accounts of forests for the years – 2016-17 to 2020-21

Area in (Sq.km)	Volume accounts (Million cum)
Opening Stock (A)	
Depletion/degradation due to economic activities (-) (B)	
Afforestation (+)(C)	
Accumulation due to natural or Artificial regeneration in forest land (+)	
Transfer for non-forest purposes (E)	
Other volume changes (F)	
Changes in stock	
Closing stock (G)	

Ecosystem services supply and use account in monetary terms – use table

Ecosystem Asset Account (Stock and Flow)
Use
Selected Ecosystem Services
Provisioning Services
Timber production
Non-timber forest production
Regulating Services
carbon sequestration
Soil Organic Carbon
Soil Erosion Prevention
Air quality regulation
Sulphur dioxide
Nitrogen dioxide
Pollination Services
Water conservation
Cultural Services
Recreation Services

Economic Loss of Forest Ecosystem Services (In Rs Crore)



Economic Loss of Forest Ecosystem Services in Karnataka (Rs in Crore)

Year	Loss of Carbon Sequestration in vegetation	Loss of Soil Organic Carbon	Soil Erosion Prevention	Sulphur Dioxide (So2)	Nitrogen oxide (No2)	Pollination Services	NTFPs	Household Income Loss	Loss of timber
2015-16	4.9	7.8	3.49	1.2	3.82	0.15	0.009	0.3	4.8
2016-17	100.77	160.46	65.79	2.22	7.21	3.05	0.1	6.26	14.5
2017-18	62.11	140.47	41	1.41	4.49	1.89	2.45	3.9	87.2
2018-19	123.02	278.22	77.25	2.66	8.46	3.58	5.86	7.35	174.51
2019-20	363.01	578.04	226.17	7.81	24.8	10.48	0.1	21.53	522.25
2020-21	137.51	232.59	85.77	2.96	9.3	3.97	2.37	8.1	185.47
Total	791.32	1397.58	499.47	18.26	58.08	23.12	10.889	47.44	988.73

Ecosystem Asset Account (Stock and Flow)

Ecosystem Asset Account (Stock and Flow) (Rs in Lakhs)						
Use/Year	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Selected Ecosystem Services						
Provisioning Services						
Timber production	0.003	2.47	108.15	153.67	0.005	127.64
Non-timber forest production	13	147.86	171.77	192.87	118.03	438.44
Regulating Services						
carbon sequestration	192.3	2378.31	2677.42	42771.39	1989.6	7782.12
Soil Organic Carbon	306.22	3787.08	4263.35	68108.47	3167.9	12400
Soil Erosion Prevention	136.52	1552.79	1803.92	27422.52	1239.52	4604.31
Air quality regulation						
Sulphur dioxide	47.15	53.6	62.06	94.71	42.72	158.8
Nitrogen dioxide	149.7	170	197.53	300.28	135.52	504.9
Pollination Services	0.63	72	117.12	1271.76	230.64	213.52
Cultural Services						
Recreation Services						

Restoration of Forest Ecosystem Services through Eco-Budget

Restoration of Forest Ecosystem Services through Eco-Budget

OECD has introduced green budget is refers *"using the tools of budgetary policy-making to help achieve environmental goals". This includes "evaluating environmental impacts of budgetary and fiscal policies and assessing their coherence towards the delivery of national and international commitments"* (Cremins and Kevany, 2018:6).

Eco-budget is "an estimate the value of forest loss and degradation and the same compensate through the financial allocation for ecological restoration on better environmental outcomes for human well-being".

Eco-budget is the fiscal transfer for loss and degradation of forest ecosystem services to enhancing sustainable forest management and reduce the negative environmental externalities. The health forest and ecosystem services have been significant contribution for sustainable economic growth.

Eco-Budget in Karnataka

The calculated loss of timber provisioning services is estimated at Rs 988.73 crore, carbon sequestration services at Rs 2188.90 crore, soil erosion prevention services at Rs 499.47 crore and pollination services at Rs 23.12 crore, in total during the past five years. The losses to forest ecosystem services are estimated at Rs 3831.28 crore (Balasubramanian, 2022).

An Eco-Budget of Rs. 100 crore will be allocated to compensate the negative effect created on Forest system due to natural and human interventions over past five years (GoK, 2022).

Restoration of Degraded Forest Ecosystem

Rejuvenation of barren hills, restoration of degraded forest areas, Kandla afforestation in coastal areas and afforestation in 3,211 hectare area under shelter belt management and 168 km long afforestation in the water shed area of river Krishna and programme for planting 25 lakh saplings are being implemented.

Eco-compensation

Ecological compensation programme is one of the best tool for the sustainable conservation of forest ecosystem services. Ecological compensation refers to as a fiscal transfer for environmental and natural resource management. This tool balances economic growth and environmental conservation in the same direction.

Nature-smart policies help in reducing the risk of ecological damage. For instance, reforming subsidies, including for water consumption, the harmful impact on biodiversity and ecosystem services needs to be considered at the local decision-making level.

Nature-based solutions are defined as "actions to protect, sustainably manage and restore natural or modified ecosystems to addressing societal challenges, while at the same time ensure human well-being and biodiversity benefits" (Pulgar-Vidal, 2021:4).

The loss of forest ecosystem services should be estimated and integrated into the sub-national accounts for sustainable financial allocation for environmental conservation.

The focus of the eco-budget should be circulated to all line department, particularly the forestry sector, to prepare an annual database on ecosystem services lost due to natural and man-made the district level.

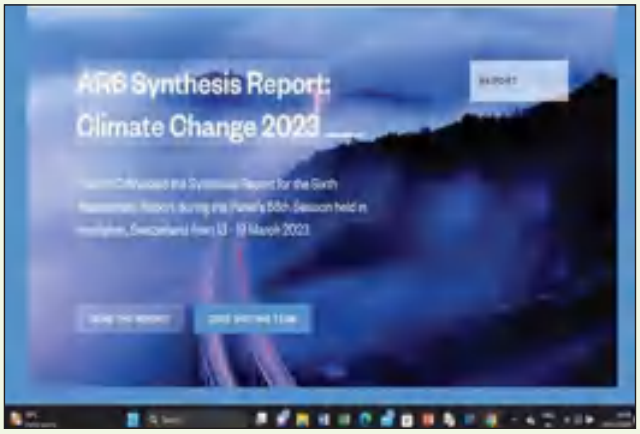
In the valuation of economic losses to forest ecosystems, we should take livelihood losses of forest dependent communities, wildlife loss, for flung aquifer loss, small insects and pollinators losses into account.

Thank you

15. Assessment of carbon stock in India's forests: Mr. Prakash Lakhchaura, Dy. Director General, Forest Survey of India, Dehradun

Assessment of Forest Carbon Stock in India's Forest

Prakash Lakhchaura,
Deputy Director General
Forest Survey of India



A Current Status and Trends

Observed Warming and its Causes

A.1 Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850–1900 in 2011–2020. Global greenhouse gas emissions have continued to increase, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, lifestyles and patterns of consumption and production across regions, between and within countries, and among individuals (high confidence). {2.1, Figure 2.1, Figure 2.2}.

A Current Status and Trends

Current Mitigation Progress, Gaps and Challenges

A.4 Policies and laws addressing mitigation have consistently expanded since AR5. Global GHG emissions in 2030 implied by nationally determined contributions (NDCs) announced by October 2021 make it likely that warming will exceed 1.5°C during the 21st century and make it harder to limit warming below 2°C. There are gaps between projected emissions from implemented policies and those from NDCs and finance flows fall short of the levels needed to meet climate goals across all sectors and regions. (high confidence) {2.2, 2.3, Figure 2.5, Table 2.2}

B Future Climate Change, Risks, and Long-Term Responses

Future Climate Change

B.1 Continued greenhouse gas emissions will lead to increasing global warming, with the best estimate of reaching 1.5°C in the near term in considered scenarios and modelled pathways. Every increment of global warming will intensify multiple and concurrent hazards (high confidence). Deep, rapid, and sustained reductions in greenhouse gas emissions would lead to a discernible slowdown in global warming within around two decades, and also to discernible changes in atmospheric composition within a few years (high confidence). {Cross-Section Boxes 1 and 2, 3.1, 3.3, Table 3.1, Figure 3.1, 4.3} (Figure SPM.2, Box SPM.1)

B Future Climate Change, Risks, and Long-Term Responses

Carbon Budgets and Net Zero Emissions

B.5 Limiting human-caused global warming requires net zero CO2 emissions. Cumulative carbon emissions until the time of reaching net-zero CO2 emissions and the level of greenhouse gas emission reductions this decade largely determine whether warming can be limited to 1.5°C or 2°C (high confidence). Projected CO2 emissions from existing fossil fuel infrastructure without additional abatement would exceed the remaining carbon budget for 1.5°C (50%) (high confidence). {2.3, 3.1, 3.3, Table 3.1}

C Responses in the Near Term

Urgency of Near-Term Integrated Climate Action

C.1 Climate change is a threat to human well-being and planetary health (very high confidence). There is a rapidly closing window of opportunity to secure a livable and sustainable future for all (very high confidence). Climate resilient development integrates adaptation and mitigation to advance sustainable development for all, and is enabled by increased international cooperation including improved access to adequate financial resources, particularly for vulnerable regions, sectors and groups, and inclusive governance and coordinated policies (high confidence). The choices and actions implemented in this decade will have impacts now and for thousands of years (high confidence). {3.1, 3.3, 4.1, 4.2, 4.3, 4.4, 4.7, 4.8, 4.9, Figure 3.1, Figure 3.3, Figure 4.2} (Figure SPM.1; Figure SPM.6)

World's status of carbon stock

- FRA 2020 received information on forest carbon stock in 2020 from 192 countries and territories (representing 99 percent of the world's forests).
- The total forest carbon stock (i.e. including all carbon pools) is estimated at 662 Gt (163 tonnes per ha), comprising 300 Gt in soil organic matter, 295 Gt in living biomass and 68.0 Gt in dead wood and litter.
- Soil organic matter constitutes the biggest pool, with 45.2 percent of the total carbon, followed by above-ground biomass, below-ground biomass, litter and dead wood

World's status of carbon stock

- The global forest carbon stock decreased between 1990 and 2020 , from 668 Gt to 662 Gt due to an overall decrease in forest area.
- There were considerable regional and sub-regional differences in the trend.
- The carbon stock in forest biomass increased significantly in East Asia, Western and Central Asia, Europe and North America (where forest area increased) and decreased considerably in South America and Western and Central Africa.
- Although total forest carbon stocks decreased globally between 1990 and 2020, carbon stock per hectare increased for all pools.

National Statement by Prime Minister Shri Narendra Modi at COP26 Summit in Glasgow

- In the midst of this global brainstorming on climate change, on behalf of India, I would like to present five nectar elements, 'Panchamrit', to deal with this challenge.

First- India will take its non-fossil energy capacity to 500 GW by 2030.

Second- India will meet 50 percent of its energy requirements from renewable energy by 2030.

Third- India will reduce the total projected carbon emissions by one billion tonnes from now till 2030.

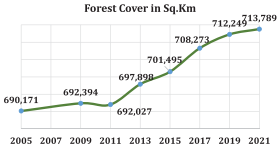
Fourth- By 2030, India will reduce the carbon intensity of its economy by more than 45 percent.

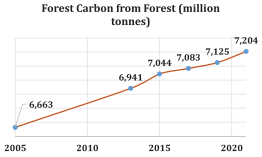
And fifth- by the year 2070, India will achieve the target of Net Zero.

These 'Panchamrits' will be an unprecedented contribution of India to climate action

S.No	ISFR	Forest Cover in Sq.Km
1	2005	6,90,171
2	2009	6,92,394
3	2011	6,92,027
4	2013	6,97,898
5	2015	7,01,495
6	2017	7,08,273
7	2019	7,12,249
8	2021	7,13,789

S.No	ISFR	Forest Carbon from Forest (million tonnes)
1	2005	6,663
2	2013	6,941
3	2015	7,044
4	2017	7,083
5	2019	7,125
6	2021	7,204





FSI role in International commitment of Carbon reporting

International commitments: UN Framework Convention on Climate Change by UNFCCC

- Reporting of Green House Gas inventory of forestry sector to MoEF & CC for reporting to UNFCCC under climate change convention through following communications.
  - NATCOM: National Communication (on an interval of 10 years). 1st NATCOM-1984-94, 2nd NATCOM-1994-2004, 3rd NATCOM: 2004-2014
  - BUR: Biennial Update Reports(on an interval of two years. 1st BUR-2014, 2nd BUR-2016, 3rd BUR-2018
- Information provided by FSI for NATCOM and BUR is
  - Change in the forest area and carbon stock in India's forest.
  - Estimated on the basis of information on forest cover mapping and National Forest Inventory data.
- Out of the five reporting sectors to UNFCCC i.e Energy, Industry, Agriculture, wasteland and LULUCF, forestry falls under LULUCF which offset about 14% of total country's emission. LULUCF is the only sector which is a net sink.
- Forestry sector is a net sink for last two NATCOMs and all the BURs due to good policies of the Govt for better protection of forests and several afforestation programmes in the country.

International commitments: Global Forest Resource Assessment by FAO

- FAO carries out assessment of global forest resource on an interval of 5 years and publish a report on the findings.
- The assessment is done through a country reporting process through a net work of National Correspondents (NCs).
- For India, Forest Survey of India is the nodal agency for reporting of India's information to FAO.
- Most of the reporting tables are derived from the forest cover mapping and National Forest Inventory data of FSI. Some of the information are derived from other sources such as ICFRE, SFDs etc.
- The latest report published by FAO is FRA-2020
- As per FRA 2020, India ranks amongst top 10 countries in terms of Forest Area extent and ranks 3rd in terms of Annual forest gain (2015-20) despite of heavy pressure on our forests.

International commitments: REDD+

- REDD+ is a finance based mechanism with following 5 components:
  1. Reducing emissions from deforestation
  2. Reducing emissions from forest degradation
  3. Conservation of forest carbon stocks
  4. Sustainable management of forest
  5. Enhancement of forest carbon stocks
- For REDD+, FSI has been declared as a MRV (Monitoring, Reporting and Verifications) institution for the country.
- FSI has developed a Forest Reference Level for the country which is a benchmark for assessing REDD+ performance and 1 of the 4 elements required by the UNFCCC for countries participating in REDD+.
- In addition, the second pillar of REDD+ i.e. National Forest Monitoring System has also been developed by FSI.

FSI initiatives in Forest carbon estimation

FSI initiatives in Forest carbon estimation

- FSI has been the major contributor on forest biomass estimation and carbon stock change (during 1984 and 1994) in India's Initial National Communication (INC) submitted to UNFCCC in 2004.
- In INC (also referred as NATCOM -I) process, the FSI estimated forest carbon of only woody growing stock.
- For Second National Communication (SNC) to UNFCCC, FSI conducted 'Greenhouse gas inventory in Forest Land Remaining Forest Land & Land Converted into Forest Land for the period 1994 to 2004' under 'Land Use, Land-Use Change and Forestry (LULUCF)'.

FSI initiatives in Forest carbon estimation

- For SNC, FSI estimated carbon stock for 1994 and 2004 in respect of Forest Land Remaining Forest Land & Land Converted into Forest Land.
- FSI published a separate report on 'Carbon stock in India's Forest' in 2011.
- A separate chapter on 'Carbon stock' was given in ISFR 2011. Since then, the information on total carbon stock and change with respect to previous assessment is a part of successive ISFRs.

Monitoring of Nationally Determined Contributions (NDC) target pertaining to Forest Carbon

- **As per Paris Agreement, the Commitment under NDC of India is** 2.5 – 3.0 billion tonnes of CO_2 equivalent by 2030 as compared to the base year of 2005.
- **FSI monitors the achievement of target of NDC through biennial report of FSI i.e. ISFRs.**
- **ISFR presents the total carbon stock in India's forests and change in the stock as compared to the previous assessment.**
- **As per the latest ISFR 2021, we have already achieved 1.97 billion tonnes of CO_2 eq as compared to the base year.**
- **FSI has carried out different exercises for projection of gain in CO2 eq by 2030 based on:**
  - **The projections of forest and tree cover by 2030,**
  - **Plantation targets of NAEB/GIM by 2030 and**
  - **Plantation targets as given in the Vision documents of MOEF & CC.**
- **All the exercise has indicated that the target of NDC will be well achieved by 2030 provided sustained efforts are made for increasing the forest and tree cover of the country.**

IPCC Methodology for Carbon Stock Assessment

Sectors to Report Green House Gas inventory as per UNFCCC

Five Sectors, namely

- Energy,
- Industry,
- Agriculture,
- Waste, and
- Land Use Land Use Change & Forestry (LULUCF)

Reporting of green house gas inventory for LULUCF

Six categories namely

- **Forest land**,
- Cropland,
- Grassland,
- Wetlands,
- Settlements and
- Other lands

LULUCF has sub-categories

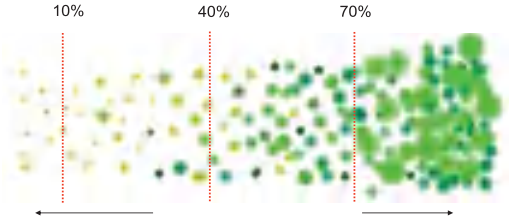
- Forest land remaining Forest land:
  - An increase implies: improvement in stocking
  - A decrease implies: degradation of resources
- Land converted to Forest land:
  generally considered as afforestation

How to define forests: UNFCCC

- **Forest -** Forest is defined structurally on the basis of
  - **Crown cover** percentage: Tree crown cover - 10 to 30 %
  - **Minimum area** of stand : area between 0.05 and 1 ha and
  - **Minimum height** of trees: Potential to reach a minimum height at maturity in situ of 2 to 5 m

Definition of Forest Cover of FSI

- Forest Cover (biennial forest cover mapping by FSI)
  - Minimum land area 1.0 hectare
  - Minimum tree canopy density 10 %
  - Includes all tree species e.g. Bamboo, Palm, coconut,, orchards etc



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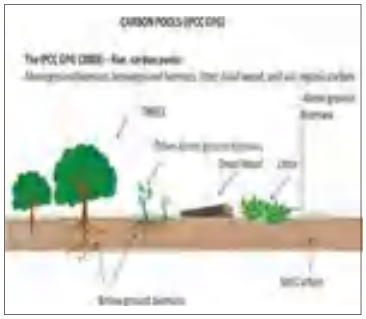
Various Forest Carbon Pools

UNFCCC recognizes following 5 pools

- Living Biomass
  1. Above ground
  2. Below ground
- Dead Organic Matter
  3. Dead wood
  4. Litter & forest floor
- Soils
  5. Soil Organic Carbon



Forest Carbon Pools

Pools		Description
Living Biomass	Above ground biomass	All living biomass above the soil including stem, stump, branches, bark, seeds and foliage.
	Below ground biomass	All living biomass of live roots. Fine roots of less than 2mm diameter (country specific) are often excluded.
Dead Organic Matter	Dead wood	Includes all non living woody biomass not contained in the litter, either standing or lying on the ground. (also includes dead roots and stumps larger than or equal to 10 cm in diameter or country specific (India – 5 cm).
	Litter	Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country (India - 5 cm), lying dead, in various states of decomposition above the mineral or organic soil.
Soil	Soil organic matter	Includes organic carbon in mineral and organic soils (including peat) to a specific depth chosen by the country (India - 30 cm) and applied consistently through the time series.

Basic Input requirement for GHG inventory

GHG inventories require information

- **Activity data** on extent of an emission or removal category
- **Emission factors** GHG per unit of area (removal of CO_2 per ha of added forest area)

Note: carbon stock is measured in metric tons of carbon (generally, t C ha^{-1})

Approaches for activity data

Three different approaches are given in the IPCC GPG

Approache1: Total area of each land-use category but no information on conversions (only net changes)

Approache2: Tracking of conversions between land-use categories (only between 2 points in time)

Approache3: Spatially explicit tracking of land-use conversions over time

Tiers for the emission factors

Tiers 1: IPCC default values

Tiers 2: Country specific data for key factors

Tiers 3: Detailed national inventory for key C stocks, repeated measurement for key stocks through time or modeling

.

Carbon Accounting

Use of the IPCC basic equation:

Emission Estimate = Activity Data x Emission Factors

Activity Data (AD): LULC from Land Monitoring System

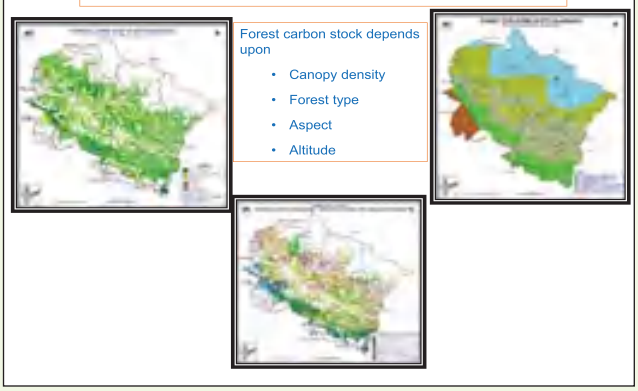
Emission Factors (EF): Forest Inventory

Methodologies for Assessing 'Activity data'

Three different methodologies

- Wall-to-wall mapping using remote sensing data
- Mapping of sampled areas using remote sensing data and
- Using field survey methods

Stratification of Forest area



Forest carbon stock depends upon

- Canopy density
- Forest type
- Aspect
- Altitude

Assessment of Forest Carbon Stock for India

Assessment of Forest Carbon Stock for India

- Forest cover maps,
- Forest types maps,

→ For estimation and stratification of 'Activity data'

- National Forest Inventory,
- Estimation of missing components of forest biomass, and

→ For developing 'Emission factors'

- Integrating the above four components to estimate the forest carbon and change

Forest Cover and change Assessment

INPUTS

- Satellite data of the entire country from National Remote Sensing Centre (NRSC) IRS-Resourcesat-2 LISS III (23.5m spatial resolution)
- SOI Topographic sheets - 1: 50,000

METHODOLOGY

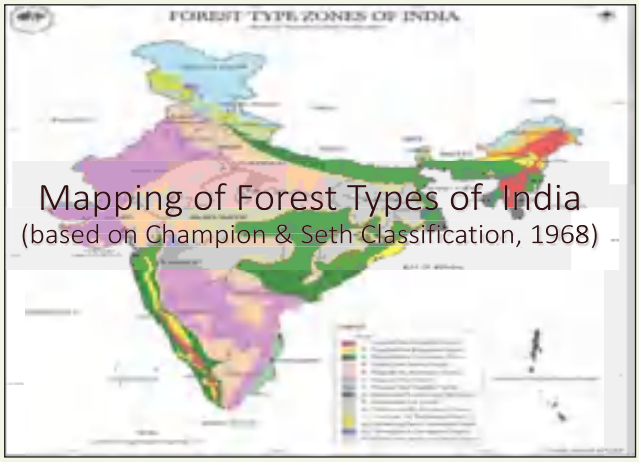
- Digital / visual Interpretation
- Ground Verification
- Minimum mappable area is 1.0 ha

OUTPUTS

Forest cover maps on 1:50,000 scale in digital or hard copy form showing following forest cover classes:

CATEGORY	CANOPY DENSITY
Very Dense Forest	More than 70% canopy
Moderately Dense Forest	40-70%
Open Forest	10-40%
Scrub	Less than 10% in forest lands

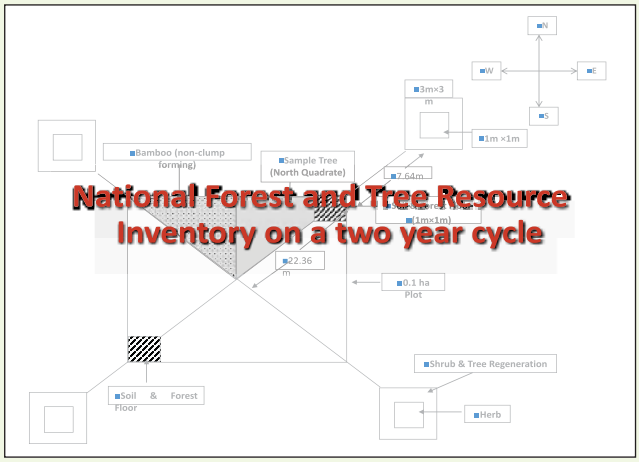
It takes almost two years to complete the assessment process



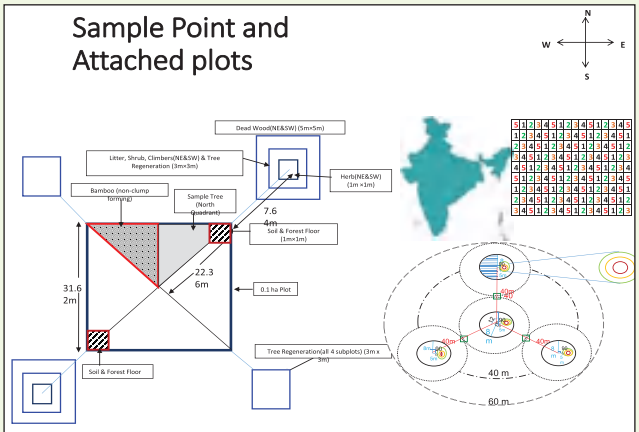
Forest Types of India*

MAJOR GROUPS (climate)	TYPE GROUPS (temp. & moisture)	SUB-GROUPS (location)
1. Moist Tropical Forests	Group 1-Tropical Wet Evergreen Forests Group 2-Tropical Semi-Evergreen Forests Group 3-Tropical Moist Deciduous Forests Group 4-Littoral And Swamp Forests Group 5-Tropical Dry Deciduous Forests Group 6-Tropical thorn Forests Group 7-Tropical Dry Evergreen Forests Group 8-Southern Subtropical Broadleaved Hill Forests Group 9-Subtropical Pine Forests Group 10- Subtropical Dry Evergreen Forests Group 11-Montane Wet Temperate Forests Group 12-Himalayan Moist Temperate Forests Group 13-Himalayan Dry Temperate Forests Group 14-Sub Alpine Forests Group 15-Moist Alpine Scrub Group 16- Dry Alpine Scrub	*Sub-group- 22 Nos.*
2. Dry Tropical Forests		
3. Montane Temperate Forests		
4. Montane Subtropical Forests		TYPES (local edaphic cond.)
5. Sub Alpine Forests		*Types - 200 Nos.*
6. Alpine Scrub		

*As per Champion and Seth classification(1968)



Sample Point and Attached plots



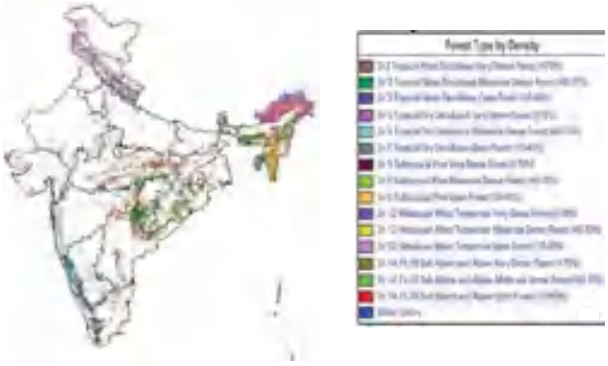
Remaining Components of Forest Biomass

The following biomass components are not generally measured under NFI

- Biomass of stem below 10 cm dia, branches below 5 cm, foliage etc of NFI trees
- Biomass of all tress below 10 cm dbh,
- Biomass of Shrubs, herbs, climbers etc.
- Biomass of dead wood
- Litter (branches only)
- Biomass of tree bark
- Below ground root biomass

Process of Carbon Assessment in India

Strata based on Forest Type & Density Classes



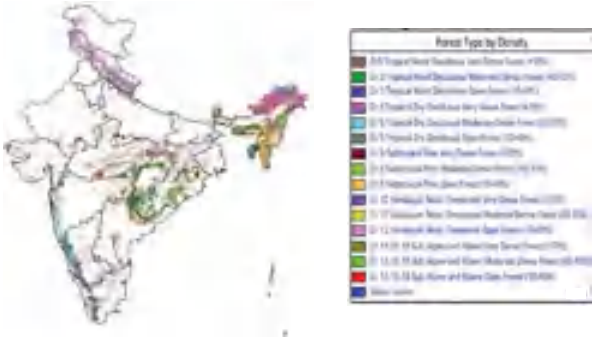
Forest Density Classes

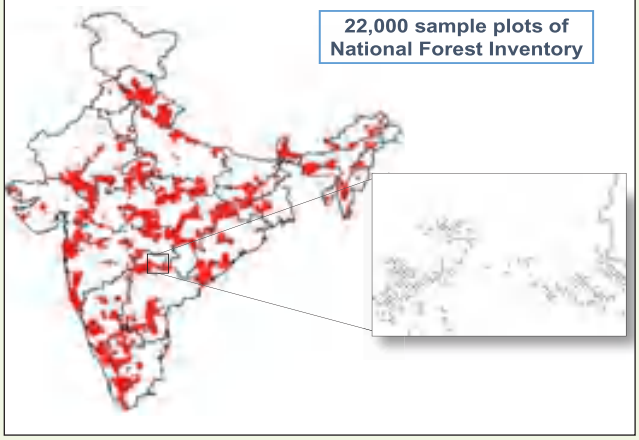
- Very Dense Forest
- Moderately Dense Forest
- Open Forest

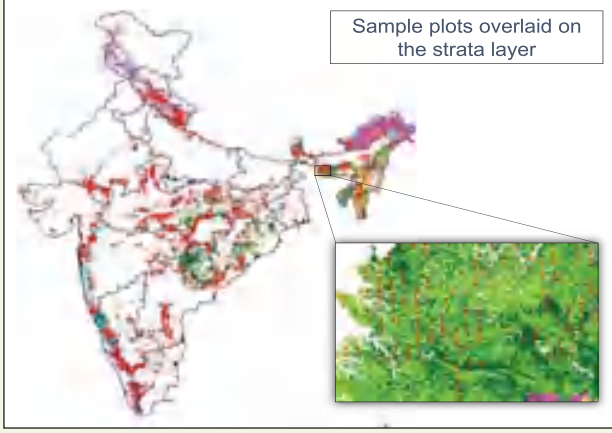
Forest Cover in Different Forest Type Groups

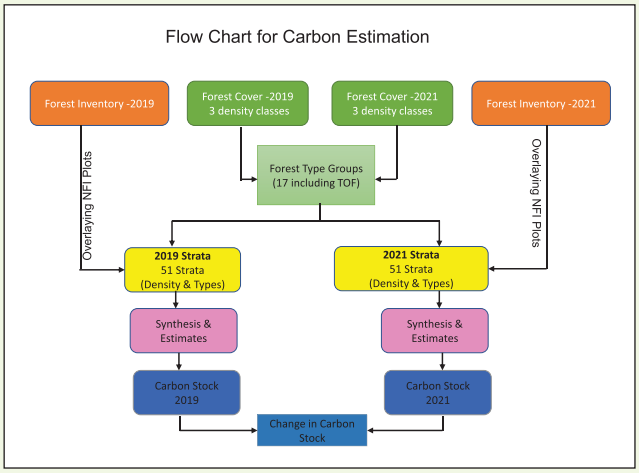
Type Group
Group 1 Tropical Wet Evergreen
Group 2 Tropical Semi-Evergreen
Group 3 Tropical Moist Deciduous
Group 4 Littoral & Swamp
Group 5 Tropical Dry Deciduous
Group 6 Tropical Thorn
Group 7 Tropical Dry Evergreen
Group 8 Subtropical Broadleaved Hill
Group 9 Subtropical Pine
Group 10 Subtropical Dry evergreen
Group 11 Montane Wet Temperate
Group 12 Himalayan Moist Temperate
Group 13 Himalayan Dry Temperate
Group 14 Sub-Alpine Forests
Group 15 Moist Alpine Scrub
Group 16 Dry Alpine Scrub
Sub Total
Plantation/TOF

Strata based on Forest Type & Density Classes









Change in forest carbon stock During 2019 - 2021

Component	Carbon Stock in as per ISFR 2021	Carbon stock in forest as per ISFR 2019	Net change in Carbon stock	Annual increase in Carbon stock
Above Ground Biomass	2319.9	2256.5	63.4	31.7
Below Ground Biomass	718.9	700.8	18.1	9.1
Dead wood	47.7	35.8	11.9	6.0
Litter	107.3	127.9	-20.6	-10.3
Soil Organic Carbon	4010.2	4003.6	6.6	3.3
Total	7204.0	7124.6	79.4	39.7

16. Role of Asia Flux Network on measurement of carbon flux from tropical peatland: Dr. Lulie Melling, Director, Sarawak Tropical Peat Research Institute, Malaysia

Role of AsiaFlux Network on Measurement of Carbon Flux from Tropical Peatland

Lulie Melling, PhD [1, 2]

1. Sarawak Tropical Peat Research Institute, MALAYSIA
2. Member of the AsiaFlux Science Steering Committee

International Workshop on 'Enhancing Ecosystem Services by Improving Forest Quality and Productivity, and SLEM Knowledge Dissemination' 22 to 24 March 2023 at Dehradun, INDIA

Paris Agreement and Carbon Neutrality on a Global Scale

What is AsiaFlux ?

AsiaFlux is a **regional research network** (affiliated to the **global FLUXNET**) of long-term study of **climate change** in relation to carbon, water and energy fluxes in Asia.

Objective:

- To generate scientific **empirical data** and carry out comprehensive analysis to formulate a **Science-Based Land Use Policy** to govern land-use management and biomass production in mitigating climate change, and sustain the economic development and social advancement in Asia.

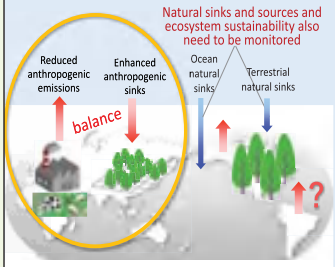
Purposes Of AsiaFlux

- Develop collaborative researches and data sets on the cycles of carbon, water and energy
- Organize workshops and training on current and related global change themes; and
- Cultivate the next generation scientists with skills and perspectives to address global climate change

Current No. AsiaFlux sites : 115 sites as of June, 2022

Paris Agreement and Carbon Neutrality on a Global Scale

Carbon Neutrality:
Achieving a balance between anthropogenic emissions and anthropogenic removals by sinks



Global sinks and sources of GHGs

Possible issues:

(1) Even if energy decarbonization were to be well taken, emission reduction from food production, etc. are limited.

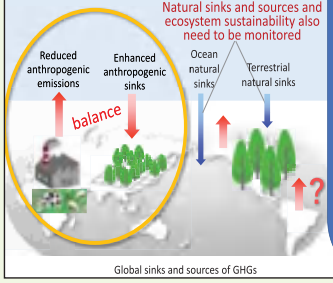
(2) Sinks need to be enhanced, but they compete with biodiversity conservation and food security over land and water.

(3) Natural emissions may increase due to climate change: Forest fires due to drought and heat waves, increased GHG emissions due to thawing of frozen soil, etc.

4

Paris Agreement and Carbon Neutrality on a Global Scale

Carbon Neutrality:
Achieving a balance between anthropogenic emissions and anthropogenic removals by sinks



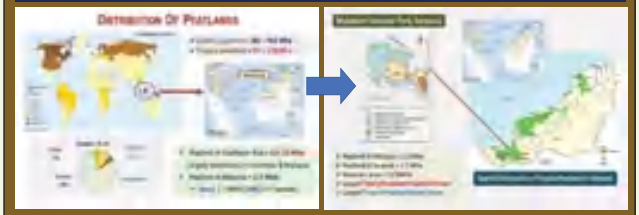
Global sinks and sources of GHGs

AsiaFlux community can contribute to:

- Multi-scale monitoring for GHG budget, biomass (C-stock), and region-specific indicators for biodiversity and ecosystem sustainability
- Detecting unknown natural sinks/sources
- Achieving transparency evaluated by multiple approaches under international collaborations for accomplishing the 'best available science'
- Quick reporting required for the UNFCCC Global Stocktake

5

Tropical Peatland



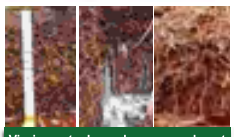
- Global Peatland & Tropical Peatland
- Location : State of **Sarawak**, Malaysia – Part of the Borneo Island
- Focus on the **Maludam National Park** – Totally Protected Peatland Forest

6

Soil Science & Tropical Peat

- Being the last exploited land resource, it is also the **least researched and understood** soil type among tropical soils.
- As compared to Temperate & Boreal Peat, Tropical Peatland Research is a **New Research Frontier**

Tropical Peatland was suffering from a "**Cinderella Syndrome**"was an **unknown** and, therefore, **unloved**



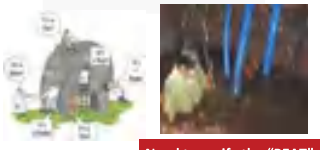
Virgin peat – Less decomposed peat

Non-Virgin Peat - Well-humified peat

6

Tropical Peatland

Please don't imagine the "PEAT"



Need to verify the "PEAT"

- **Don't Judge the Book by its Cover**
  - you never know what's written in a book unless you read it
- **Don't Judge the Soil by its Surface**
  - you never know what's hiding beneath your feet unless you dig the soil pits.

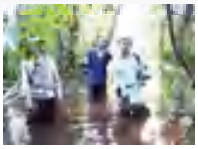
John Rasic 2021

Virgin peat – Less decomposed peat

Non-Virgin Peat - Well-humified peat

Challenges in Tropical Peatland Research

Anguish of walking in soft soil & wet whole day



Crossing the river infested with crocodiles

Fieldwork in harsh work environment;

- Walk on wet, porous, uneven peat surface, tree roots and buttresses
- Wade through flooded part of the forest to go to the study site
- Heat exhaustion (> 40°C) in opened-canopy peatland.

9

Tropical Peat Characteristics

Topo-hydrological Characteristics of peat basin/peat dome

↓

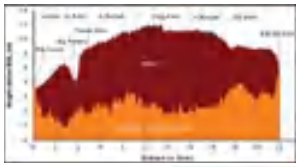
Forest Type

↕

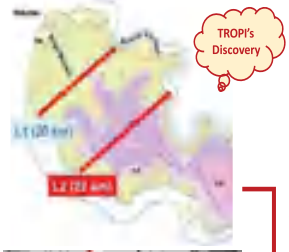
Peat Type

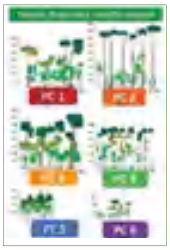
↓

Bio-physical and Chemical Properties of the Peat Soil

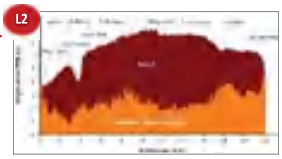


Maludam National Park





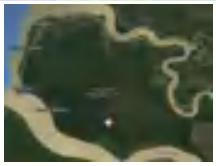
Peat Water Sample from edge of the peat dome



Why Sarawak, Malaysia ?

- In 2010, Sarawak pioneered and commissioned three (3) Eddy Flux tower on **tropical peatland** in the world – Pushing for **15 years data.**
- Currently the **ONLY** eddy flux tower being maintained by a research institute in Malaysia
- **MALUDAM NATIONAL PARK -** most comprehensive and longest systematic documentation of a Tropical Peatswamp Forest in the world
  - Carbon & Meterological Flux
  - Peat Soil Chemistry
  - Watertable
  - Subsidence
  - Tree Inventory & Biomass
- Has the **longest footpath** towards a Tropical Peat Dome for accessibility – **5km**
- **Global Flux Network** including NASA are engaging with Sarawak Tropical Peat Research Institute

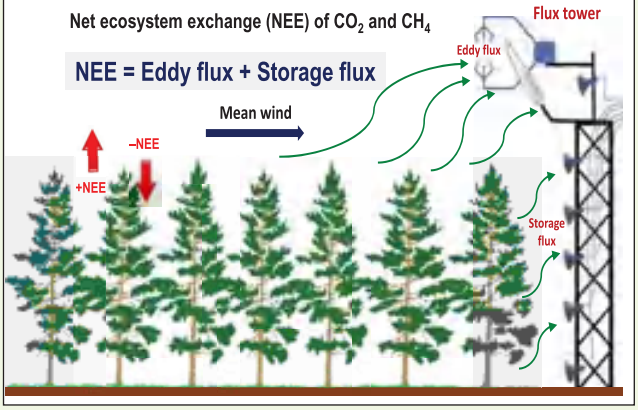
Sarawak Flux Tower



Ecosystem-Scale Carbon Flux

Net ecosystem exchange (NEE) of CO_2 and CH_4

NEE = Eddy flux + Storage flux

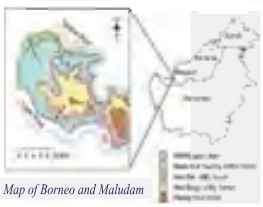


Location Of The Maludam Peat Swamp Forest Eddy Flux Tower

Beauty of Tropical Peat Swamp Forest

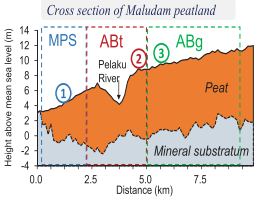
14

Location of Study site: Maludam National Park, Sarawak, Malaysia



Map of Borneo and Maludam

Cross section of Maludam peatland

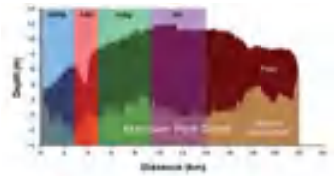


1. Mixed Peat Swamp (MPS) | 2. Alan Batu (ABt) | 3. Alan Bunga (ABg)

Peat thickness: 535 ± 14 cm | 743 ± 11 cm | 883 ± 60 cm

15

Maludam National Park, Sarawak



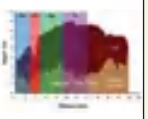
SITE	Mixed Peat Swamp (MPS)	Alan Batu (ABt)	Alan Bunga (ABg)	Padang Alan (PA)
Distance to coast (km)	1.2	4.4	5.9	8.6
Peat depth (cm)	596	837	897	968
Air temperature (°c)	30	30	33	31
Relative humidity (%)	84	80	72	74
Water table (cm)	-12.2	-11.5	-3.2	2.7
Light intensity	1807	636	3891	7439

Different letters (^{a,b,c}) indicate significant difference at p<0.05

Soil Physicochemical Properties - at the three forest types

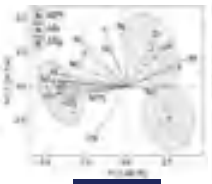
Properties	MPS	ABt	ABg	MPS	ABt	ABg
	0-25 cm			25-50 cm		
BD† (g cm^{-3})	0.14 a*	0.11 b	0.10 c	ND	ND	ND
pH	3.4 a	3.5 a	3.4 a	3.3 b	3.5 a	3.4 a
Ash (%)	1.7 a	1.0 b	0.7 c	1.7 a	1.0 b	0.7 c
Total C (g kg^{-1})	562 a	523 b	514 c	573 a	544 b	528 c
Total N (g kg^{-1})	17 b	18 a	16 c	13 b	16 a	16 a
C/N ratio	34 a	30 b	33 a	45 a	34 b	34 b

†Bulk density. : *Different letters indicate presence of significant differences at $P < 0.05$.

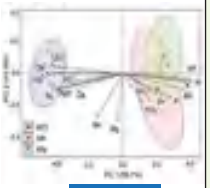


Busman et al. (2022)

- All the soil samples showed typical characteristics of ombrotrophic tropical peat soils.
- Principal component analysis (PCA) illustrated clear clustering of the three forest types in relation to their distinct soil physicochemical properties.

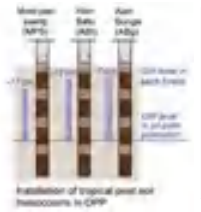


PCA (0 – 25 cm)



PCA (25 - 50 cm)

Carbon Flux Measurements Techniques for TROPI



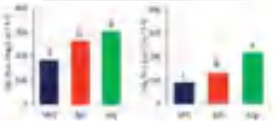
1. Field Incubation

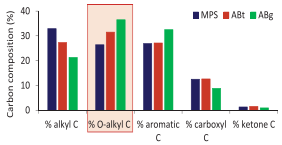
2. Closed Chamber

3. Automated Chamber

4. Eddy-Covariance

1. Field incubation – CO_2 & CH_4 fluxes measurement





Forest TYPE	CO_2 flux (mg C m^{-2} h^{-1})	CH_4 flux (ug C m^{-2} h^{-1})
MPS	181	91
ABt	260	134
ABg	300	218

Larger CO_2 and CH_4 fluxes from ABt and ABg soils are attributable to the composition of **%O-alkyl C (labile C)**

Sangok et al., 2017

Manual Chamber Soil Carbon Flux

Automated Soil Carbon Flux System

Automated Chamber System

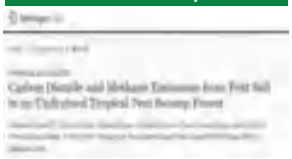
Soil respiration (R_s)

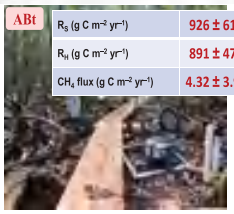
Heterotrophic respiration (R_h)

Automated Gas Sampling System

Soil Carbon Flux in Maludam National Park

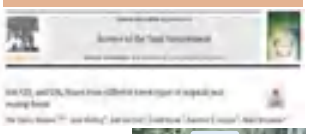
Automated Chamber System



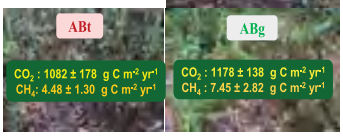


R_S (g C m^{-2} yr^{-1})	926 ± 610
R_H (g C m^{-2} yr^{-1})	891 ± 476
CH_4 flux (g C m^{-2} yr^{-1})	4.32 ± 3.95

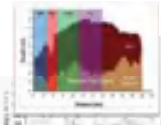
Manual Closed Chamber

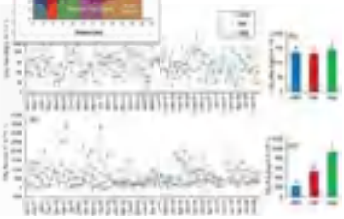


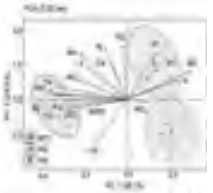
Long-term soil CO_2 and CH_4 fluxes from 2011 to 2018

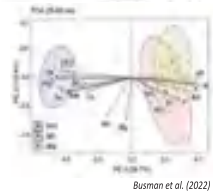


Closed chamber – Long-term CO_2 & CH_4 fluxes measurement









Forest TYPE	CO_2 flux (mg C m^{-1} h^{-2})		CH_4 flux (µg C m^{-1} h^{-2})	
	Dry season	Wet season	Dry season	Wet season
MPS	159.0	120.4	157.1	273.8
ABt	145.2	129.4	534.6	497.5
ABg	149.3	145.1	1004.5	654.2

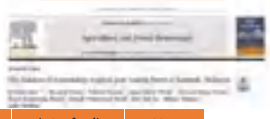
Busman et al. (2022)

Long-Term Monitoring of Ecosystem-Scale Carbon Flux

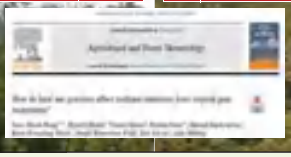
Maludam National Park

CO_2	NEE (g C m^{-2} yr^{-1})	420 ± 194
	RE (g C m^{-2} yr^{-1})	2775 ± 184
	GPP (g C m^{-2} yr^{-1})	2375 ± 380
CH_4	FCH_4 (g C m^{-2} yr^{-1})	8.46 ± 0.51

Cermat Ceria



CO_2	NEE (g C m^{-2} yr^{-1})	-136 ± 51
	RE (g C m^{-2} yr^{-1})	3546 ± 149
	GPP (g C m^{-2} yr^{-1})	3682 ± 149
CH_4	FCH_4 (g C m^{-2} yr^{-1})	4.17 ± 0.69

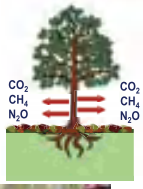


Secondary peat swamp forest

TREE STEM CARBON FLUX

Collaboration with University of Tartu, Estonia

	Height	Sample volume
C	170 cm	25 ml
B	120 cm	25 ml
A	20 cm	25 ml



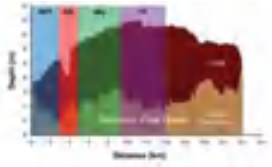

Boring & gas sampling


Stem chamber

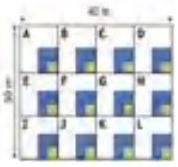

Gas sampling

Experimental Design

Experimental Plot



Plot Layout

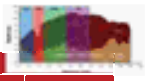


1. **Subplot (Tree)**
All trees with diameter ≥ 5 cm were measured and tagged

2. **Sub area (Sapling)**
All trees with diameter ≥ 1.0 cm to < 5 cm were measured and tagged

3. **Sub area (Seedling)**
All trees diameter less than 1 cm and ≥ 20 cm in height were measured and tagged

FOREST STAND STRUCTURE & FLORISTIC COMPOSITION



No.	Forest Association	DBH (cm)	Canopy Height (m)	Density		Principal Species	
				tree/ha	species/ ha	Scientific Name	Local Name
1.	MPS (Mixed Peat Swamp Forest) (3.1)	5.0 – 59.5	3.0 – 33.3	797	52	1) *Litsea spp* 2) *Nephelium maingayi* 3) *Blumeodendron tokbrai* 4) *Dacryodes sp* 5) *Syzygium sp*	1) Medang 2) Serait 3) Empungan 4) Seladah 5) Ubah
2.	ABt (Alan Batu Forest) (3.6)	5.0 – 54.9	2.1 – 39.5	1170	51	1) *Shorea albida* 2) *Dillenia pulchella* 3) *Ilex spp.* 4) *Litsea spp.* 5) *Syzygium spp.*	1) Alan 2) Simpoh 3) Kerdam 4) Medang 5) Ubah
3.	ABg (Alan Bunga Forest) (3.7)	5.0 – 80.9	3.1 – 24.5	1635	21	1) Shorea albida 2) Combretocarpus rotundatus. 3) Dactylocladus stenostachys 4) Syzygium spp. 5) *Xylopia corilfolia*	1) Alan 2) Keruntum 3) Jongkong 4) Ubah 5) *Ako*
4.	PA (Pdang Alan Forest) (3.8)	5.0 – 87.2	3.7 – 22.5	991	16	1) Shorea albida 2) Combretocarpus rotundatus. 3) Dactylocladus stenostachys 4) *Syzygium sp* 5) Xylopia corilfolia	1) Alan 2) Keruntum 3) Jongkong 4) Ubah 5) *Selunsur*

FOREST STAND STRUCTURE

No	Forest association	DBH (cm)	CANOPY Height (m)	DENSITY	
				Tree /ha	Species /ha
1.	MPS Mixed Peat Swamp	5 – 60	3 – 33	797	52
2.	ABt Alan Batu Forest	10 – 55	2 – 40	1170	51
3.	ABg Alan Bunga Forest	10 – 81	3 – 25	1635	21
4.	PA Padang Alan Forest	10 – 87	4 – 23	991	16

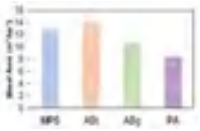


Fig. Basal area of forest type

MB > MA > MC > MD

Site	Basal Area (m^2 ha^{-1})
MPS	12.8
ABt	14.0
ABg	10.6
PA	8.4

Larger size of trees were found mostly in MA and MB which resulted in higher basal area

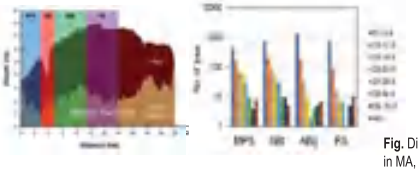
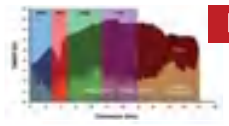
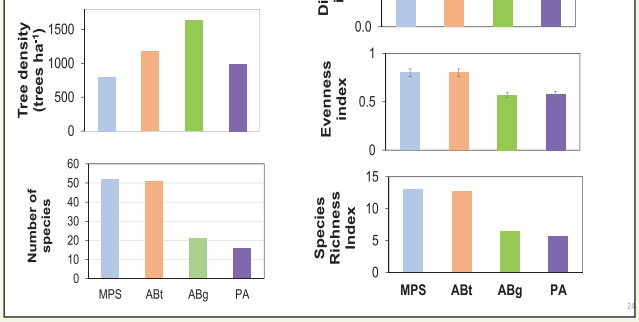


Fig. Distribution of tree DBH in MA, MB, MC, MD

FLORISTIC COMPOSITION & Indexes





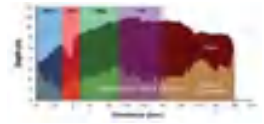
FLORISTIC COMPOSITION - Dominance species and common species

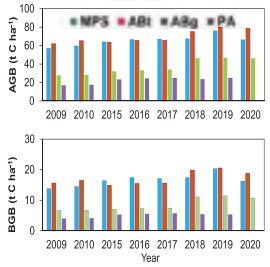
No	Forest association	Dominance species	
		Scientific name	Local name
1.	MPS (Mixed Peat Swamp Forest) (3.1)	1) *Litsea spp* 2) *Nephelium maingayi* 3) *Blumeodendron tokbrai* 4) *Dacryodes sp* 5) *Syzygium sp*	1) Medang 2) Serait 3) Empungan 4) Seladah 5) Ubah
2.	ABt (Alan Batu Forest) (3.6)	1) *Shorea albida* 2) *Dillenia pulchella* 3) *Ilex spp.* 4) *Litsea spp.* 5) *Syzygium spp.*	1) Alan 2) Simpoh 3) Kerdam 4) Medang 5) Ubah
3.	ABg (Alan Bunga Forest) (3.7)	1) Shorea albida 2) Combretocarpus rotundatus. 3) Dactylocladus stenostachys 4) Syzygium spp. 5) *Xylopia corilfolia*	1) Alan 2) Keruntum 3) Jongkong 4) Ubah 5) *Ako*
4.	PA (Pdang Alan Forest) (3.8)	1) Shorea albida 2) Combretocarpus rotundatus. 3) Dactylocladus stenostachys 4) *Syzygium sp* 5) Xylopia corilfolia	1) Alan 2) Keruntum 3) Jongkong 4) Ubah 5) *Selunsur*

- Most recorded species have been categorized as pioneer species especially in MPS.
- There were **six (6) species** commonly found in all phasic communities.

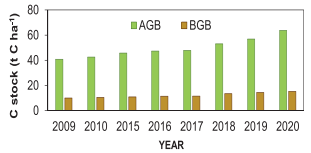
No	Scientific Name	Local Name
1.	*Cyathocalyx biovulatus*	Pendok
2.	*Elaeocarpus marginatus*	Emperdu
3.	*Gonystylus bancanus*	Ramin
4.	*Nephelium maingayi*	Serait
5.	*Vatica mangachapo**	Resak
6.	*Xylopia corilfolia*	Ako

FOREST CARBON STOCK





AGB – above-ground biomass (stems, branches, twigs)
BGB – below-ground biomass (live roots)



FOREST TYPE	AGB	BGB	AGB	BGB	C stock
	t ha⁻¹		t C ha⁻¹		
MPS	139.3	35.4	65.5	16.6	82.1
ABt	147.6	36.4	69.4	17.1	86.5
ABg	78.2	18.2	36.7	8.5	45.3
PA	46.9	10.6	22.0	5.0	27.0
Mean	103.0	25.2	48.4	11.8	60.2

Conversion Factor : 0.47 (IPCC, 2006)

Challenges of Carbon Flux Measurements in Tropical Peatland

Environment
- Constantly high-water table on the ground
- Hot and humid climates degrade some equipment easily
- Frequent rainfall deters sampling task
- Carbon fluxes can vary significantly over time and space, and it is difficult to obtain representative measurements

Accessibility
- Uneven and flooded terrain limit logistics
- Isolated site requires endurance
- Off- grids electrical equipment is needed for camping
- Poor network coverage restrains online task

Manpower
- Require highly skilled manpower to calibrate the flux sensors and analyzers; also to do the data processing
- Complex data processing and interpretation to obtain reliable results

Funding
- To convince policy makers on the Ineed for long term study for the maintenance of the data

Establishment Of Sarawak Tropical Peat Research Institute (TROPI)
– Research Information Management Systems (RIMS)

AsiaFlux Conference 2022

Flux Training Course (Capacity-building)

Ice-Breaking

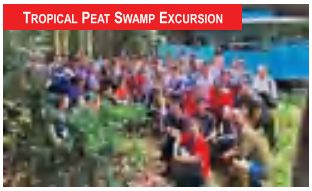
Young Scientist Meeting

Gala Dinner

AsiaFlux Conference 2022

Scientific Session
More than 250 delegates from 23 countries

Tropical Peat Swamp Excursion

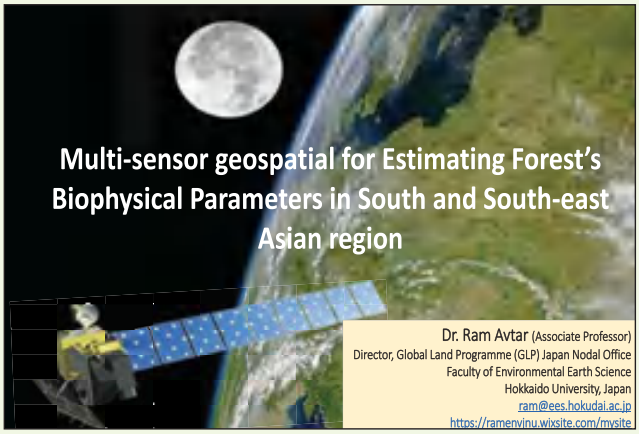


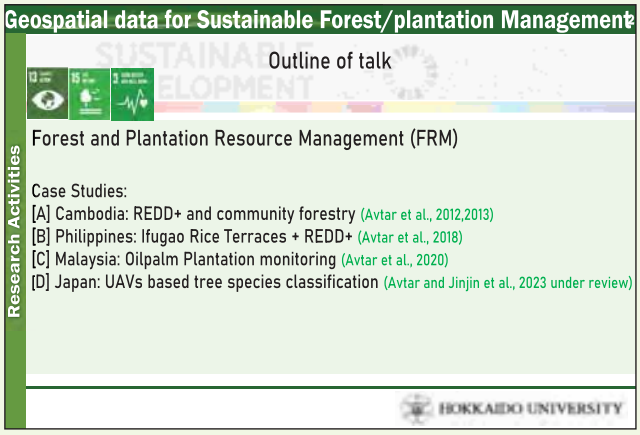
SUMMARY

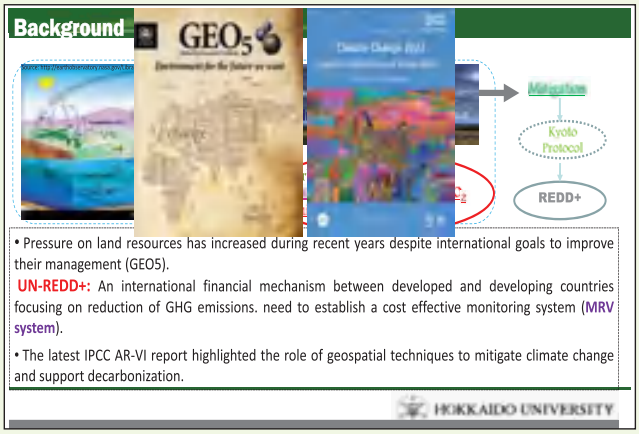
To promote climate change mitigation and adaptation in the AFOLU (Agriculture, Forestry, and Other Land Use) sector and to ensure carbon neutrality and climate stability:

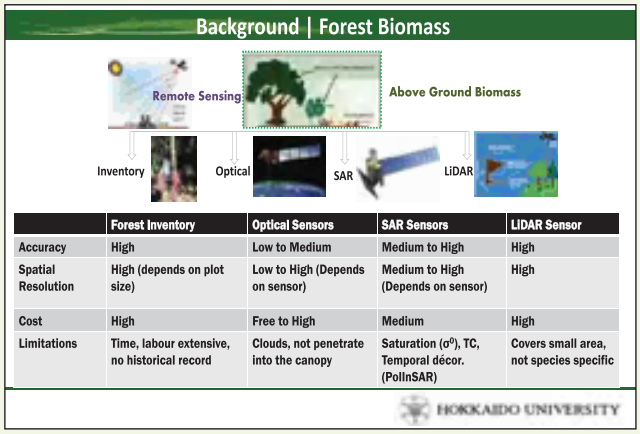
1. AsiaFlux network and the datasets can contribute to multi-scale monitoring for GHG budget, biomass (C-stock), and region-specific indicators for biodiversity and ecosystem sustainability to assess conflicts and co-benefits among climate change actions.
2. GHG budgets are evaluated by multiple approaches using top-down and bottom-up approaches to achieve 'best available science' and increase transparency.
3. Quick reporting is required to contribute to the UNFCCC Global Stocktake.
4. Further data accumulation and model improvement with international collaborations are needed to confirm reliability.

17. Role of geospatial data in carbon monitoring in Cambodia, Malaysia, Philippines and India: Dr. Ram Avtar, Associate Professor, Hokkaido University, Japan

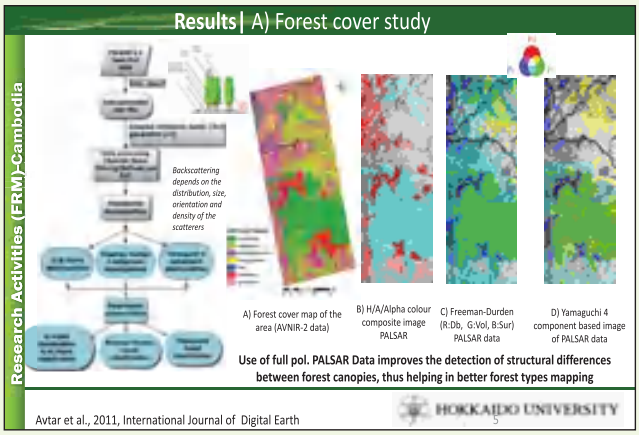


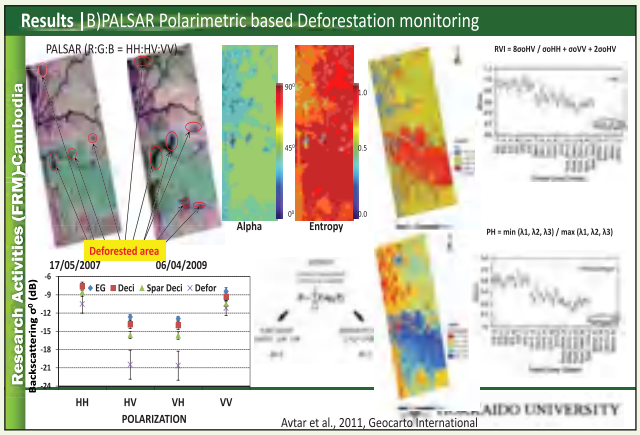


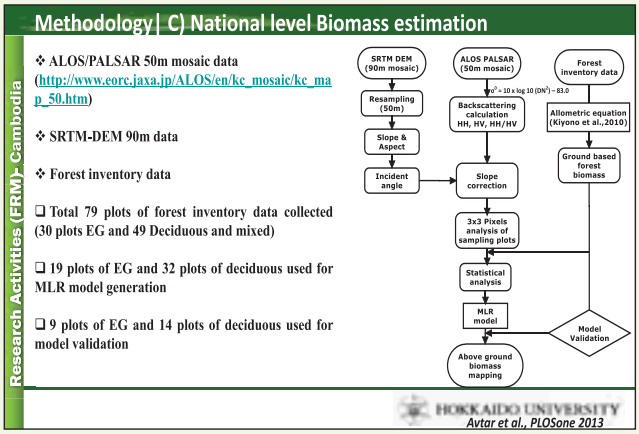


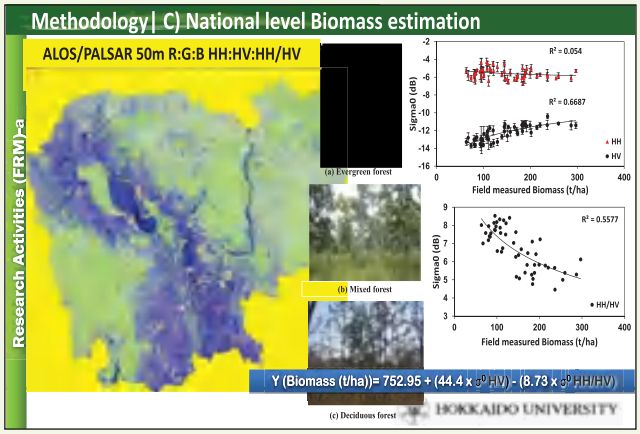


	Forest Inventory	Optical Sensors	SAR Sensors	LiDAR Sensor
Accuracy	High	Low to Medium	Medium to High	High
Spatial Resolution	High (depends on plot size)	Low to High (Depends on sensor)	Medium to High (Depends on sensor)	High
Cost	High	Free to High	Medium	High
Limitations	Time, labour extensive, no historical record	Clouds, not penetrate into the canopy	Saturation (σ^0), TC, Temporal décor. (PolInSAR)	Covers small area, not species specific



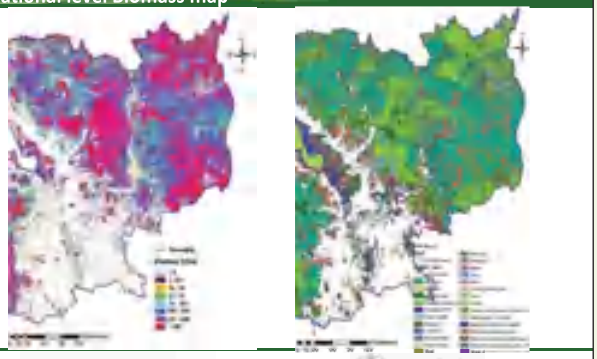






National level Biomass map

Research Activities (FRM)- Cambodia

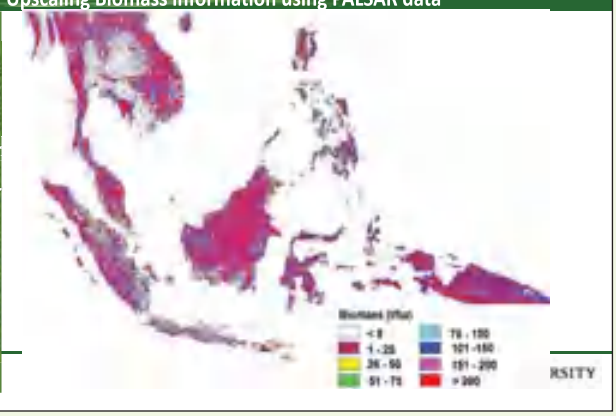


Biomass map of Cambodia

LULC map of Cambodia

Upscaling Biomass information using PALSAR data

Research Activities (FRM)- Cambodia



Spatial Modeling and Scenario Analysis: Cambodia 11

Research Activities (FRM)- Cambodia

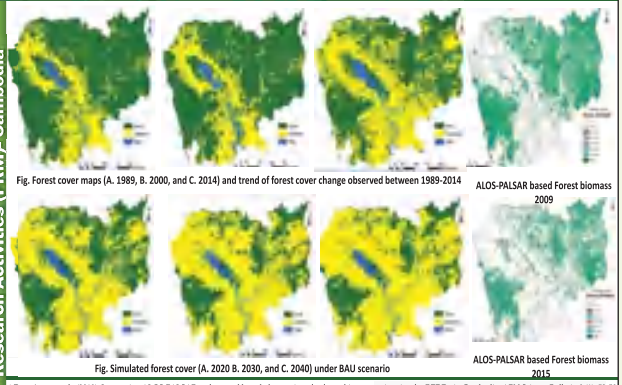


Fig. Forest cover maps (A. 1989, B. 2000, and C. 2014) and trend of forest cover change observed between 1989-2014

ALOS-PALSAR based Forest biomass 2009

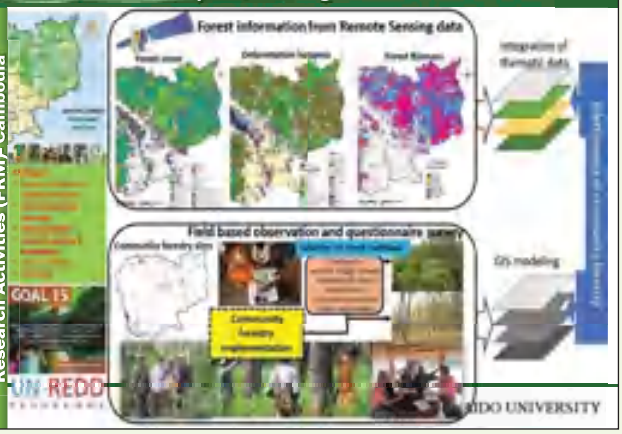
Fig. Simulated forest cover (A. 2020 B. 2030, and C. 2040) under BAU scenario

ALOS-PALSAR based Forest biomass 2015

1.**Ram Avtar**, et al., (2018). Integrating ALOS-PALSAR and ground based observations for forest biomass estimation for REDD+ in Cambodia. APN Science Bulletin 8 (1), 52-58
2.**Ram Avtar**, et al., (2020), Spatial modeling and BAU scenario analysis of Cambodia forest. Scenarios and Models for Ecosystem Assessments and Policy Theory and Applications by Edward Elgar publishing.

Sustainable Community Forest Management for SDGs 13 & 15 12

Research Activities (FRM)- Cambodia

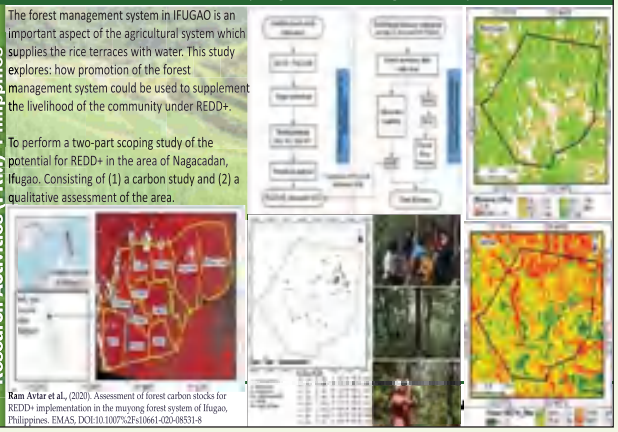


Assessment of Carbon Stock: Muyong Forest Management System, IFUGAO 13

Research Activities (FRM)- Philippines

The forest management system in IFUGAO is an important aspect of the agricultural system which supplies the rice terraces with water. This study explores: how promotion of the forest management system could be used to supplement the livelihood of the community under REDD+.

To perform a two-part scoping study of the potential for REDD+ in the area of Nagacadan, Ifugao. Consisting of (1) a carbon study and (2) a qualitative assessment of the area.

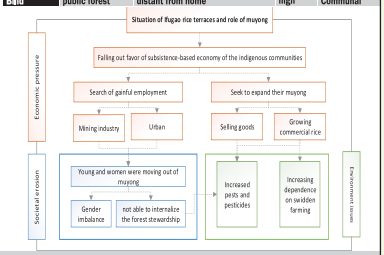


Ram Avtar et al., (2020). Assessment of forest carbon stocks for REDD+ implementation in the muyong forest system of Ifugao, Philippines. EMAS, DOI:10.1007%2Fs10661-020-08531-8

REDD+ Implementation in Community-based Muyong Forest Management 14

Research Activities (FRM)- Philippines

Local Name	Description	Location	Slope	Management
Payoh	rice field	below muyong	none	Private
Boble	settlement	in-between payoh and muyong	none	Private
muyong	private woodlot	above terraces, adjacent to home	high	Private
Habel	agricultural land	distant from home	high	Private
Bild	public forest	distant from home	high	Communal



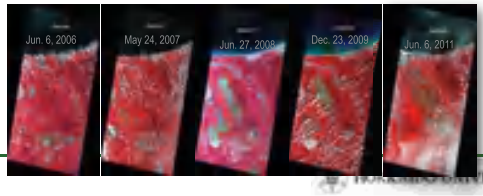
Ram Avtar; et al. (2019). REDD+ Implementation in Community-Based Muyong Forest Management in Ifugao, Philippines. Land, 8 (11), 164;

- The implementation of REDD+ in muyong system will be a win-win action for the local community because both share the objective of managing the forest sustainably.
- Good forest governance and strong stakeholders' collaboration is needed for the success of REDD+ intervention.

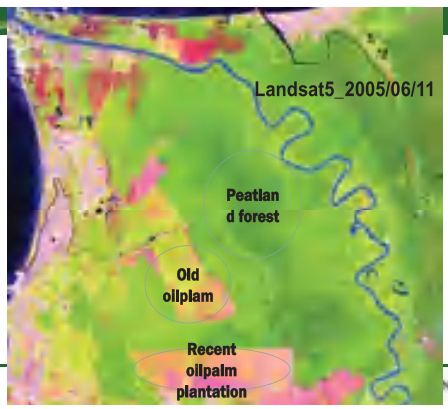
Oilpalm plantation expansion

Research Activities (FRM)- Malaysia

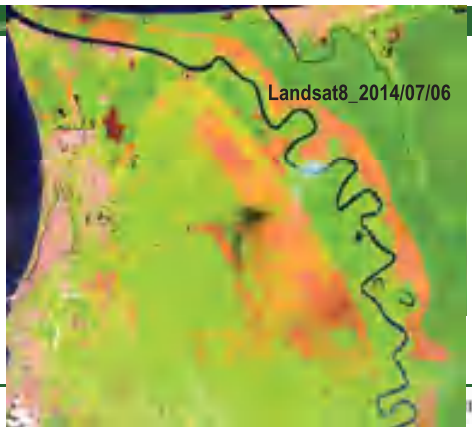
Expanding plantation areas around Miri, Sarawak revealed by time series images of Landsat



Research Activities (FRM)- Malaysia



Research Activities (FRM)- Malaysia

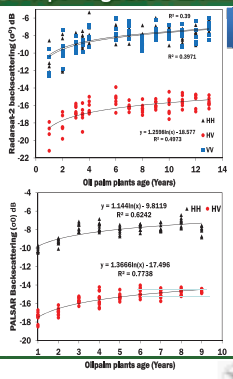


Relationship between Oilpalm age and SAR backscattering

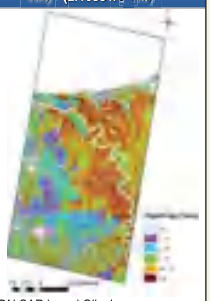
18

Research Activities (FRM)- Malaysia

crown size and age of oilpalm



Y (Age(Years)= 37.6934 - (0.129 x σ⁰ HH) + (2.1688 x σ⁰ HV)

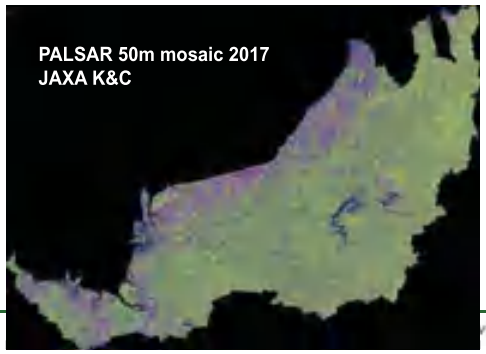


PALSAR based Oilpalm age map

HOKKAIDO UNIVERSITY

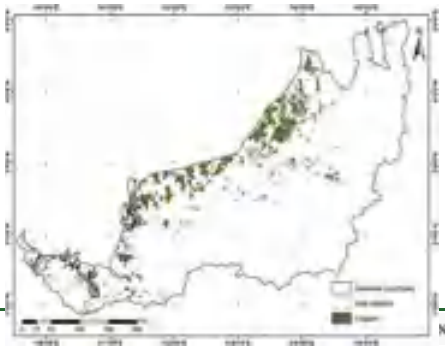
PALSAR multi-temporal mosaic data

Research Activities (FRM)- Malaysia



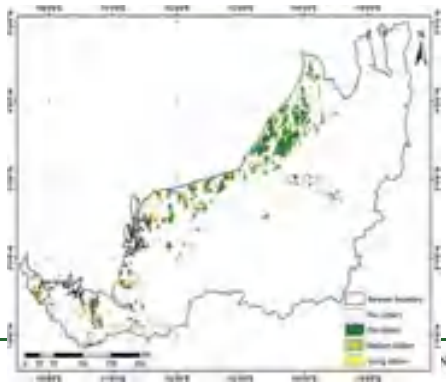
Oilpalm plantation map based on PALSAR

Research Activities (FRM)- Malaysia



Oilpalm growth stages map based on PALSAR

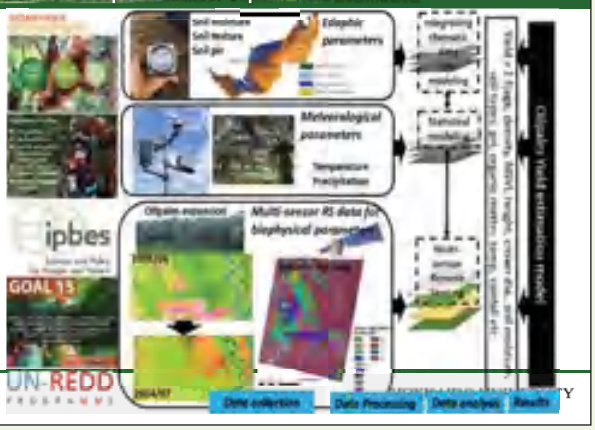
Research Activities (FRM)- Malaysia



Multi-sensor Geospatial data for Oilpalm Yield Estimation

22

Research Activities (FRM)- Malaysia

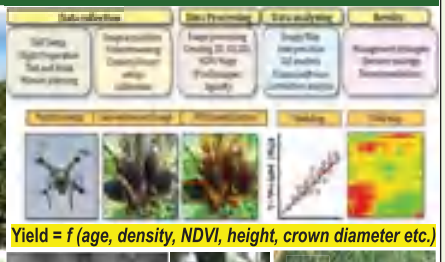


UAV and Oilpalm yield estimation

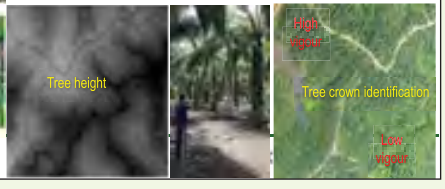
23

Research Activities (FRM)- Malaysia

Field photographs of Oil palm Malaysia



Yield = *f (age, density, NDVI, height, crown diameter etc.)*



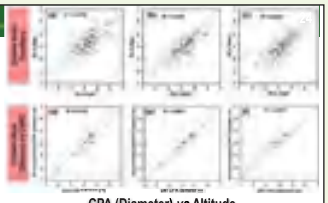
UAV based oilpalm monitoring

Research Activities (FRM)- Malaysia

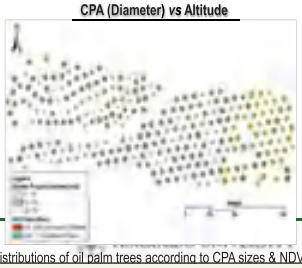
3D view of (a) DSM subtracted using (b) DEM to produce (c) CHM.

Illustration of height, crown area, and CPA.

Ram Avtar* et al., (2020) Assessing the Influence of UAV Altitude on Extracted Biophysical Parameters of Young Oil Palm. Remote Sensing, 12(18), 3030;



CPA (Diameter) vs Altitude



Distributions of oil palm trees according to CPA sizes & NDVI

Tree species classification based on multi-source geospatial data

Research Activities (FRM)- Japan

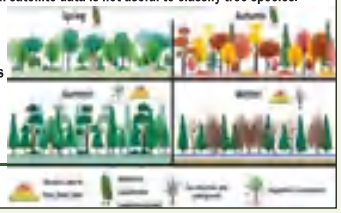
UAV for forest mapping

- Timely and accurate classification of tree species can help people better understand, manage, and protect forests. Therefore, effective and efficient techniques for classifying tree species are highly demanded (Liu, J et al., 2019).
- There have been various studies using remote sensing satellite data to monitor forest cover and forest cover changes (Avtar et al., 2012).

However, these medium/coarse resolution satellite data is not useful to classify tree species.

UAVs technology have received more attention from the scientific communities (Otero et al., 2018)
(a) capture high-resolution data
(b) acquire data within a short time
(c) low operational costs

Provide leaf level information.



Extraction of forests biophysical parameters using UAV data

Research Activities (FRM)- Japan

Multispectral Data Collection

1. **DJI Inspire2 & DJI Phantom4 RTK** (Sensor mounting platform)
2. **DJI Multispectral sensor & Micascence Multispectral sensor** (RGB, Red edge ,Near infrared, etc.)
3. **DJI d-RTK2 station** (High precision positioning)

DJI Inspire2 UAV with mica-sense blue and red-edge camera

DJI Phantom multispectral RTK

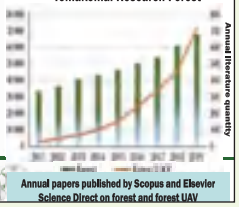
Tomakomai Research Forest

LIDAR Data Collection

1. **DJI M300RTK** (Sensor mounting platform)
2. **DJI L1 LiDAR sensor** (Raw LiDAR & RGB data acquisition and storage)
3. **DJI d-RTK2 station** (High precision positioning)

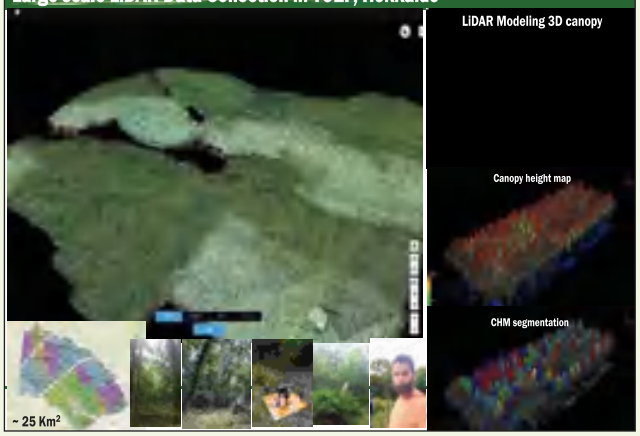
DJI M300RTK UAV

DJI Zenmuse L1



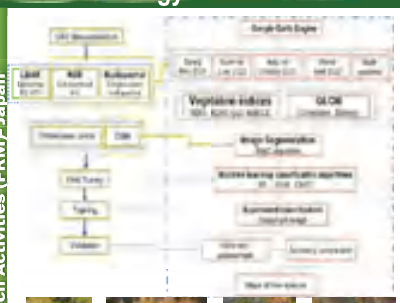
Annual papers published by Scopus and Elsevier Science Direct on forest and forest UAV

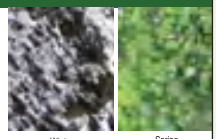
Large scale LIDAR Data Collection in TOEF, Hokkaido



Methodology

Research Activities (FRM)- Japan



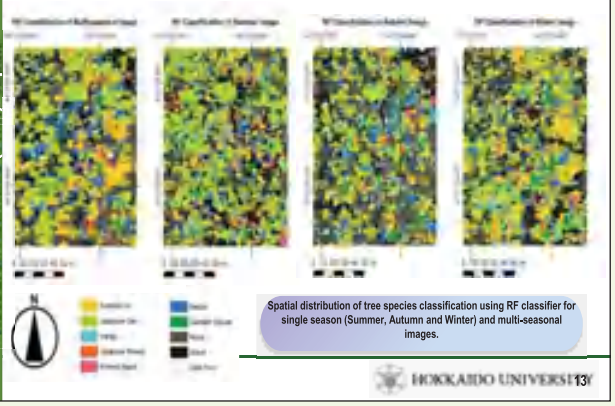


The examples showing the canopies in different season

The examples showing the canopies of five target tree species and snag obtained from the UAV multispectral images

Tree species classification in different seasons

Research Activities (FRM)- Japan

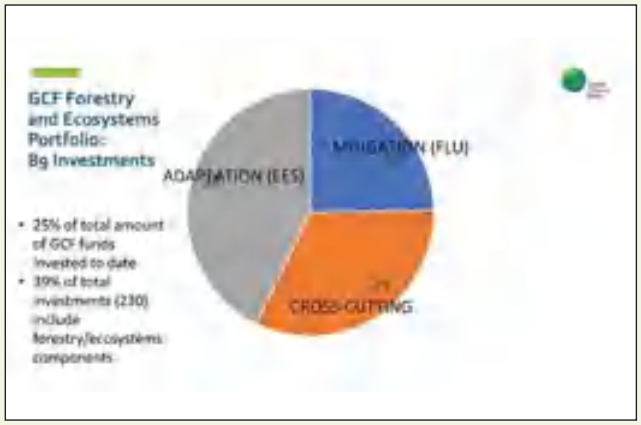


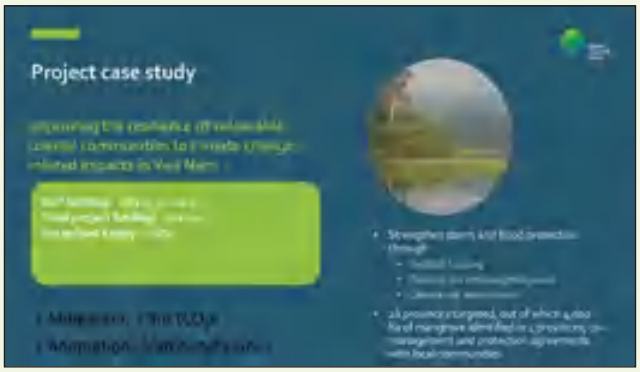
Spatial distribution of tree species classification using RF classifier for single season (Summer, Autumn and Winter) and multi-seasonal images.

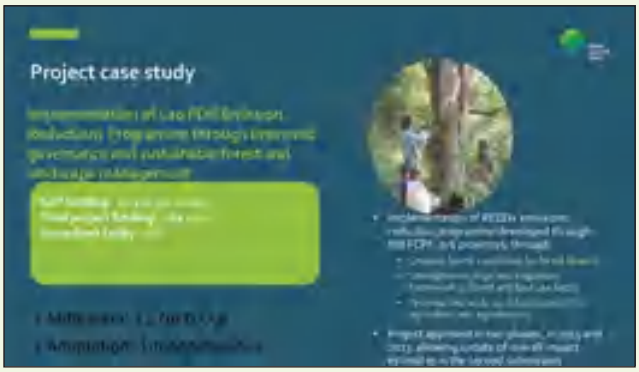
Summary

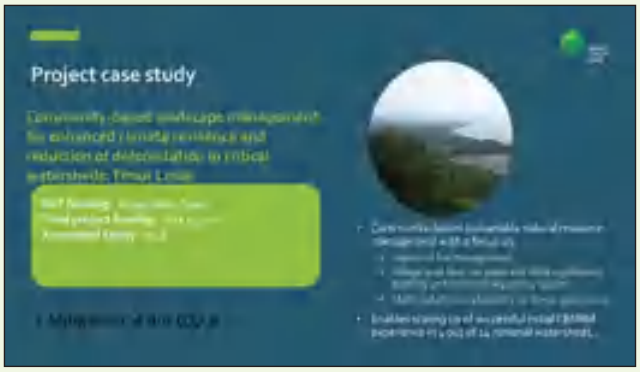
- ✓ Geospatial techniques are robust in mapping and monitoring forest's biophysical parameters estimation
- ✓ Mapping of biophysical parameters are important to evaluate the status and qualities of forest & plantations for sustainable management.
- ✓ The latest IPCC AR-VI highlighted the role of geospatial technologies to mitigate climate change and to achieve several SDGs to support decarbonization.
- ✓ Integrated use of multi-sensor geospatial data is a cost-effective option in forestry and plantation management because of effective estimation of biophysical parameters potentially allowing advancements in precision forestry.

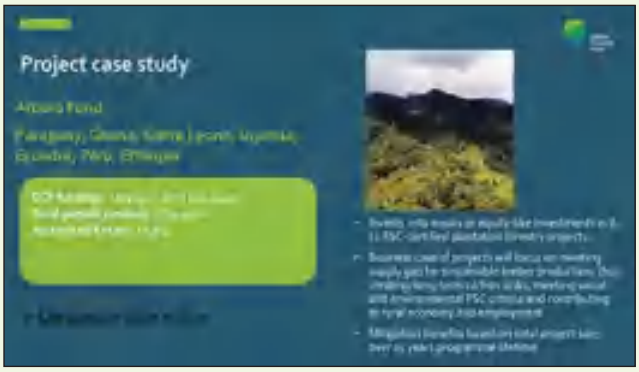
18. Forestry, land use and ecosystem services under the Green Climate Fund: Mr. Ben Vickers, Land Use, Forests and Ecosystems Senior Specialist, Green Climate Fund, Songdo, Incheon City, Republic of Korea (Online)




Project case study

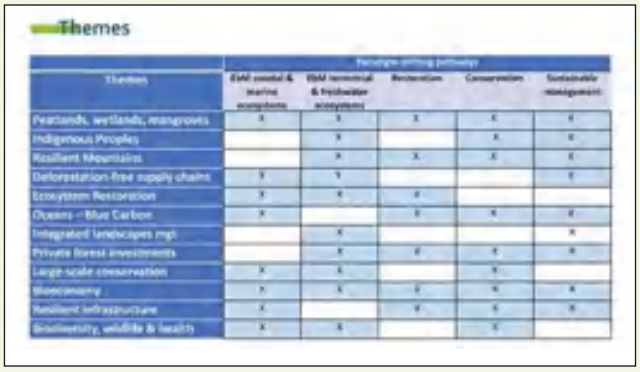

Project case study


Project case study


Project case study


Sector Guides:
EES
FLU
Ecosystems & ecosystem services
Forests & land use


Solutions and opportunities
FLU-EES
Scientific Priorities
Political Priorities


Themes


Deforestation-free supply chains
A pronged approach
Existing initiatives
Instruments
Partners


GREEN
CLIMATE
FUND

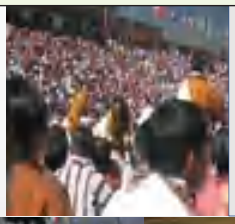
19. Bhutan's initiative on forest carbon assessment: Mr. Dawa Zangpo, Deputy Chief Forestry Officer, Department of Forests and Parks Services, Ministry of Energy and Natural Resources, Bhutan

Bhutan's Initiative on Forest Carbon Assessment

Dawa Zangpo
Deputy CFO, Forest Monitoring and Information Division
Department of Forests and Park Services, Ministry of Energy and Natural Resources
BHUTAN
dawazangpo2@moenr.gov.bt

Outline

- General information about Bhutan
- Forest policies, facts and management
- Need for forest carbon assessment
- National Forest Inventory
  - NFI sampling and plot design
  - Data collection and analysis
  - Results (growing stock, biomass and forest carbon stock)
- Bhutan's FRL and FREL
- Way Forward

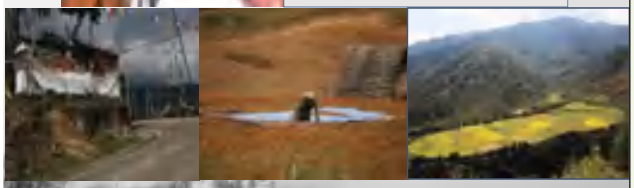


Country area: 38394 sq.km

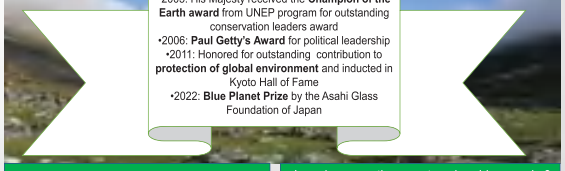
Population(2022): Approximately 760,000

Religion: Dominantly Buddhist , some Hindu and Christians

Economy: 70 % of the population agrarian. Hydropower and tourism is the major revenue generator



Forest Policies, Facts and Management



- 2005: His Majesty received the **Champion of the Earth award** from UNEP program for outstanding conservation leaders award
- 2006: **Paul Getty's Award** for political leadership
- 2011: Honored for outstanding contribution to **protection of global environment** and inducted in Kyoto Hall of Fame
- 2022: **Blue Planet Prize** by the Asahi Glass Foundation of Japan

- Constitutional Mandate of 60 percent forest cover for all times to come.
- Environment Conservation-one of the four pillars of **GNH**
- Commitment to remain **carbon neutral** In 2009, COP15, 1st NDC, 2015
- Is carbon negative country, absorbing nearly 3 times more CO_2 than what being emitted to atmosphere annually
- More than 70 percent of country under forest cover
- 51% of land under protected area
- Only about 6 % of **forest managed for timber**

Forest Management Regimes

71% of land under forest cover

5% of forest under production management (21 FMUs)

51% of land under Protected Area (5 NP, 4 WS, 1 SNR, 1 RBP, 8 BCs)

3% of forest under community forest (843 CFs)

Local forest management areas (78) 8 %

Why Forest Carbon Assessment?

- Commitment to remain **carbon neutral**
- Forest as a **nature based solution** to combat impacts of climate change
- REDD+ and opportunities for **climate financing**
- **International reporting** requirements (UNFCCC, UNCCD)

What was available/status?

- **Initial National Communication (INC)** to UNFCCC (2000)
  - Used the **IPCC default factors** to estimate the GHG emissions
  - Removal (sequestration) higher than emission
- Carbon neutral commitment at COP 15, 2009
- **Second Nation Communication (SNC)**, 2011
  - Used the IPCC default factors
  - Net removal of **6.3 million tonnes** of CO_2
  - Contribution only from **Forest Carbon Sink**

How to improve transparency ?

Use of more **country specific data**

- Development of **country specific allometric biomass equation**
- **Biomass Expansion Factor**
- **National Forest Inventory**
- **Land Use Land Cover (LULC) change estimation**

1. Development of country specific allometric biomass equation

Species	Equations	t1	t2	t3
Abies densa	-5.76+3436.38*ba+36408.9*X2	0.004562	0.110447	0.303648
Cupressus corneyana	-3.96+4300*ba+50295*X2	0.003905	0.098999	0.37853
Juniperus recurva	-4.85+3234*ba+26753*X2	0.006816	0.075555	0.263935
Larix griffithii	-3.84+3455*ba+29738*X2	0.008396	0.131148	0.330317
Picea spinulosa	-6.164+3934*ba+43569*X2	0.006648	0.113411	0.321234
Pinus roxburghii	-3.44+5098*ba+56376*X2	0.0023	0.1029	0.368529
Pinus wallichiana	-1.57+3444*ba+55382*X2	0.00309	0.098407	0.394911
Tsuga dumosa	-4.8+3854*ba+15174*X2	0.006181	0.138544	0.440845
Castanopsis tribuloides	1.39+5303*ba+2722*X2+4129*X3	0.007382	0.134038	0.40222
Quercus glauca	-3.97+6437*ba+36970*X2	0.006536	0.099043	0.374257
Quercus griffithii	-9.38+5438*ba+15835*X2	0.00731	0.132139	0.364998
Quercus lanata	-0.77+4500*ba+25308*X2	0.013335	0.141882	0.393956
Rhododendron arboreum	-0.19+1637*ba+43190*X2	0.006834	0.091863	0.207339
Alnus nepalensis	-12.3+5474*ba+1581*X2	0.008812	0.131185	0.415138
General conifer	-12.3+3299*ba+52756*X2	0.004927	0.107521	0.369822
General broadleaf	-1.06+4341*ba+30173*X2+4013*X3	0.006648	0.119459	0.368977

X2: cubic spline function of BA

X3: Condition of tree (forked:1 or not forked:0)

2. Biomass Expansion Factor

- Estimated using Randomized Branch Sampling (RBS) data collected for development of species-specific biomass models

$$BEF = \frac{W_{aboveground}}{W_{bole}}$$

Where,

$W_{aboveground}$ is total agb of tree (kg). W_{bole} is bole biomass (kg)

- 8 conifer species data (357 sampled trees)
- 6 broad-leaved (199 sampled trees)
- **Two BEF developed**

Timber Type	BEF
Broadleaf timber	1.83
Conifer timber	1.29

3. National Forest Inventory

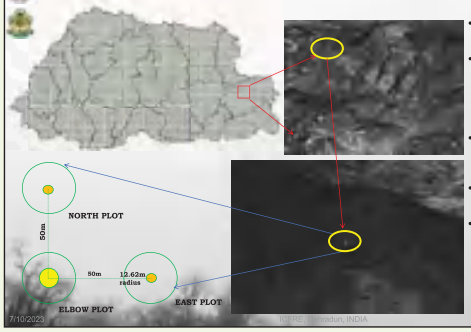
Objectives

- **60 % forest cover** for all times to come
- **Sustainable forest management** → sustainable development
- Establish an **institution** that will enable **periodic forest inventory** and **monitoring of changes** over time
- Commitment to remain **carbon neutral**
- **REDD/REDD+** mechanisms (**Emission factors** and **National Forest Monitoring System**)

Forest Resource Assessment exercises in Bhutan

Source	Year	Method	Natural forest cover (%)
Pre Investment survey	1971-1981	Inventory and RS based	61.8
Negi	1983	RS exercise	70.48
MPFD	1991	RS exercise	61.2
LUPP	1995	RS exercise (SPOT)	64.36
JAFTA	2000	RS exercise (Landsat TM)	83.16
PPD, MoA	2006	RS exercise (Landsat TM)	82.16
TERI	2007	RS exercise (IRS-P6)	73.38
LCMP	2010	RS exercise (ALOS)	70.46
LULC	2016	RS exercise (Landsat 8)	71
1st NFI	2016	Inventory	71
2nd NFI & Forest cover mapping	2022	Inventory & RS Based	?

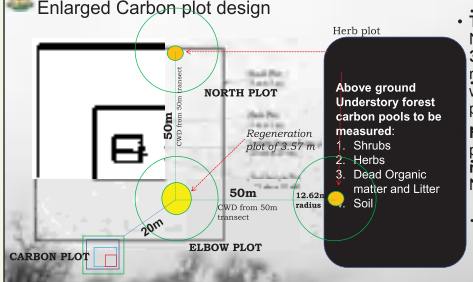
NFI SAMPLING DESIGN



- Total of **2424** cluster plots laid **4km by 4km**
- Each **cluster plot** consists of **3 circular plots** of **12.62 m radius** placed on a **"L" shaped transect** at **50 m** apart
- **Trees**: All trees having a minimum **DBH of 10 cm**
- **Saplings**: Trees having DBH between **5- 10 cm**
- **Shrubs**: Woody perennials without a definite crown and with **minimum height of 0.5 m** to a **maximum height of 5 m**

NFI PLOT DESIGN

Enlarged Carbon plot design



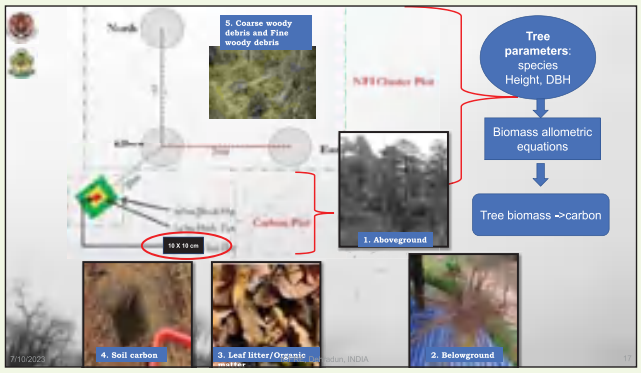
Above ground Understory forest carbon pools to be measured:

1. Shrubs
2. Herbs
3. Dead Organic matter and Litter
4. Soil

- **Above-ground understory** and regeneration were measured in sub-plots of the Elbow plot centre and consists of destructive sampling of plot
  - 3m X 3 m plot for shrubs
  - 1m X 1 meters plot for herbs
  - 30 cm X 30 cm for litter and
  - 20 cm X 20 cm plot for soil.
- **20%** of 2424 cluster plots i.e **488**

Tree regeneration was tested sub-plots of **3.57 m radius** for regeneration is laid within the Elbow.

Herbs: Nested sub-plots of **0.57 m radius** laid within North & East plots.

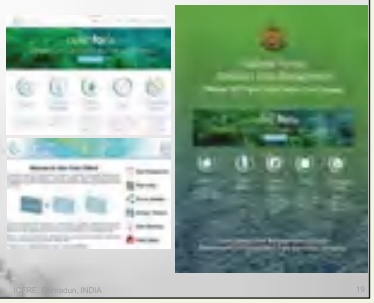


Data collection

- Data collection was done using **Trimble GPS** (1st NFI)
- **Android Tab** (2nd NFI) using **Open Foris Collect** (FAO)

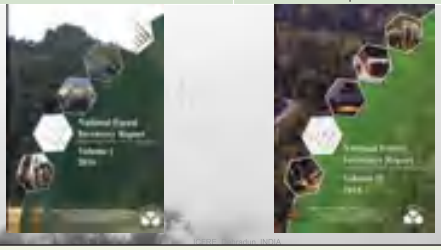
Data analysis

- NFI data analysis was performed using **Open Foris Collect**, **Open Foris Calc** (FAO) and **customized modules in R** statistical program



Results

NFI Report Volume I (2016)	NFI Report Volume II (2018)
Forest Cover and Growing stock (**tree count**, **Basal area** and **volume**)	**Biomass**, **forest carbon stock**, regeneration and increment status, species diversity, forest health and disturbance and predictions of wildlife habitat



Forest Cover and Growing stock estimates

Forest Cover	Area (ha)	Forest cover (%)
Forest	2,730,889	71
Non-Forest	1,108,511	29
Total	3,839,400	100

Tree count (No. of trees)	
Total	765,026,264
Per hectare	280

Total Basal Area (m^2)	
Total	107,911,592
Per hectare	40

Volume estimates (m^3)	
Total	944,261,791
Per hectare	346

1. Aboveground
Biomass: 736.25 million t at 269.32 t/ha
Carbon: 346.04 million t at 127.05 t/ha

2. Belowground
Biomass: 179.49 million t at 73.34 t/ha
Carbon: 39.87 million t at 34.47 t/ha

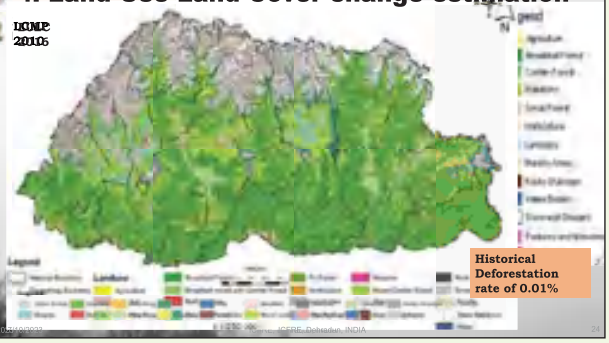
Total Biomass:
972.9 million tonnes at 362.35 t/ha
Total Forest Carbon:
645.12 million tonnes at 234.85t t/ha

5. Coarse woody debris and Fine woody debris
Biomass: 18.14 million t at 6.44 t/ha
Carbon: 8.53 million t at 3.03 t/ha

3. Leaf litter/Organic matter
Biomass: 39.03 million t at 13.25 t/ha
Carbon: 18.34 million t at 6.23 t/ha

4. Soil carbon
187.85 million t at 64.07 t/ha

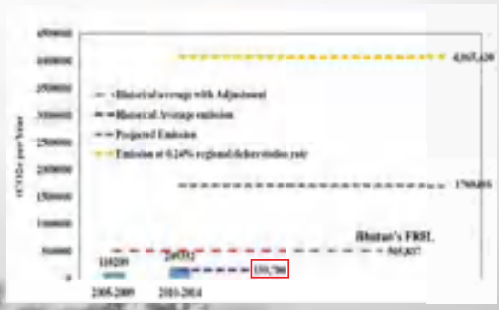
4. Land Use Land Cover change estimation



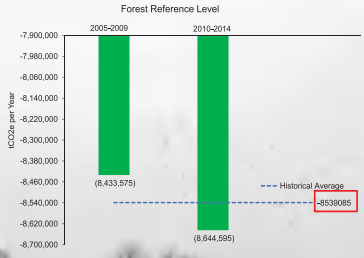
Historical Deforestation rate of 0.01%

Bhutan's Forest Reference Emission Level (FREL) And Forest Reference Level (FRL)

BHUTAN's Forest Reference Emission Level



BHUTAN's Forest Reference Level (FRL)



Net sequestration from **Forestry sector**: **8.37 million tonnes of CO_2 e**

Considering emissions from other sectors ***Bhutan's Net sequestration : 6.79 million tonnes of CO_2 e*** **(BUR, 2022)**

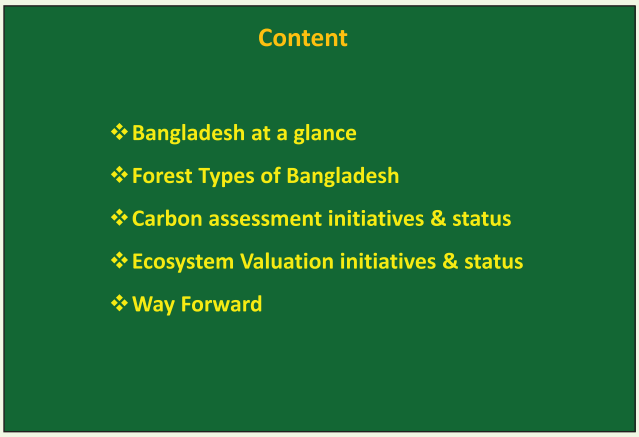
Way forward

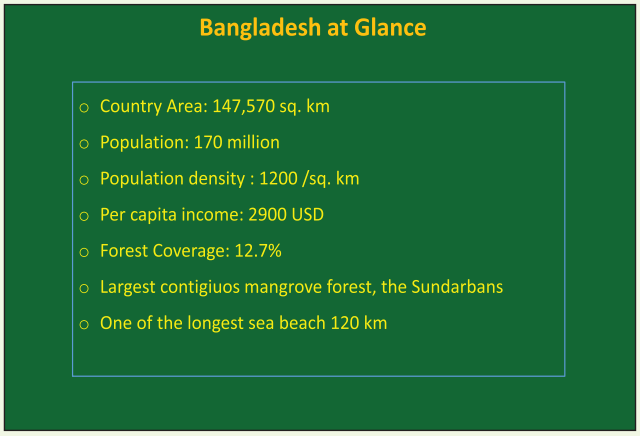
- Strengthening National Forest Monitoring System (NFMS)
- Implementation of REDD+ strategy
- Participation in voluntary carbon market
- Carbon assessment beyond forestry

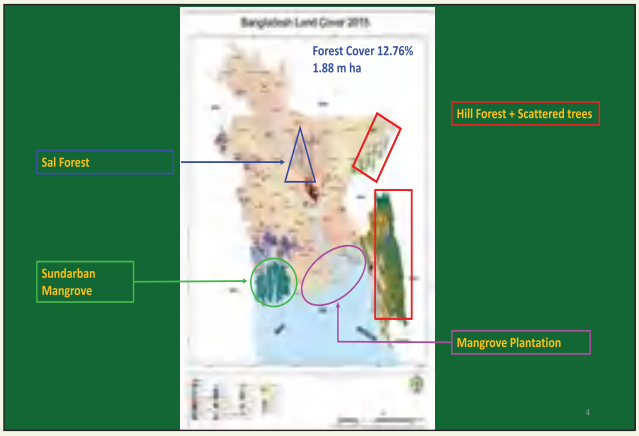
Thank you

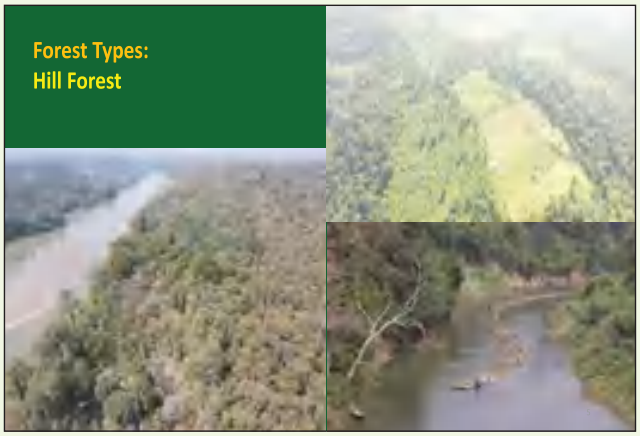
For viewing the publications in the presentation please visit www.dofps.gov.bt

20. Bangladesh initiatives on forest carbon assessment and ecosystem services valuation: Mr. Zaheer Iqbal, DCF, Bangladesh Forest Department

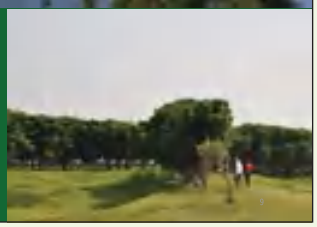








Forest Types:
Fresh Water Swamp



Bangladesh Forest carbon Assessment

Natural Mangrove : Sundarbans 2009-10

- Initiative: Gov't, USAID-USFS
- Carbon Pools measured: Above Ground, below ground, Soil & Dead wood
- 155 sample plots, systematic sampling
- One common biomass equation (Chave et al 2005) applied for all species with individual tree species wood density applied;
- Sundarbans Carbon density 256.6 ton/ha
- Sundarbans total Carbon 106 million ton.
- Requested some development partners to explore

Bangladesh Forest carbon Assessment (Cont'd)

Carbon assessment of 14 Protected areas 2011-2014

- Initiative: Gov't, USAID-USFS
- Carbon Pools measured: Above Ground, below ground, Soil, Dead wood & Litter
- Sample plots, systematic sampling with required intensity
- Volume equation, wood density & conversion factor used to get Carbon content

11

Bangladesh Forest carbon Assessment (Cont'd)

1st National Forest Inventory , 2017-18

- Initiative: Gov't & USAID
- Carbon Pools measured: All 5 pools
- 1858 Sample plots: systematic with different intensity in 5 zones
- 29 species specific allometric equations used
- National Carbon content 1426 Million ton
- 65% carbon stocks are in Trees outside forests
- Biomass & Carbon used for FRA, FREL & SDG 15.2

12

Bangladesh Forest carbon Assessment (Cont'd)

Carbon Assessment & Economic Valuation of Urban Trees

- Initiative: USAID, USFS & Gov't
- Dhaka Municipal corporation area & National Botanical Garden (NBG)
- Data collection completed for municipality & NBG is going on
- i-Tree tools used
- Carbon storage & sequestration, pollution removal, avoided run off, Oxygen production expected

13

Bangladesh REDD+ Status

- We are in the Readiness stage
- Natinal Forest Monitoring System has been developed
- REDD+ strategy endorsed by the MoEFCC
- Safeguard matters yet to be developed.

14

Ecosystem Services valuation

- Previous assessments- Only timber volume & value
- Then- Volume , Carbon content and values
- Now ecosystem valuation included
- Complete valuation of a ecosystem not yet done
- only a few initiatives by the government & research organization
- Some individual research publications are there

15

Forest Department's effort for Ecosystem Service Valuation

Economic Valuation of the Cultural, Storm Protection & Resource dependency on Sundarban Mangroves in Bangladesh
USAID-CREL/Winrock/Chittagong University/JDR

Tourism/cultural services: US$53.18 million/year

Storm protection services: US$485.29 million/cyclone/ year

1 km intact mangrove forest can save on average BDT.15,279/- per household during cyclones,

Provisioning services of eight key different resources (fish, shrimp, wood, medicinal plants, thatching materials, crab, honey and bees wax) and estimated their economic value at US$145.2 million per year.

Total economic value of these Sundarban mangrove services being US$683.67 million annually (0.35% of GDP 2015

Forest Department's effort for Ecosystem Service Valuation (Cont'd)

Outcomes of National Forest Inventory Socio-economic Survey, 2018

- ❖Every household surveyed benefits from at least one tree and forest related service according to the survey (6400 HH surveyed),
- ❖About three quarters of the major primary products are supplied from Trees outside Forests (ToF);
- ❖The total value of the primary tree and forest products collected is **3.11%** of the 2017-18's national Gross Domestic Product (GDP) measured in current price.
- ❖Trees and forests contribute **1.29%** of the 2017-18's Gross National Income (GNI) measured in current market price.

BFI Data – Bangladesh Forest Inventory (bforest.gov.bd)

Other Initiatives of ESV

World Bank Supported SUFAL Project

- ❖ Methodology will be developed for three forest ecosystems; Hill, Sal and Mangrove plantation;
- ❖Payment for ecosystem services for two hill forests

BFRI Initiative: Baroiadhala NP ESV

- ❖Provisioning, regulating, cultural & supporting services parameters considered
- ❖Economic benefit generation USD 2860/ha/yr
- ❖Total economic value USD 6.60 million/year

18

Ecosystem Services valuation (Cont'd)

- ✓GIZ will support to finalize methodology for valuation of Sundarban mangrove
- ✓ USAID & USFS will support for capacity strengthening
- ✓A web based ESV publication database has been developed
- ✓(bfis.bforest.gov.bd/esvd/public/)
- ✓ Bangladesh bureau of Statistics with is trying to develop a National capital accounting system

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Opportunities and Challenges for Carbon Trading

Opportunities

- Restoration, reforestation in Chittagong Hill Tracts
- Good opportunity for mangrove plantations
- Sundarban mangrove on conservation principle
- Social Forestry plantations
- Plantation./restoration of Village common forests (VCF) in Hill tracts
- Few institutions are coming forward to invest

Challenges:

- Forestry is not a priority sector
- Restoration, reforestation in Chittagong Hill Tracts not yet started
- Finalization of REDD+ process
- Uncertainty of successful forestation programme
- Conditions to be imposed by carbon buyers

20

Way Forward

- ➢ Hill tracts regional council seems positive for restoration/reforestation
- ➢ Responses from investors for Carbon trading
- ➢ Development partners are coming forward Carbon trading and ESV
- ➢ MoEFCC and Bureau of Statistics need to work together for National accounting
- ➢ Some piloting for REDD+ and ESV are required

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21. Assessment of forest carbon stocks in Nepal: Mr. Thakur Subedi, Research Officer, Forest Research and Training Centre, Ministry of Environment and Forest, Nepal

Assessment of Forest Carbon Stocks in Nepal

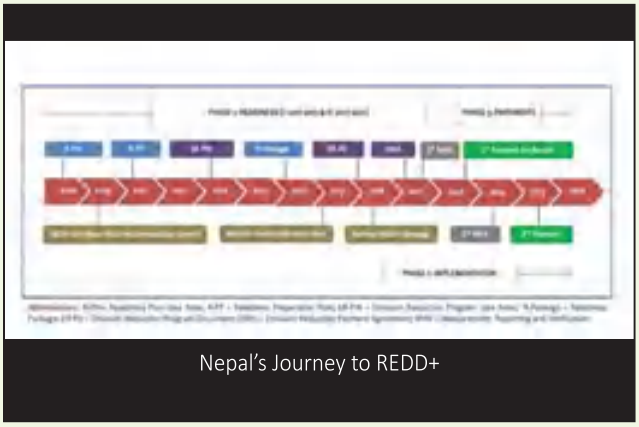
Thakur Subedi
Under Secretary (Tech.)
Forest Research and Training Centre (FRTC)
Nepal

Outline of the Presentation

- Background
- Nepal's Journey to REDD+
- National Forest Monitoring System
- MRV in Nepal

Background

- Climate change major threat of life
- Nepal as party of UNFCCC and other EA, committed to mitigate and adopt the adverse effect
- Forest has multidimensional effect
- FRA provides foundation for policy makers to national and international communities
- Nepal provides several policy and institutional mechanism
- Forest Cover: ~45%
- PA coverage: ~ 24 %



Nepal's Journey to REDD+

National Forest Monitoring System

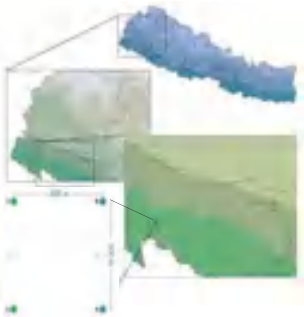
SN	Assessments	Year	Objectives
1	National-level forest inventory	1963-1967	Assessment of timber
2	National-level forest inventory (NFI)	1987-1998	Assessment of timber and fuel wood
3	Forest Resource Assessment	2010-2014	Assessment of all forest resources including carbon
4	Re-measurement	2016-2022	

FRA Sampling Design

Two-phase stratified systematic cluster sampling

Phase-I

- 4 km by 4 km systematic grid were overlaid on a map of Nepal
- Each grid intersection considered as a cluster where in 6 plots
- 9,230 clusters (55,358 plots) interpreted by using Rapid Eye imagery and Google Earth based on standard procedures
- Generated data on FAO land use class



FRA Sampling...

Phase-II

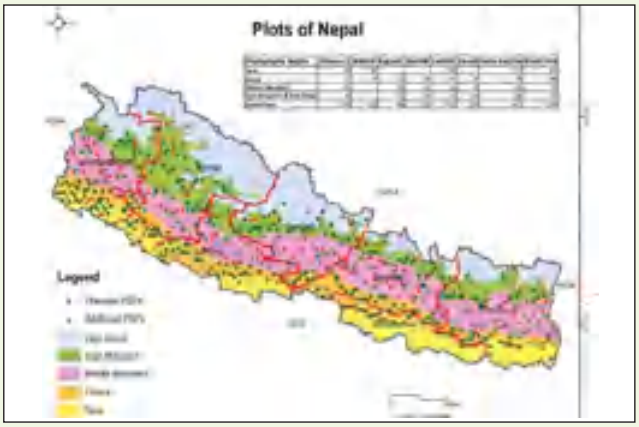
- Selection of plots (both forest and non-forest) for field measurement
- Extensive field inventory all over the country

Clusters with Number of forest plots

- Cluster with 5-6 number of Forest plots
- Cluster with 3-4 number of Forest plots
- Cluster with 1-2 number of Forest plots
- Cluster without Forest plots

2,544 sample plots
(Forest: 1,553; OWL: 105; OL: 886)
measured in the field

Plots of Nepal



Plot design (CCSP)

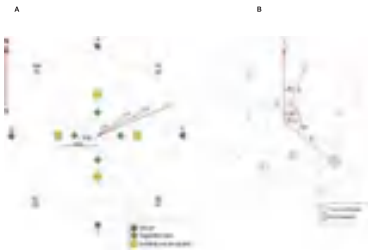


Figure: Layout of the concentric circular sample plot (CCSP) (A) and determination of tree positions based on bearing and distance measurements (B).

FRA variables

Plot variables	Stand description	Tree-level characteristics	Dead wood
Disturbances	Shrub and small trees	Soil samples	Biodiversity characteristics
Epiphytes, Parasites, Climbers and their host species	NTFP	Major wildlife (sign)	Bamboo Resource
	Invasive Alien Species	Forest Disease and Pest	

Calculation of Volume

Diameter Height Modelling

Mehtatalo, L. and Lappi, J. forthcoming. Forest Biometrics with examples in R. Textbook in preparation. Available at http://cs.uef.fi/~lamehtat/index.html.

R Studio

Non Linear Mixed Effect Models

fixed: DBH

random: Plot effect (location)

Available Functions

Naslund: $h(d) = bh + d^2/(a + b\,d)^2$

Curtis: $h(d) = bh + a\,(d/(1 + d))^b$

$h(d)$= height of tree with DBH=d

bh=breast height (1.3 m)

d= DBH in cm

a and b = Parameters a, b (and c for 3- parameter functions) of the applied function

Volume Calculation

- NR adjusted
- Total volume of the tree is calculated with volume functions
- Volume equations developed by Sharma and Pukkala (1990)
- ln(v) = a + b ln(d) + c ln(h)

where,

ln = Natural logarithm to the base 2.71828.

V = Volume (m3)

d = DBH in cm

h = Total tree height in m

a, b and c are coefficients depending on species

Calculation of Biomass and Carbon

Biomass

Stem Mass (Biomass)

- Biomass models prescribed by MPFS (1989)

1. Stem biomass = Vol. × Density

where,

Vol. = Stem volume in m3

Density = Air-dried wood density in kg/m3

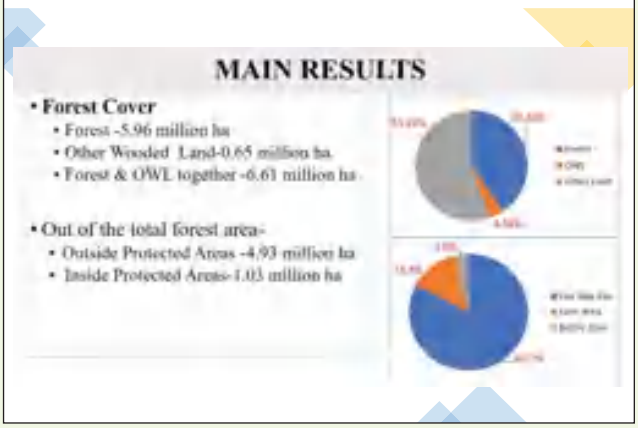
2. Branch biomass = Ratio × Stem biomass

3. Foliage biomass = Ratio × Stem biomass

Total Biomass=1+2+3

Carbon

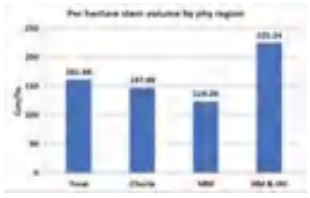
- The carbon content estimated from oven-dried biomass by multiplying the biomass with a carbon-ratio factor of 0.47 (IPCC default)



Main Results

Growing stock

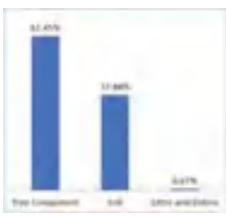
- Number of stems 2563.27 million (429.93/ha) (>10 cm DBH)
- Stem volume = 982.33 m3 (164.76 m3/ha)



Main Results

Carbon Stock

- Total forest carbon = 1056.82 m tons (177.26 t /ha)
- Tree component (live/dead standing, dead wood, Below ground), forest soils and litter and debris constitute 108.93, 67.15 and 1.19 t/ha respectively



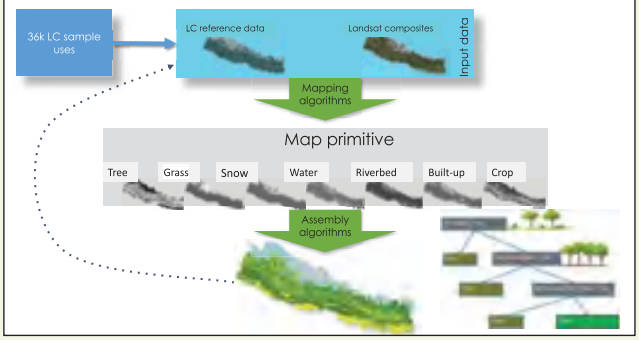
Tree species diversity

- 443 spp
- 239 genera and
- 99 families

National Land Cover Monitoring System Methodology

- Machine learning technique for land cover mapping;
- Powerful web-platform (Google earth engine) for cloud-based processing free historical archive data;
- No high configure computer infrastructure needed;
- Developed data consistency across the country

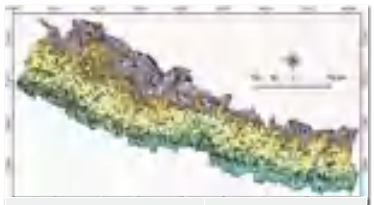
National Land Cover Monitoring System Methodology



National Land Cover Status 2019

Land cover classes	Area (ha)	Percentage %
Forest	6166766	41.69
Cropland	3581047	24.21
Grassland	1963286	13.27
Snow	930199	6.29
Bare rock	835030	5.64
OWL	535179	3.62
Glacier	463872	3.14
Riverbed	163721	1.11
Built-up	78296	0.53
Water body	71587	0.48
Bare soil	4033	0.03
Total	14793015	100

Accuracy assessment report of Nepal Land cover



Source of points	Number reference points
Permanent sample plot	1700
Field visit	321
Collect earth online (CEO)	2000
Total	4021

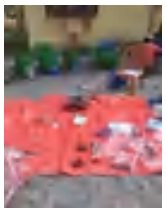
Preparation of Allometric Equation

Design
- Stratified
- Direct and indirect method
- Intensive measurement

Species selection
- Major 16 spp
  - Stem vol >1%
  - Coverage 2/3
- Now 7 spp

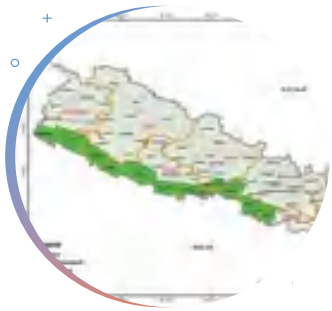
Sample trees selection
- Size coverage
- Geographic representation
- Randomization
- Unbiased

Preparation of SOP



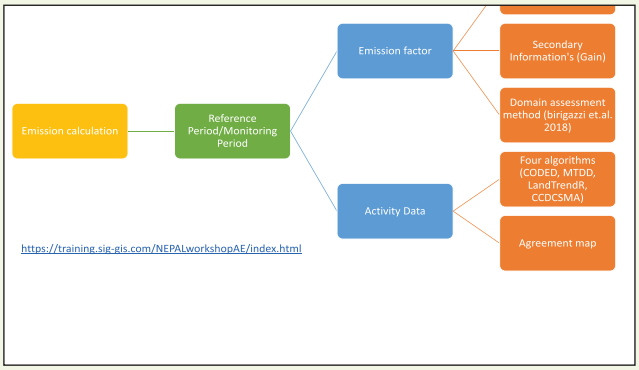
Preparation of Allometric Equation

- Felling and field data collection
  - Collection of site and stand variable
  - Tree variable collection
  - Measurement along the trunk
  - Sample disk collection
  - Volume measurement
  - Lab processing



ER Program Area

- 5 Provinces
- 13 districts of TAL
- 16 DFOs
- ~15% of Nepal's land area
- ~20% of Nepal's forests
- ~25% of Nepal's pop.
- 1.17 million ha forests (29% PA+ 27% CF + 5% ColF + 39% GMF)
- 2209 CFUG + 6 PAs + 18 Col FUG + 159 LH FUG



https://training.sig-gis.com/NEPALworkshopAE/index.html

https://training.sig-gis.com/NEPALworkshopAE/index.html

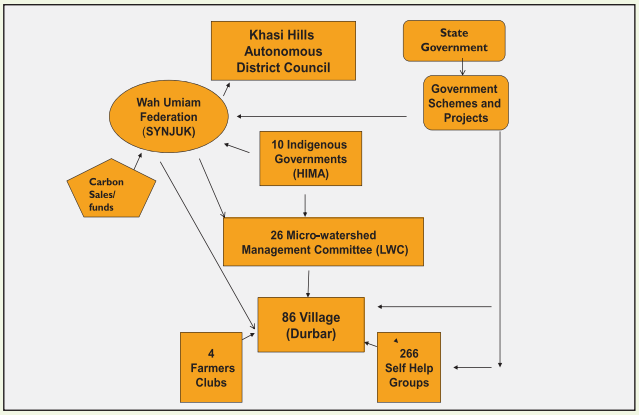
Strengths and Challenges

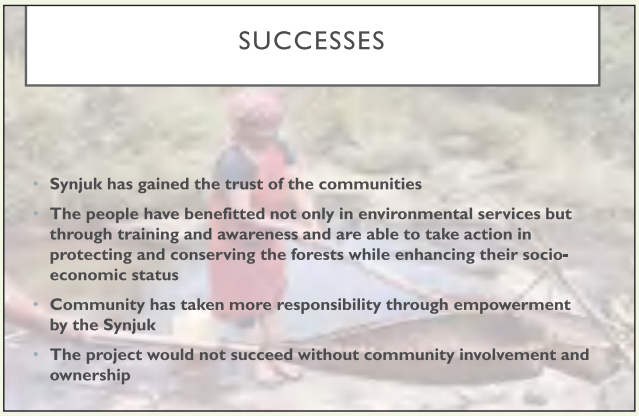
Strengths
- Capacity building
- More accuracy
- Established REDD institution
- Sufficient number of permanent sample plot
- Allometric equation
- Non-carbon benefit

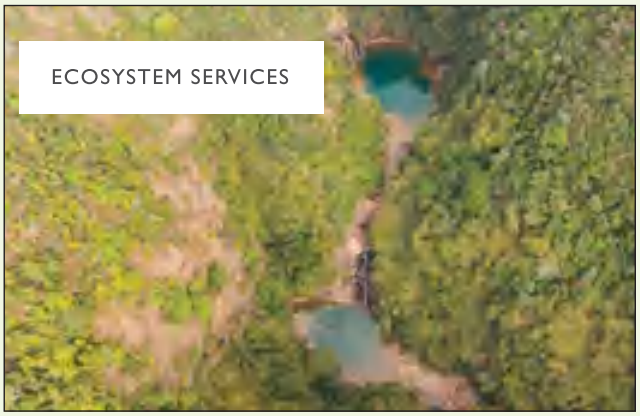
challenges
- Irregular patterned of settlements
- Heterogeneous community and use
- Migration and population pressure in Terai Forest
- Well documented SOP
- Consistency in materials and methods
- Accuracy of NLCMS at sub national levels

Thank you

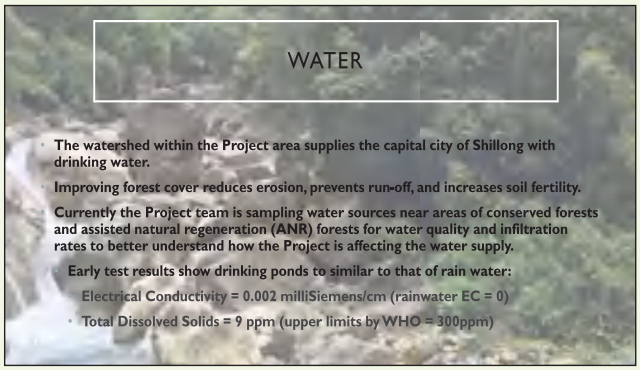
22. Ecosystem services resulting from the Khasi Hills Community REDD+ Project: Mr. Tambor Lyngdoh, Founding Chairman (Synjuk) Cum Community Conservator of Forest & Project Director, Khasi Hills Community REDD+ Project, Meghalaya

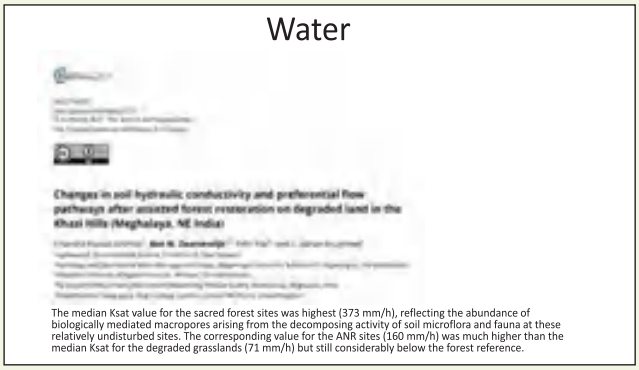




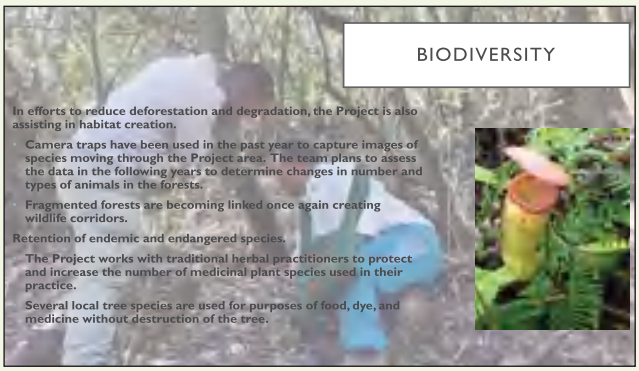



AIR QUALITY
The Project aids in reducing fuelwood for cooking, heating, and drying
LPG cookstoves, rice-cookers, and fuel-efficient stoves
Commercial kitchens serving mid-day meals
LPG reduced fuelwood usage by 30kg per day.
Forest fire prevention
Traditional practice of preventive burning
Creation and maintenance of fire-lines


WATER
The watershed within the Project area supplies the capital city of Shillong with drinking water.
Improving forest cover reduces erosion, prevents run-off, and increases soil fertility.
Currently the Project team is sampling water sources near areas of conserved forests and assisted natural regeneration (ANR) forests for water quality and infiltration rates to better understand how the Project is affecting the water supply.
Early test results show drinking ponds to similar to that of rain water:
Electrical Conductivity = 0.002 milliSiemens/cm (rainwater EC = 0)
Total Dissolved Solids = 9 ppm (upper limits by WHO = 300ppm)


Water
Changes in soil hydraulic conductivity and preferential flow pathways after assisted forest restoration on degraded land in the Khasi Hills (Meghalaya, NE India)
The median Ksat value for the sacred forest sites was highest (373 mm/h), reflecting the abundance of biologically mediated macropores arising from the decomposing activity of soil microflora and fauna at these relatively undisturbed sites. The corresponding value for the ANR sites (160 mm/h) was much higher than the median Ksat for the degraded grasslands (71 mm/h) but still considerably below the forest reference.

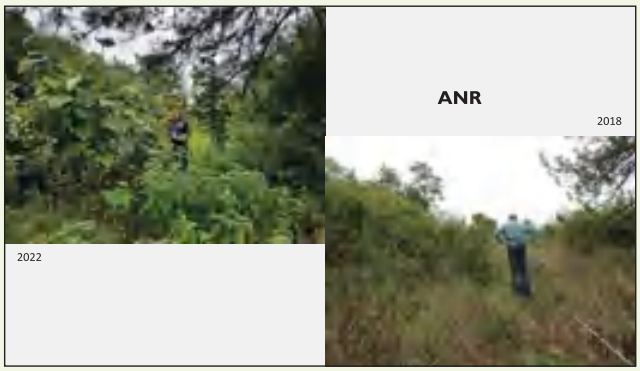

INFILTRATION

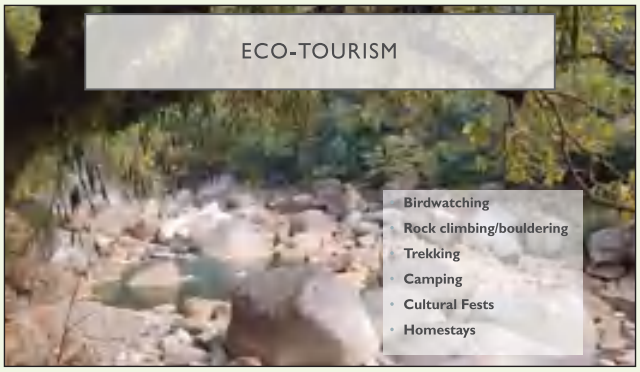

BIODIVERSITY
In efforts to reduce deforestation and degradation, the Project is also assisting in habitat creation.
Camera traps have been used in the past year to capture images of species moving through the Project area. The team plans to assess the data in the following years to determine changes in number and types of animals in the forests.
Fragmented forests are becoming linked once again creating wildlife corridors.
Retention of endemic and endangered species.
The Project works with traditional herbal practitioners to protect and increase the number of medicinal plant species used in their practice.
Several local tree species are used for purposes of food, dye, and medicine without destruction of the tree.

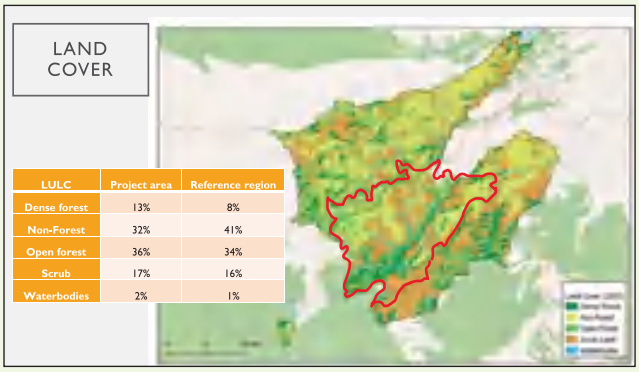

These forests provide valuable NTFPs and ecosystem services such as carbon storage, water filtration systems and reservoirs, home to many endemic species, and a unique undisturbed wildlife habitat.

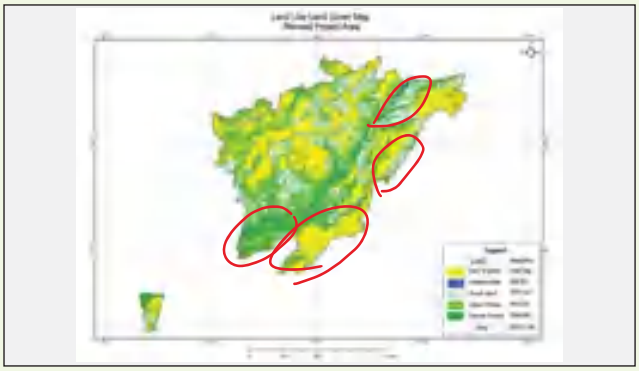

2014
2020
FOREST CHANGE


2012
2016


ANR
2018
2022

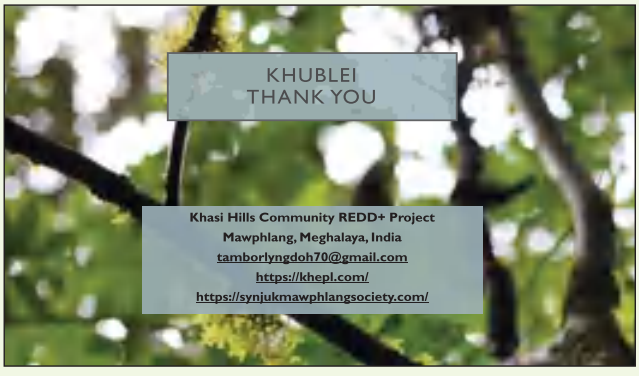






PROJECT AREA LAND COVER CHANGE

Category	2016	2021
Dense Forest	2685.30	2846.80
Open Forest	8174.19	8921.21
Scrubland	5222.81	3761.47
Waterbodies	467.10	425.52
Non-forest	6962.69	7557.09
Total	23512.10	23512.10



23. Developing a domestic forest carbon market in India: Dr. Promode Kant, Chairman, Expert Appraisal Committee (INFRA-2), MoEFCC, Govt. of India

Developing Domestic Forest Carbon Market in India

Dr Promode Kant IFS(Rtd)
Chairman, Expert Appraisal Committee (Infrastructure 2), MoEF&CC, Government of India

Committee for Developing Domestic Forest Carbon Market in India

Dr Promode Kant IFS (Rtd), Chairman
Anurag Bhardwaj IFS, Director (IC), ICFRE, Member
Dr T P Singh IFS, Secretary to Govt of Haryana, Member
V R S Rawat, former ADG, ICFRE, Member
Amit Anand, CEO, Carbon Check (India) Pvt Ltd, Noida, Member
Dr R S Rawat, ICFRE, Member Secretary

Work-in-progress, PPT based on first draft of Committee's Report

Growing carbon markets

- Carbon offset markets for airlines grown 900% over the last one decade
- Corporate carbon offsets by 170% in 2021.
- International Emissions Trading Association: additional financing from carbon markets could exceed USD 1 trillion by 2050

India's NDC target

- India's NDC in forestry sector is 2.5 to 3 Gt of additional CO2 sequestration by 2030, Base yr 2005
- Bonn Challenge target – 26 Mha
- India's 3rd Biennial Update Report (BUR3) estimates Indian forests capture 11% of total national emissions

How much work needed to reach NDC?

- FSI (2019) estimates increase in area of 18 to 24 million hectares of forest and tree cover required to meet India's NDC target.
- Ten activities considered by FSI for meeting NDC
  - Restoration of Forests impaired in last 6 yrs-13.7 Mha
  - Restoring Open Forests of more than 6 yrs vintage to MDF-18.9 Mha
  - Plantations on Culturable Wastelands-12.5 Mha

FSI's assessment of availability of land – 75 Mha

Agroforestry Plantations-13.7 Mha
Along National and State Highways-1.40 Mha
Plantations along Other Roads-2.89 Mha
Plantations along Railway Tracks-0.07 Mha
Plantations around Railway Sidings-0.01 Mha
Plantation along Rivers and Canals-0.39 Mha
Expanding Urban Green Spaces -12.2 Mha

Modes of carbon sequestrations currently happening in India

- Biodiversity enhancing carbon sequestered in PAs by SFDs
- Biodiversity enriching degraded forest restoration by SFDs outside PAs in their regular programs
- Timber/NTFP oriented A/R undertaken under JFM by SFDs
- Timber/NTFP oriented A/R by tribal beneficiaries on FRA lands
- A/R under CAMPA by SFDs for lands diverted under FCA
- Watershed improvement by SFDs for S&M conservation
- Coastal zone and mangrove afforestation by SFDs

More....

- Energy plantations by SFDs
- Roadside plantations by SFDs and Highways
- Urban afforestation by municipal bodies
- Rural afforestation by Panchayats and other Depts
- Agroforestry by farmers
- Monospecific block planting by landowners
- Bamboo planting by farmers
- Rubber, tea, coconut, arecanut and coffee planting

What should we do to encourage people to plant more trees and maintain them?

- Make forest and tree planting more remunerative by creating market for ecological services including mitigation/adaptation to CC
- But transaction costs should be minimal
- And the market we create should, at sometime in future, be able to align with Paris Article 6

Article 6 of Paris Agreement

Article 6 allows countries to voluntarily cooperate with each other to achieve emission reduction targets set out in their NDCs.

Article 6.2 creates the basis for bilateral agreements on transfers of credits in GHG emission reductions or emission removals as "Internationally Traded Mitigation Outcomes" across countries .

Article 6.4 establishes a multilateral mechanism for trading GHG emission reductions/removals between countries under the supervision of the Conference of Parties

Article 6.8 recognizes non-market approaches to promote mitigation and adaptation by way of cooperation through finance, technology transfer, and capacity building

Compliance and voluntary markets for trading in carbon offsets

Compliance markets: Kyoto compliance market, EU-ETS, US and Canadian provinces, New Zealand, Australia

Voluntary Carbon Markets

California's Cap-and-Trade Program

- Launched in 2013 – multisectoral market to bring buyers and sellers of compliance carbon offset credits
- Administered by California Air and Resource Board (ARB)
- Quite stable, $14 per ton
- Strict project development protocols and standards
- But very high transaction costs

California's Compliance Market

- Allowed on private forestlands- opportunity for forest owners to connect with a compliance market.
- Owners should have long-term management plan certified by Forest Stewardship Council (FSC) or Sustainable Forestry Initiative (SFI) or American Tree Farm System (ATFS)
- Requires that forests be managed for native vegetation, with projects consisting of at least 95% native species based on carbon stocking levels

American Carbon Registry

- Approved by ARB
- Has protocols for 3 types of forest carbon projects:
  - Afforestation/Reforestation,
  - Avoided Conversion for non-forestry use,
  - Improved Forest Management that increase or maintain the current level of carbon stocking

Initiating a domestic forest carbon market

- We begin with afforestation/reforestation/tree planting at smaller scale. Rest to follow as we gain experience
- Ease of doing things & low transaction costs is our focus
- Carbon offsets will come in various qualities characterized by Additionality/Permanence/Leakage as also by varying degree of emphasis on non-carbon ecosystem services
- Market will know upfront on what quality of offsets is on offer and it can discount lower quality product as market ought to

Objectives

To tap the full carbon capture potential of forests and other lands in India

To enhance income of land owners and farmers practicing agroforestry

To incentivize forest planting and care by FRA beneficiaries

To provide a platform for international buyers of forestry carbon credits from the Indian farmers and landowning communities

To increase India's capacity to benefit from the new market mechanism emerging under Paris Agreement

Key attributes of carbon offsets – Baseline, Additionality, Permanence, Leakage

Baseline against which changes in CO_2 sequestered are measured

Emission reductions or removals are only additional when caused by incentives from carbon crediting revenues

Permanency of CO_2 sequestered

Leakage happens when GHG reductions in one area results in an unintended increase in GHG emissions in another location – to be avoided or accounted for

Additionality, permanence and leakages to be redefined for Domestic Forest Carbon Market

Additionality for private planting by farmers on their lands and by communities to be assumed in all cases

Additionality in case of plantations by SFDs under their regular programs could be that which is in addition to average annual planting of last 10 years with each Block/Range taken as unit

Permanency to be defined by the length of period the land is kept available for forest/trees, not by the length of period the carbon sequestered remains stored at the site

Leakage assumed zero in all private forestations, and at small scale (<100 ha) by government departments. To be assessed and accounted for when undertaken on public lands >100 ha

Social and Environmental Safeguards

- Essential to minimize potential social and environmental risks when implementing land use-based activities under carbon markets.
- Rights and concession enjoyed by local communities and peoples need to be ensured.
- A system of reporting on safeguards, grievance and redress mechanisms etc has already been developed by ICFRE to minimise the associated risks

Type A activities

- Plantation on area less than 100 hectares including scattered tree planting or line planting
- For ease of management, clustering will be done by the SFD so that each such cluster will have an estimated minimum of 100 carbon credit generated annually
- Baseline will be the carbon contents of the pre-existing vegetation on the land.
- Leakage will be assumed to be zero.
- Permanence will be tested against keeping land permanently under tree cover, not by permanence of C stock

Type B activities

A/R on area more than 100 hectares - block plantation, boundary plantations, roadside plantations, smaller land areas aggregated together

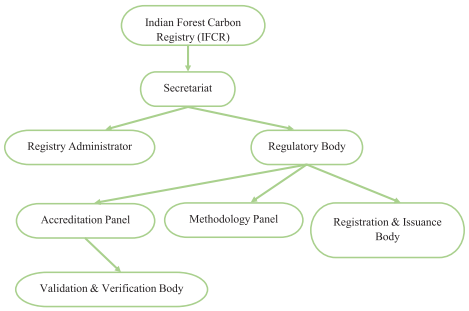
Baseline will be the carbon contents of the pre-existing vegetation

Permanence on private lands will be tested against keeping land permanently under tree cover, not by permanence of C stock

Permanence on public lands will be ensured by buffer plantation(s) of adequate size by SFDs/Forest Development Corporations

Leakage to be assumed zero on private lands. It will be assessed using an approved methodology on public lands

Credits generated will be named differently for public and private lands for ease of distinguishing between them



- **Registry Administrator:** responsible for day-to-day operations of the registry
- **Validation/Verification Body (VVB):** for providing validation and/or verification services in accordance with the IFCR rules.
- **Accreditation Panel:** to support the regulatory body for accreditation of VVBs, conduct assessment of VVBs regarding their compliance with the accreditation requirements and to provide advice on accreditation requirements and improvement of the accreditation process.
- **Registration & Issuance Body** for assessing requests for registration of project activities and requests for issuance of Offset Certificates as applicable.
- **Methodologies Panel** responsible for methodologies for baseline etc

Compatibility with Article 6 of Paris Agreement

- This market shall be made compatible with the evolving New Market mechanisms under Article 6 once some experience is gained
- Till that time the credits generated shall be used only for non-compliance purposes so that these remain available for meeting India's NDC target
- Credits generated and traded on this market and meeting the standards set by the New Market Mechanism can, however, be used for compliance with the express permission of the MoEF&CC.

THANKS

24. ISRO's initiative on measurement of forest carbon exchange – status, challenges and way forward: Dr. Kiran Chand Thumaty, Scientist 'F' and Head, Forestry Resources Division, Forestry & Ecology Group, Remote Sensing Applications Area, National Remote Sensing Centre

Enhancing Ecosystem Services by Improving Forest Quality and Productivity, and SLEM Knowledge Distribution

nrsc

ISRO's Initiative on Measurement of Forest Carbon Exchange Status, Challenges and Way Forward

Team

1. **Dr. Kiran Chand Thumaty, Scientist 'F' & Head, Forest Resources Division, Forestry & Ecology Group, NRSC, Hyderabad**
2. R. Suraj Reddy, Scientist 'E', Forest Resources Division, Forestry & Ecology Group, NRSC, Hyderabad
3. M.S.S. Praveen, Scientist 'D', Forest Resources Division, Forestry & Ecology Group, NRSC, Hyderabad
4. Rakesh Fararoda, Scientist 'E', Regional Remote Sensing Centre – West, NRSC, Jodhpur
5. G.Rajashekar, Scientist 'SG' & Group Head, Forestry & Ecology Group, NRSC, Hyderabad

Presentation Outline

- ISRO's National Carbon Project - Background
- Operations at flux tower sites (ground measurements)
- Salient Observations
- Upscaling flux measurement to regional scale using Remote Sensing proxies
- Challenges
- Studies on forest structure & Above Ground Biomass
- Way forward

2/28

National Carbon Project (NCP)
ISRO's Geosphere Biosphere Programme (ISRO-GBP)

- **During 1995-2006** separate studies by Individual PIs; site specific / regional estimate carried out.
  - Biomass
  - NPP
  - Ocean productivity
- **In 2007, a National level project was initiated under ISRO-GBP** with major goals on
  - Assessment of Carbon Pools, Fluxes and Net Carbon balance for terrestrial biosphere in India
  - Periodic assessment of carbon balance through ground observational network, remote sensing and modelling.
  - To provide support to national activity (National Communication to UNFCCC)
- **During 2009 - 2019, NCP was carried out with 4 major sub-projects**, namely
  - VCP : Vegetation Carbon Pool – National integrated sampling
  - SCP : Soil Carbon Pool – National Integrated sampling
  - **SVF : Soil & Vegetation - Atmosphere Fluxes – Flux Towers, RS-based modelling (continuing)**
  - Atmospheric Carbon Observations (continuing)

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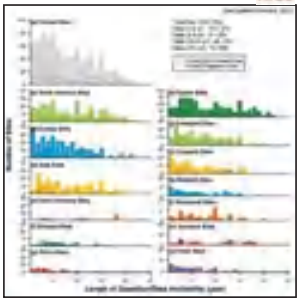
Eddy Covariance Flux Towers

Advantages
- Very high frequency (10 Hz) continuous measurements of mass & energy fluxes
- Continuous measurements of meteorological data (wind, precipitation, radiation etc)
- Continuous measurements of soil (temperature, moisture, respiration)
- Long term observations (2-3 decades) would aid in studying impact of climate variability and change on forest ecosystems and vice versa

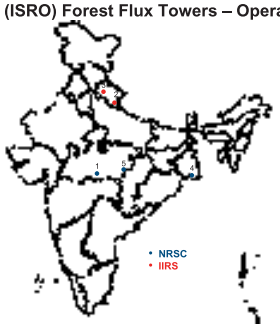
Flux tower network - status



https://fluxnet.org/sites/site-summary/

4/28

(ISRO) Forest Flux Towers – Operational Status & Data Availability



1. Teak mixed forest, Betul, M.P (> 10 years)
2. Mixed plantation, Haldwani, Uttarakhand (> 10 years)
3. Sal forests, Barkot, Uttarakhand (> 10 years)
4. Mangroves, Sundarbans, W.B (> 10 years)
5. Sal forests, Kanha, M.P (6 years)

NRSC also operates 14 eddy flux towers at different agriculture sites

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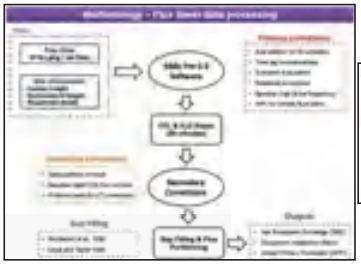
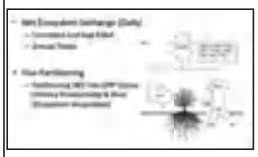
Concept & Methods





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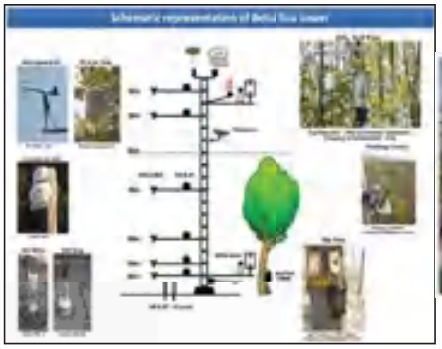

Ground Photograph

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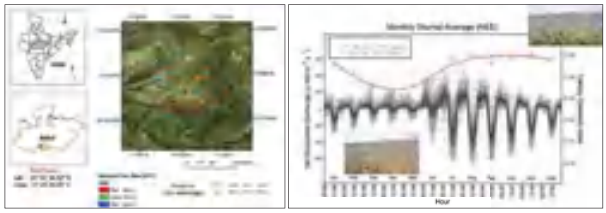
Observations - Teak mixed forests, Betul, Madhya Pradesh



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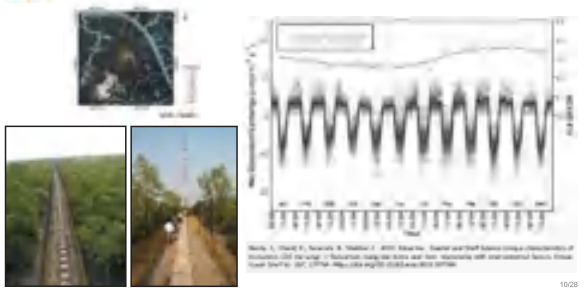
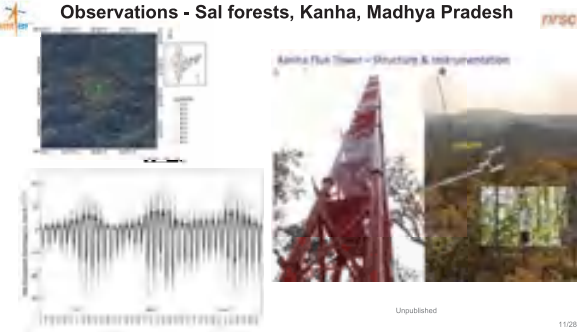
Observations - Mangroves, Sundarbans, West Bengal



10/28

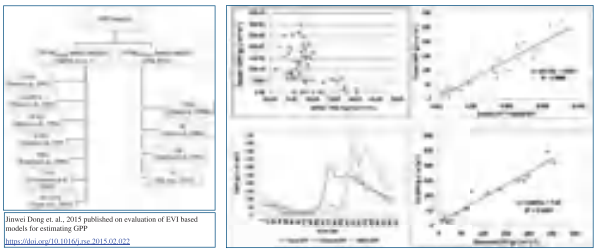
Observations - Sal forests, Kanha, Madhya Pradesh



Unpublished

11/28

Remote Sensing & Modelling



Jinwei Dong et. al., 2015 published on evaluation of EVI based models for estimating GPP
https://doi.org/10.1016/j.rse.2015.02.022

Temperature–Greeness Model, Teak mixed forests, Betul

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Challenges

Technical & Field Level

- Data gaps
- Representation across all forest types
- Funds and technical man-power for enhancing tower network
- Harmonisation of data (from different stake holders)
- Logistic Support (our activity is totally supported by MPFD and WBFD)

Policy level

- National framework including state-of-the-art C-sequestration methods/techniques
- Assimilation of data in the national frame work

Forest Structure and Above-Ground Biomass (AGB) Current & Future Remote Sensing Missions

- **Optical Remote Sensing**
  - IRS Series, Landsat series, Sentinel-2A&B....)
- **Microwave (Synthetic Aperture Radar)**
  - C-Band - up to 60 t/ha (RISAT-1A, Sentinel-1A&B....)
  - S-band - up to ~100 t/ha (NISAR - NASA-ISRO Synthetic Aperture Radar to be launched in early 2024)
  - L-Band - up to ~130 t/ha (NISAR, ALOS-2 ....)
  - P-Band > 120 t/ha (only air-borne available. Space-borne 'BIOMASS – ESA' to be launched)
- **3D Forest structure from LiDAR**
  - Terrestrial Laser Scanners
  - Air-borne LiDAR
  - Space-borne LiDAR
    - GEDI (Global Ecosystem Dynamics Investigation) on board ISS to measure forest structure and biomass.
    - ICESat (Ice, Cloud and Elevation Satellite) to measure forest height

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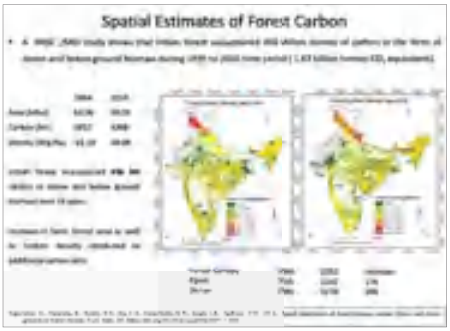
Spatial Estimates of Forest Carbon



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Uncertainties in Spatial Forest AGB Estimation

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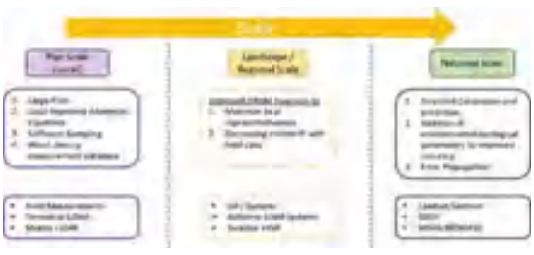
Towards Accurate Spatial AGB Estimation ....



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AGB Reference Sites – SE Asia (India + Thailand)

- Reference sites for reducing uncertainty in spatial Above-Ground Biomass (AGB) estimation over South Asian Region
- Each Site is characterized by set of few 1-ha plots and an Aerial LiDAR coverage of ~100 km²

*Uppangala is with collaboration with FIP, Pondicherry, India
*Khaoyai is with collaboration with AMAP.

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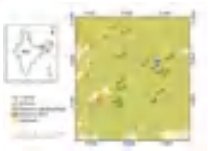
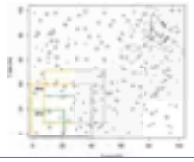
Need for Rapid Inventories – Large Plots





- Simulated plots of different sizes (from 20x20m to 260x260m with 20m increments) were created to study effects of variability in plot-level AGB estimates.
- Different shapes were also simulated (Circle and Square).
- Geo-location uncertainty was also simulated in an random interval of 3-20m across different measurements
- Field Data – 13 (1ha plots) + 1 (32 ha plot).

Mayamanikandan, T. et al., 2020

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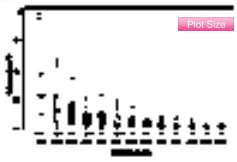
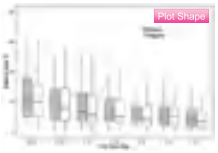
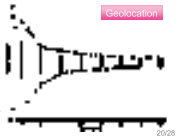
Need for Rapid Inventories – Large Plots





- We observe that the there has significant decrease in overall error at plot-level with the increase of plot size >0.64 ha (80m x 80m).
- Errors due to geo-location also subsided to <5% when plot size is increased to >60m.
- Plot shape had a limited variability across all the plot sizes

Mayamanikandan, T. et al., 2020

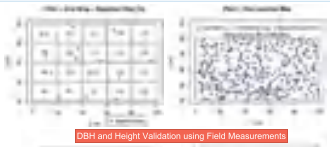


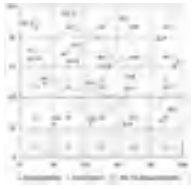
Mayamanikandan, T., Reddy, S., Fararoda, R., Chand, K., Sona, M., Praveen, S., et al. (2020). Quantifying the influence of plot-level uncertainty in above ground biomass up scaling using remote sensing data in central Indian dry deciduous forest. Geocarto International, (0), 1–15. https://doi.org/10.1080/10106049.2020.1864029

20/28

TLS based Tree/Plot Inventory

- Teak mixed dry deciduous forests
- Betul, Madhya Pradesh
- Tree density: 400 – 500 stems/ha
- 50 year old trees
- Average height of 22 m.





DBH and Height Validation using Field Measurements

Reddy, R. S., Fararoda, R., Jha, C. S., & Rajan, K. S. (2018). Automatic estimation of tree stem attributes using terrestrial laser scanning in central Indian dry deciduous forests. *Current Science (00113891), 114*(1).

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T-LiDAR Acquired forest scene – Walk through

Reddy, R. S et al., 2018

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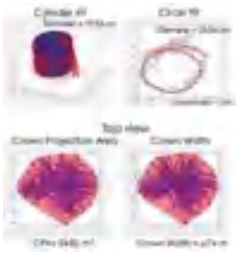
TLS Based Tree parameter extraction



Tree Inventory Parameter Extraction
- RANSAC based circle/cylinder fitting
- Convex hull based Crown Area estimation

Reddy, R. S., Jha, C. S., & Rajan, K. S. (2016). Automatic Tree Identification and Diameter Estimation Using Single Scan Terrestrial Laser Scanner Data in Central Indian Forests. Journal of the Indian Society of Remote Sensing, 46(6), 937–943. https://doi.org/10.1007/s12524-018-0753-7

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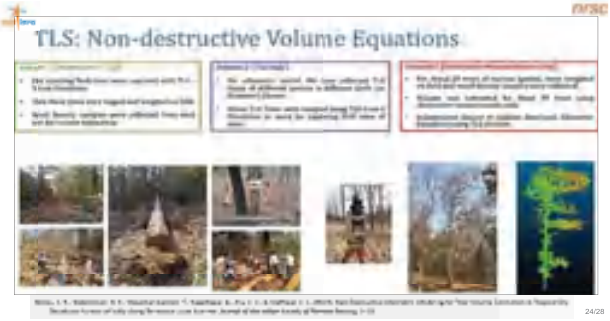
TLS: Non-destructive Volume Equations



24/28

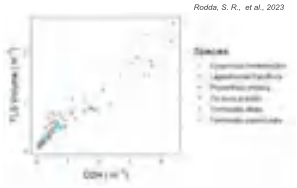
TLS – Non-destructive Allometric Equations.

- TLS Volume is related to D^2H (Diameter & Height)
- **A non-linear log-log relationship was used to predict the allometric model.**
- **N=100**

$$Biomass = a * (D^2H)^b$$

- Estimates from Model
  a = 0.706
  b = 0.729

Rodda, S. R., et al., 2023



Rodda, S. R., Ndamanuri, R. R., Mayamanikandan, T., Rajashekar, G., Jha, C. S., & Dadhwal, V. K. (2023). Non-Destructive Allometric Modeling for Tree Volume Estimation in Tropical Dry Deciduous Forests of India Using Terrestrial Laser Scanner. *Journal of the Indian Society of Remote Sensing*, 1–15.

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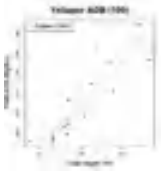
AGB Upscaling using Aerial LiDAR

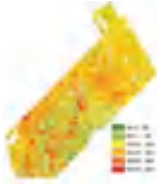
Power Model

Log(AGB) ~Log(Height)

Spatial Biomass Map (t/ha) of Yellapur using Median Height from Aerial LiDAR

Key points:
- Median Canopy Height is strongly correlated with forest above ground biomass.
- Height based models does not saturate at high biomass regions
- **Can these substitute for training satellite data towards global/national scale models ?**





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Project on impact of forest interventions on forest regeneration, soil erosion control and soil moisture retention under Narwa Vikas, Chhattisgarh

Background: Narwa vikas Proiect aimed at-
- Enhancing ground water percolation
- Water retention and storage capacity
- Forest regeneration

Catchment Area Treatment Plans (CAT) Plan
- Construction of drainage line treatment structures
- Phase-1 (2019-20) covered 4.25 lakh ha., 863 rivulets/streams, 12.55 lakh structures.
- Phase-2 (2020-21) covered 4.28 lakh ha., 1092 rivulets/streams, 12.70 lakh structures.

Request for RS based assessment of impact for
- Forest regeneration
- Soil erosion control
- Soil moisture and other relevant parameters

Proposed work plan (R & D plan approved)
- Tripartite MoU signed with CFD & CCOST
- Ground data and remote sensing proxies will be used to address forest parameters, soil erosion control and soil moisture retention

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Conclusions & Way Forward

- We propose **IndiaFlux** by bringing together all stake-holders in eddy covariance science in India.
- National framework to assimilate and analyse existing data sets.
- Hand-holding & capacity building in the area of eddy-covariance science.
- **Collaboration** with institutes & academia.
  - Tree Physiology
  - Soil studies
  - Meteorology
  - Others
- National workshop planned in 2023 to showcase and discuss future science program.
- Develop local, regional and national models for upscaling.
- To establish cal/val reference sites for inventory of forest biophysical parameters (AGB, LAI, Height etc.) and upscale to national level using multi-platform and multi-sensor data with less uncertainty.

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25. Advancing knowledge sharing and capacity building for restoring forests and landscapes: Dr. Illias Animon, Forestry Officer, FAO (Online)

Advancing knowledge sharing and capacity building for restoring forests and landscapes

Illias Animon
Forestry Officer, FAO

- **Why**
- **How**

'The future cannot be predicted, but futures can be invented'

Dennis Gabor (1963)

Source: https://www.un.org/sustainabledevelopment/news/communications-material/; https://en.wikiquote.org/wiki/Dennis_Gabor; https://en.wikipedia.org/wiki/One_Health#/media/File:One-Health-Triad-en.png; https://www.un.org/en/sections/issues-depth/population/

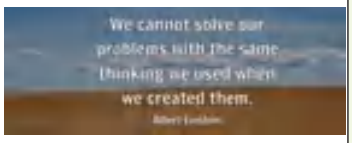
Growing demands; system failure

- Asia-Pacific region: Growing and urbanizing population; need more food/wood
- Current systems: lack integration, optimization, diversification and innovation (FAO, 2022)

Source: https://www.fao.org/forestry/food-security/en/;

Broadened and agrifood system-oriented approaches

- Sectoral and system-wide thinking



Source: https://www.fao.org/3/cb7099en/cb7099en.pdf; https://www.brainyquote.com/quotes/albert_einstein_121993

Crises to opportunities

- Reduce competition and enhance complementarities

Source: https://www.fao.org/events/detail/cofo-26/en; https://www.fao.org/coag/en/

More integrated approach

- Wood + food security together

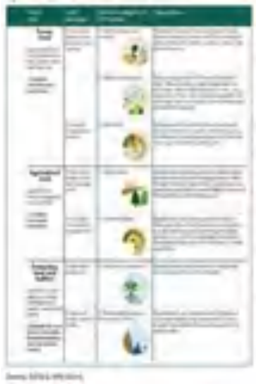
Sustainable and inclusive landscape management ✚ Value chains of products and services

Source: https://unece.org/fileadmin/DAM/timber/meetings/2019/20191104/5-jt-sw4sw-csoka.pdf

Towards a better future

- Sufficient resources for landscape approaches
- More emphasis on forest quality and restoration

https://www.fao.org/3/ca4627en/ca4627en.pdf



What is restoration? Different definitions/ views

Bringing back some form of trees in former forested lands → For socio-economic and environmental benefits ← Enhance the productivity and protective functions of forests

E.g. seeding, planting, ANR, agroforestry, enrichment planting and silvicultural management

Source: https://www.fao.org/3/i8382en/I8382EN.pdf

Restoration efforts are constrained

- Many activities at pilot scale; governance, institutional, finance, capacity, technical and knowledge barriers
- Need more targeted investments
  - where most needed/will make the most difference
  - with stronger multi-stakeholder and context-based social, technical and institutional approaches

Source: Chokalingam (2022); https://www.fao.org/support-to-investment/en/

- **Why**
- **How**

Building capacity and knowledge: FAO's focus

- FAO: a knowledge organization
- Intergovernmental status and authority to provide a neutral platform for dialogue and knowledge exchange
- Support developing standards (with knowledge products/data); supports their implementation
- Capacity building to use these standards, knowledge products etc.

Source: https://www.fao.org/3/cb7099en/cb7099en.pdf

Building capacity: various dimensions

- Capacities at three interlinked dimensions: individuals, organizations and the enabling environment
- Retaining and using effectively the capacity built

Source: https://www.fao.org/capacity-development/our-vision/en/

Building capacity : both technical and functional

- Technical capacities (e.g. silvicultural techniques)
- Functional capacities; examples
  - exchange information and knowledge
  - implement programmes and projects

Source: https://www.fao.org/capacity-development/our-vision/en/

Broader spectrum

- The ability to work cross-sectorally: build knowledge on sectors' and stakeholders' roles
- Capitalize on all knowledge sources, including of the traditional communities
- Make use of experiences/ lessons learned elsewhere

Source: https://www.fao.org/3/ca4627en/ca4627en.pdf

Broader spectrum

- Acquire new skills/knowledge; fast changing world with technologies- uptake patchy (FAO, 2019)
- Embrace the complexity; apply mind beyond sector with a transformation-oriented mindset

Source: https://www.fao.org/3/ca4627en/ca4627en.pdf

UN Restoration Decade Principles

Source: https://www.fao.org/3/cb6591en/cb6591en.pdf

Golden rules

Source: Sacco *et al.* (2021), Global Change Biology, 27 (7), 1328-1348

FAO's support on FLR capacity building: examples

- Conflict resolution capacity building (sectoral/stakeholder)
- FLR practitioner course: technical and functional capacities

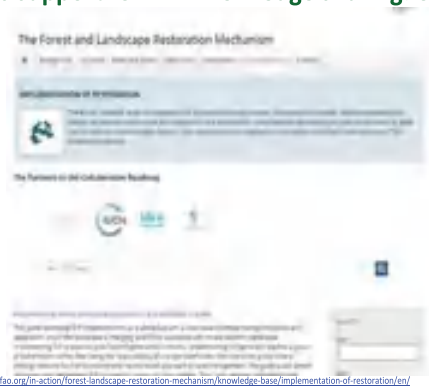
FAO's support on FLR capacity building: examples

- FLR Days: for preparing bankable projects
- Supporting the implementation of the National Agroforestry Policy in India: grassroots-level extension
- Help develop protocols for quality planting material and certification of nurseries for agroforestry

FAO's support for FLR knowledge sharing: examples

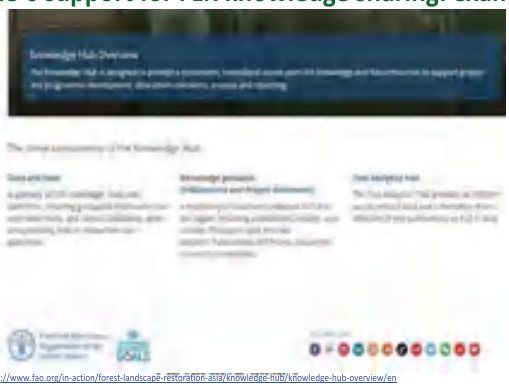
Source: https://www.fao.org/sustainable-forest-management/toolbox/modules/forest-and-landscape-restoration/basic-knowledge/en/

FAO's support for FLR knowledge sharing: examples



Source: https://www.fao.org/in-action/forest-landscape-restoration-mechanism/knowledge-base/implementation-of-restoration/en/

FAO's support for FLR knowledge sharing: examples



Source: https://www.fao.org/in-action/forest-landscape-restoration-asia/knowledge-hub/khowledge-hub-overview/en

FAO's support for FLR knowledge sharing: examples

- Regional urban forestry meetings

- Analyzing and disseminating inspirational FLR cases

Source: https://www.fao.org/3/cb6631en/cb6631en.pdf

FAO's support for FLR knowledge sharing: examples

Source: https://www.fao.org/in-action/forest-landscape-restoration-asia/flr-videos/restore-asia-pacific-flr-video-journal/en

Knowledge Shared = KnoWledge²

Source: https://stangarfield.medium.com/what-are-some-inspirational-quotes-about-learning-or-sharing-knowledge-856751bdea6c

Take away points

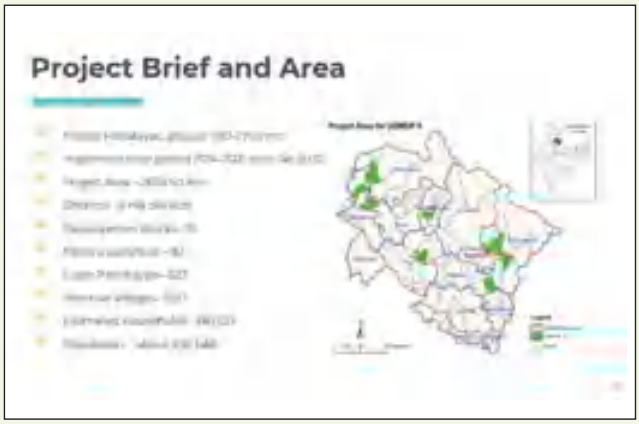
- Systems thinking; embrace complexity
- Transformative change and adaptive management with all key sectors and stakeholders
- Not only what we do but how we do; *do things right and do right things* through innovations

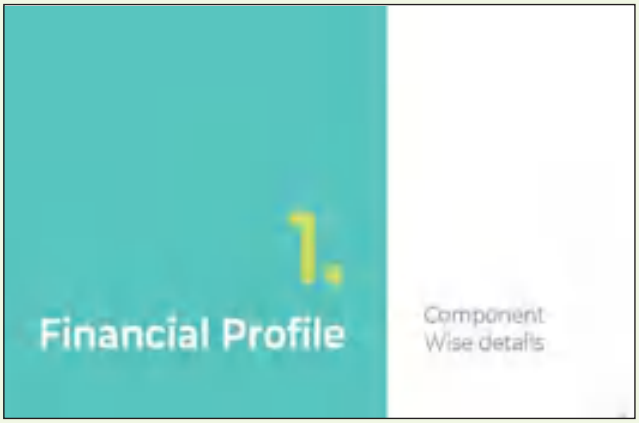
Source: https://www.brainyquote.com/quotes/peter_drucker_134881

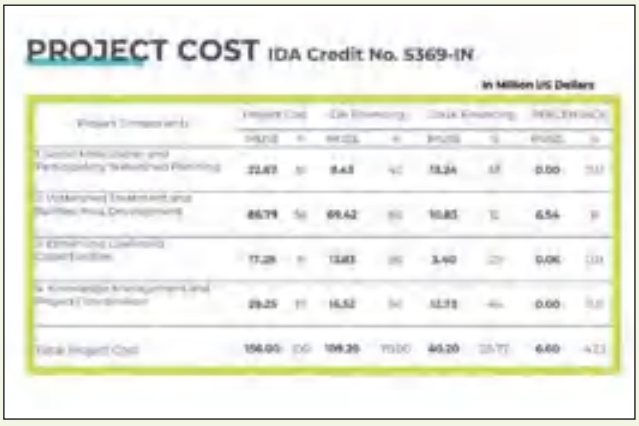
Emphatic thanks

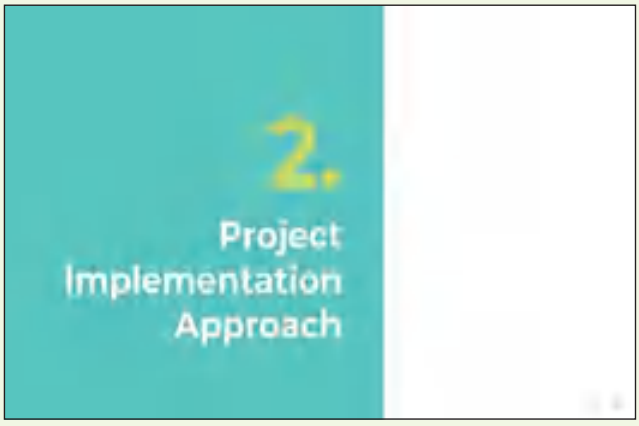
illias.animon@fao.org

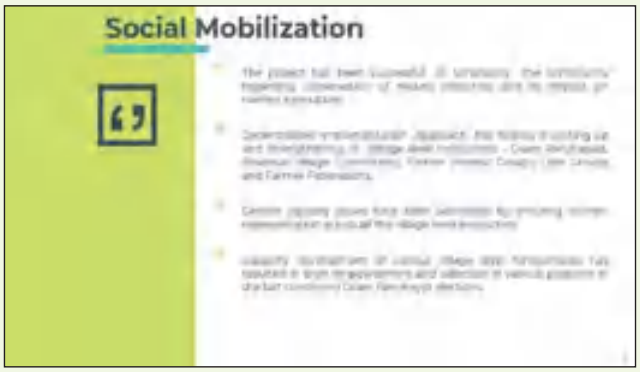
26. Enhancing ecosystem services by building climate resilient watersheds: Mrs. Neena Grewal, Project Director - Uttarakhand Decentralised Watershed Development Project-II, Uttarakhand, Dehradun










Social Mobilization


Collective Decision Making-
Planning &
Implementation

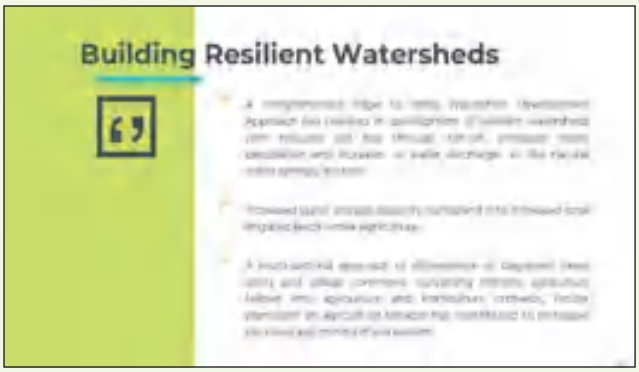

Demand driven planning-
Participatory Approach


Ownership of assets-
User Groups

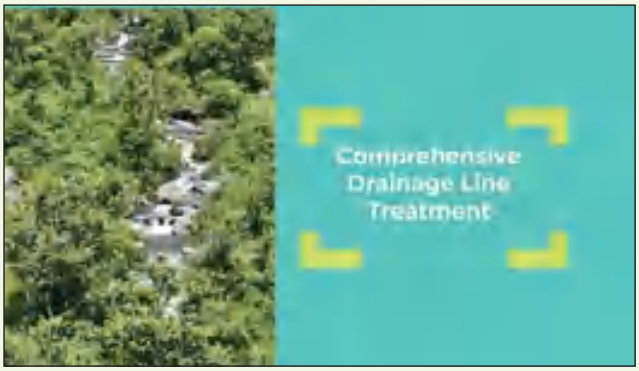

Inclusiveness-
Women Aam Sabha


Social Audit-
Participatory Monitoring &
Evaluation


Financial Autonomy-
Gram Panchayats


Building Resilient Watersheds


Natural Resource Management-
Afforestation


Comprehensive Drainage Line Treatment

Success Stories-1

Rejuvenation of Naviaye Naula Through Community Participation Village Sangiakoti District- Pauri

Rejuvenation of Naviaya Naula Through Community Participation
Village Sangiakoti, District- Pauri

- Outmigration issues Households reduced from 44 (in 0) in the last three decades
- People leaving agriculture and due to regular potable water supply through pipelines the Naula water was not much used
- Traditional and revered water source Naviaya Naula was drying up
- Constant sensitization of the community especially women on sustainability of natural resources
- Women of the village dug 100 recharge pits of size 2.00m*1.00m*1.50m in the upper catchment of the Naula in the summer of the year 2016

Rejuvenation of Naviaya Naula Through Community Participation
Village Sangiakoti, District- Pauri

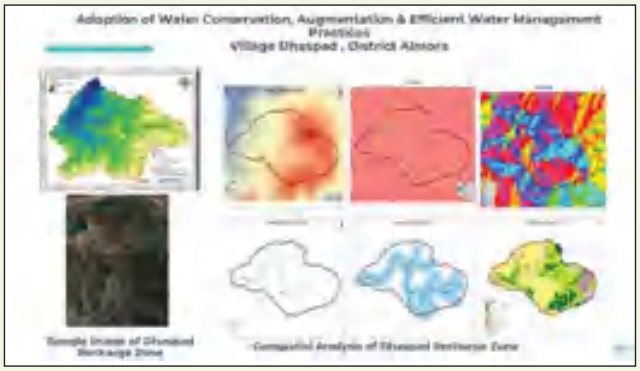
- After one rainy season, water emerged in the water source in January 2017
- This motivated them to dig up 25 more recharge pits and 800 contour trenches in its upper catchments in the summer of 2017 and now water is available in the Naula throughout the year
- The sensitization of the locals especially women towards sustainability of the water sources has resulted in the rejuvenation of Naviya Naula.

Success Stories-2

Adoption of Water Conservation, Augmentation & Efficient Water Management Practices Village Dhaspad, District Almora

Adoption of Water Conservation, Augmentation & Efficient Water Management Practices
Village Dhaspad , District Almora

- Dhaspad village with 40 households and population of 226
- Almost 90% agriculture was rainfed before the project and it was not sustainable
- About 30 households provided with irrigation facilities through multilayer
- Water augmentation interventions carried out in 2 ha. of recharge zone of Dhaspad



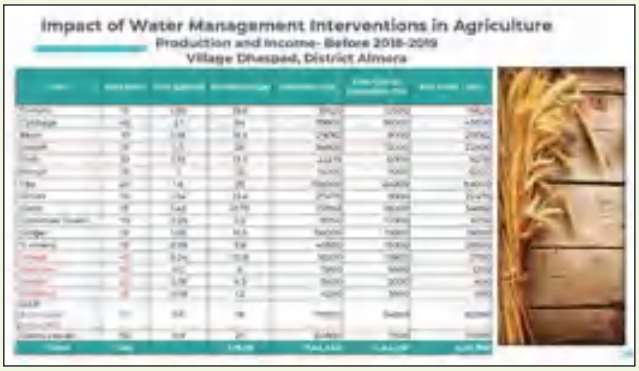

Watershed Management Interventions


Water Conservation & Augmentation Interventions
Village Dhaspad , District Almora


Water Harvesting Interventions
Village Dhaspad , District Almora
Water Harvesting interventions
16 Roof water harvesting tanks (10 cum),
5 Concrete irrigation tanks (75m3),
1 Geo membrane tank (20m3),
18 LDPE tanks (2cum),
1 Solar powered water lifting scheme

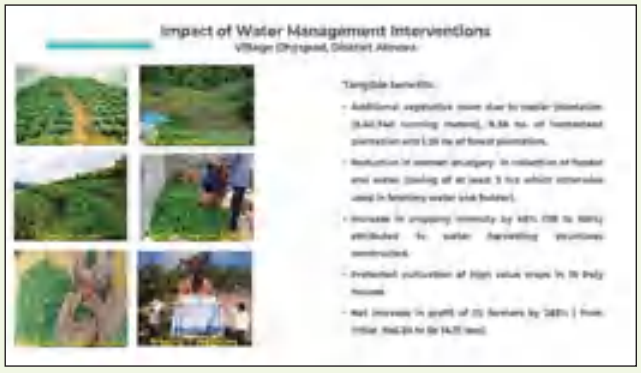

Comparison of Solar, Diesel & Electricity operating pumps
Village Dhaspad, District Almora


Solar Powered Pumping Scheme
Village Dhaspad, District Almora


Impact of Water Management Interventions in Agriculture
Production and Income- Before 2018-2019
Village Dhaspad, District Almora

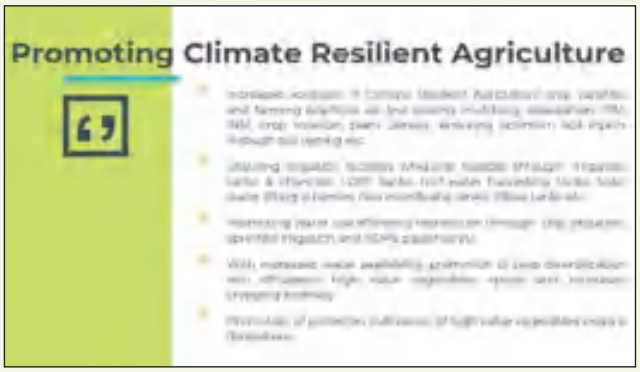

Impact of Water Management Interventions in Agriculture
Production and Income- After 2019-2020
Village Dhaspad, District Almora


Impact of Water Management Interventions
Village Dhaspad, District Almora


Impact of Water Management Interventions
Village Dhaspad, District Almora

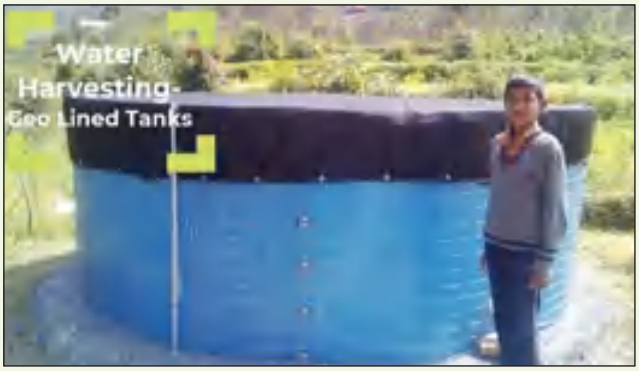

Impact of Water Management Interventions
Village Dhaspad, District Almora


Adoption of Water Conservation, Augmentation & Efficient Water Management
Village Dhaspad , District Almora
3rd National Water Award Year 2022

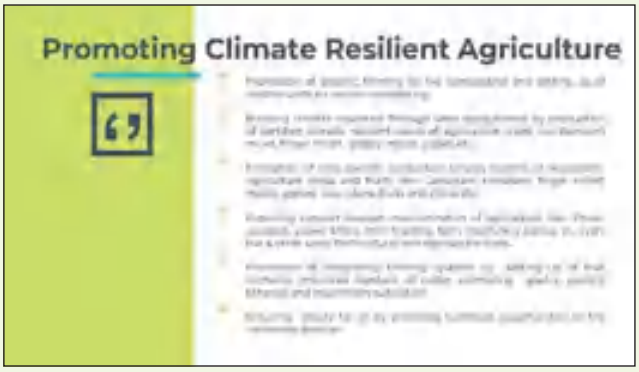

Promoting Climate Resilient Agriculture


Water Harvesting-
Irrigation Tanks


Water Harvesting-
LDPE Tank


Water Harvesting-
Geo Lined Tanks


Water Harvesting-
Solar Water Lifting Pumping Schemes


Promoting Climate Resilient Agriculture


Cluster Approach-
Vegetable Clusters


Cluster Approach-
Horticulture Cluster

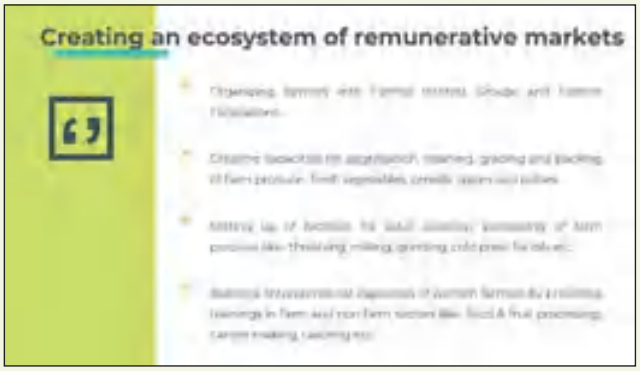

VL Shyahi Hal
Improved Agricultural tool - reducing drudgery


Adoption of modern technologies


Protected Cultivation-
Polyhouse


Integrated Farming-
Goatry


Livelihood Opportunities-
Vulnerable Groups


Creating an ecosystem of remunerative markets


Exposure Visit-
Women FIGs

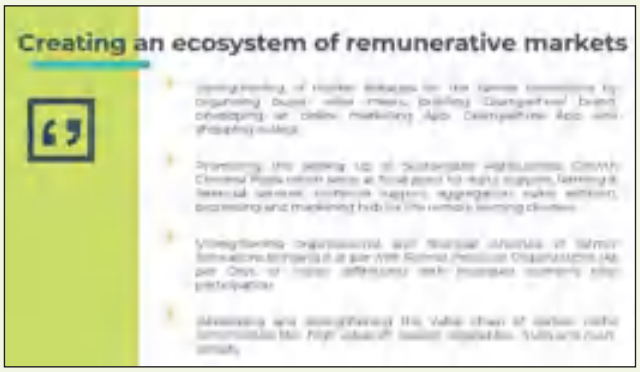

Improved Agriculture practices-
Mulching

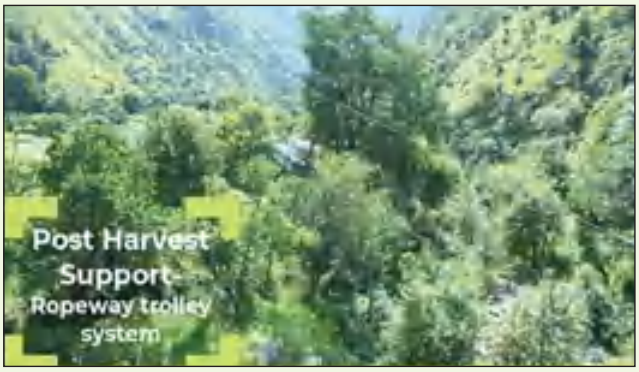

Grading & Packaging-
Women FIGs


Enterprise Development-
Women Entrepreneurs


Building Entrepreneurial capacities-
Women FIG


Livelihood Initiatives-
Non-farm based


Creating an ecosystem of remunerative markets

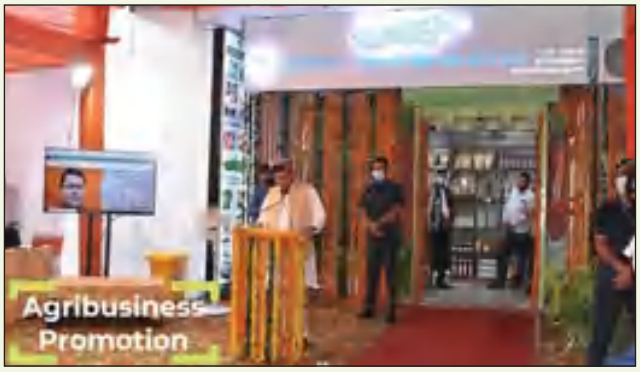

Post Harvest Support-
Ropeway trolley system

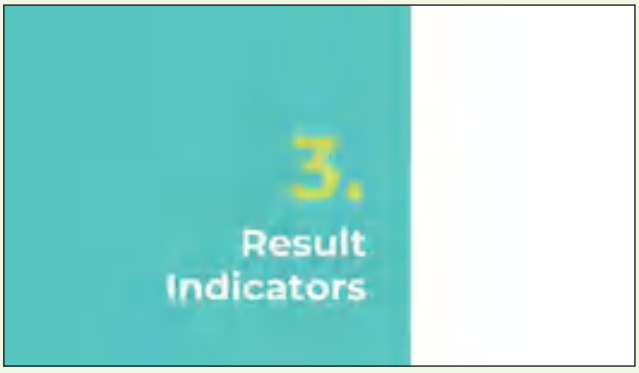

Post Harvest Support-
Automated Grading Machine

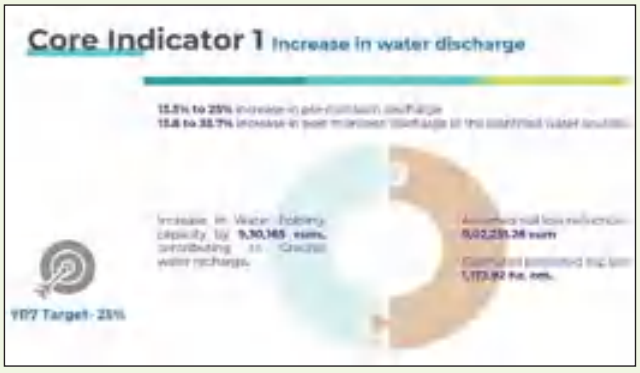

Agribusiness Support-
Growth Centers

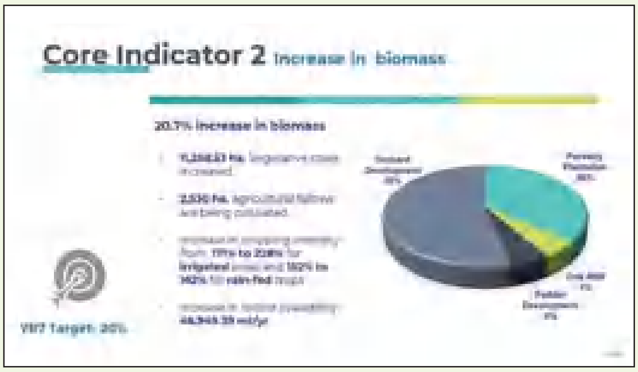

Agribusiness-
Value Addition

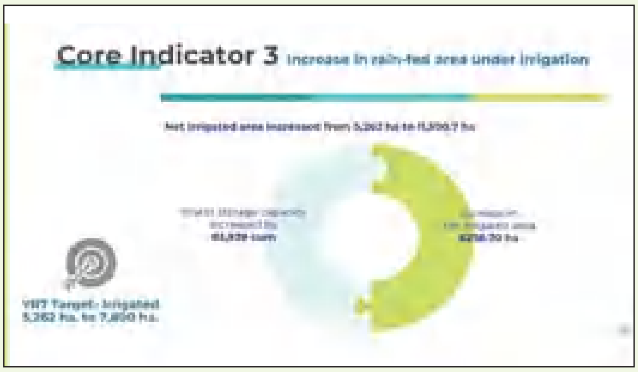

Marketing-
Gramyashree stores
GRAMYASHREE

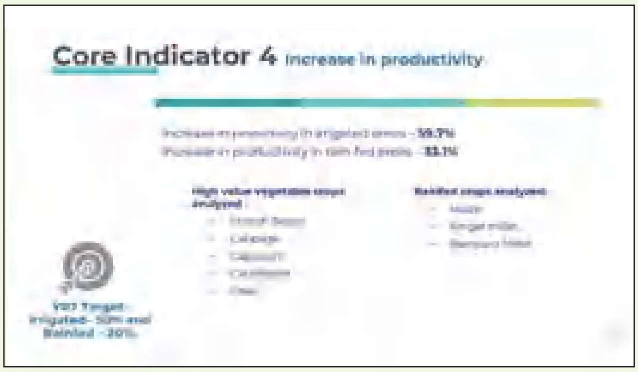

Agribusiness Promotion

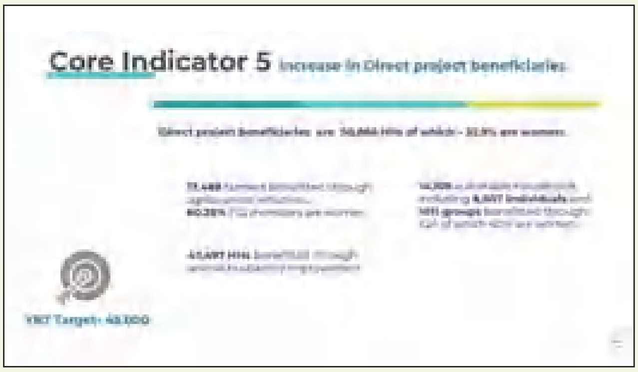

3.
Result Indicators


Core Indicator 1 Increase in water discharge

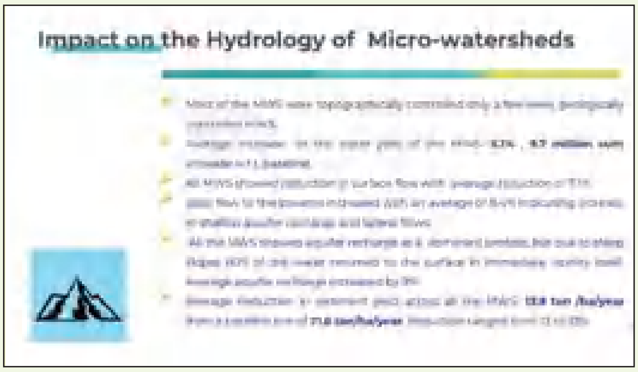

Core Indicator 2 Increase in biomass
20.7% increase in biomass

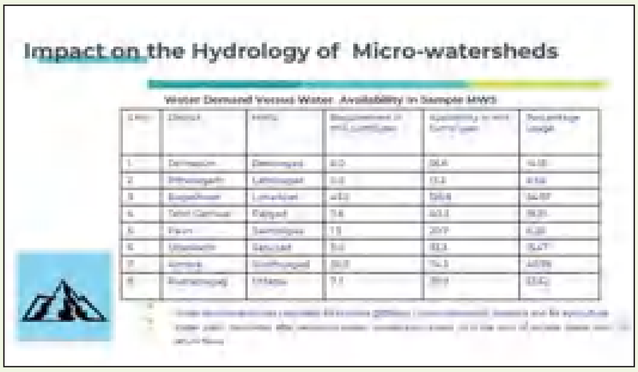

Core Indicator 3 Increase in rain-fed area under irrigation

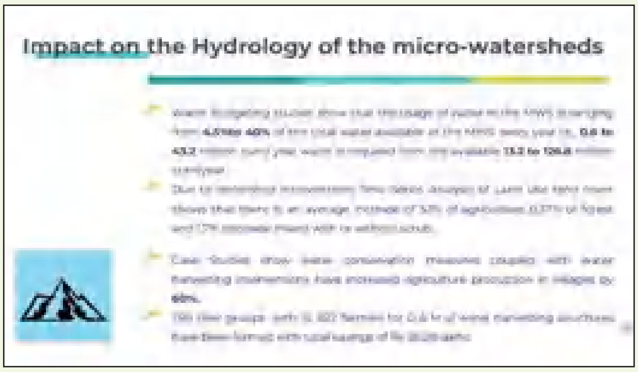

Core Indicator 4 Increase in productivity

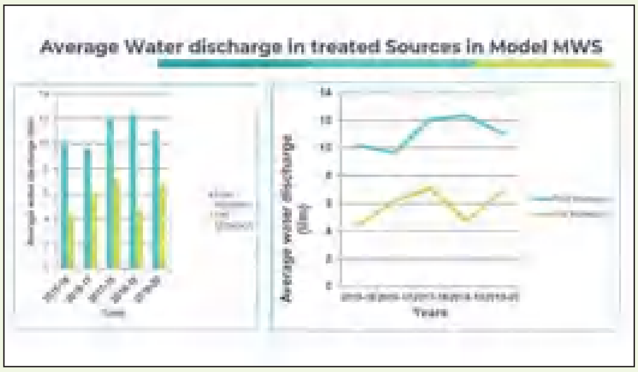

Core Indicator 5 Increase in Direct project beneficiaries

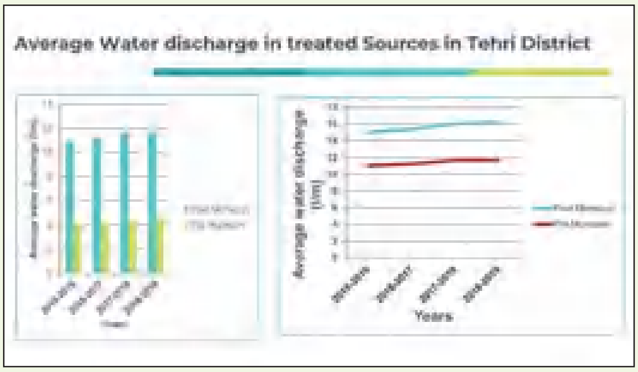

4.
Impacts of
Watershed
Approach


Impact on the Hydrology of Micro-watersheds


Impact on the Hydrology of Micro-watersheds

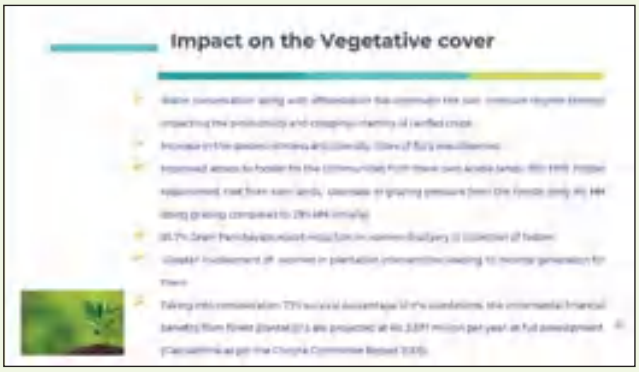

Impact on the Hydrology of the micro-watersheds


Average Water discharge in treated Sources in Model MWS
Average water discharge (l/m)
Years


Average Water discharge in treated Sources in Tehri District
Average water discharge (l/m)
Years

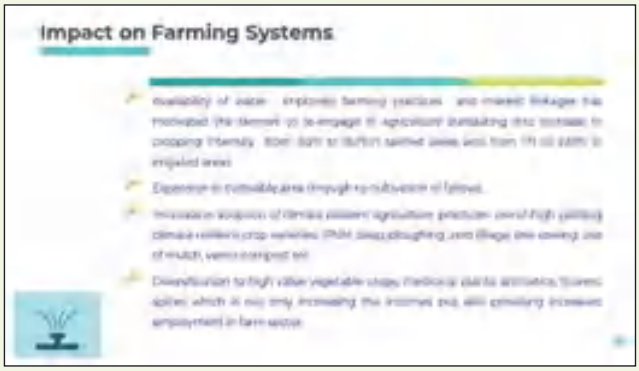

Improved water availability- Diversification of Agriculture


Improved water availability- Diversification of Agriculture


Impact on the Vegetative cover


Increase in Biomass- Increased availability of fodder


Afforestation- Livelihood for women


Impact on Farming Systems


Adoption of Climate Resilient Agriculture Practices


Adoption of Climate Resilient Agriculture Practices

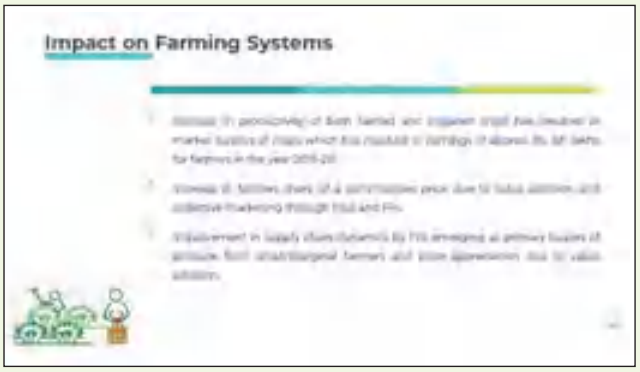

Diversification- Off Season Vegetables


Integrated Farming System
Horticulture Orchards


Protected
Cultivation-
Floriculture


Integrated
Farming System-
Goatry

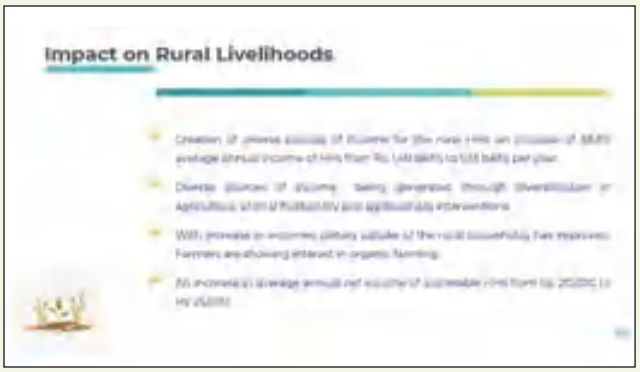

Integrated
Farming System-
Poultry

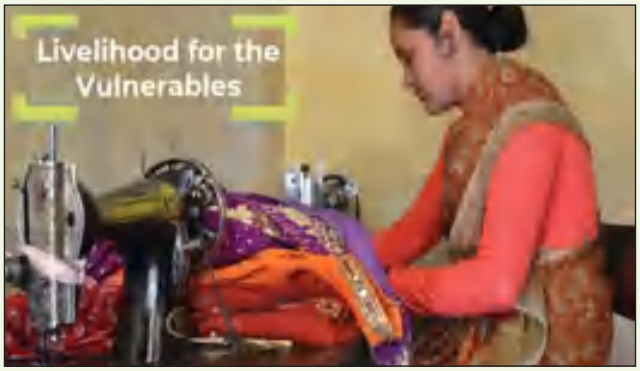

Impact on Farming Systems


Productivity


Value Addition of
Increased
Productivity

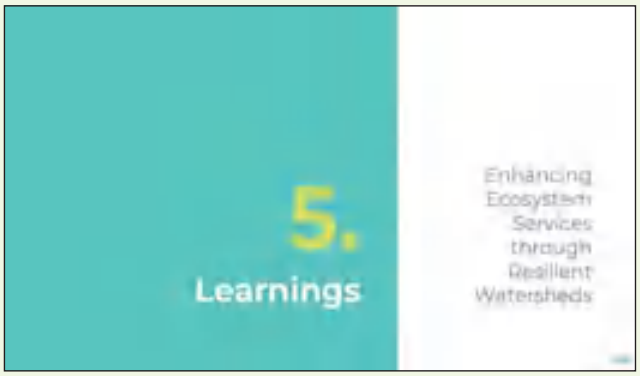

Marketing of
Increased
Productivity

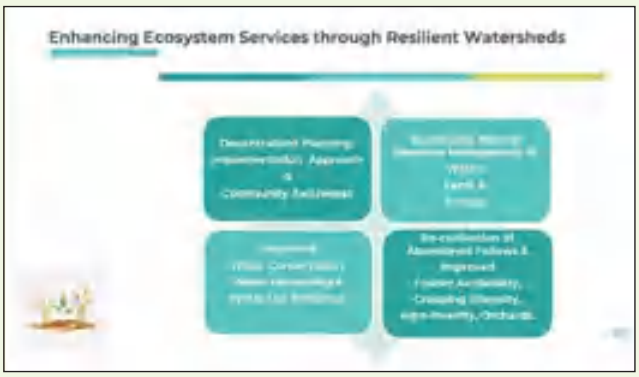

Impact on Rural Livelihoods

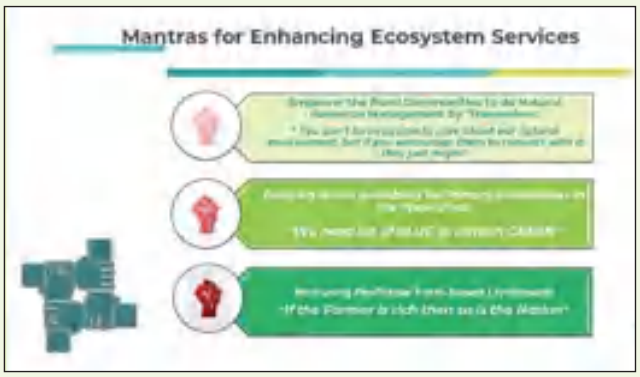

Livelihood for the
Vulnerables

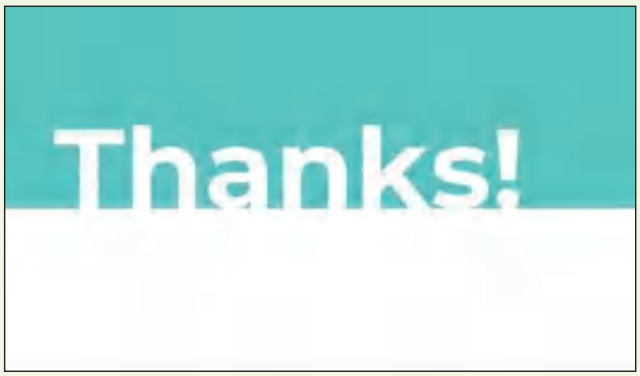

Women
Entrepreneurs


Employment
Opportunities from
traditional Art forms

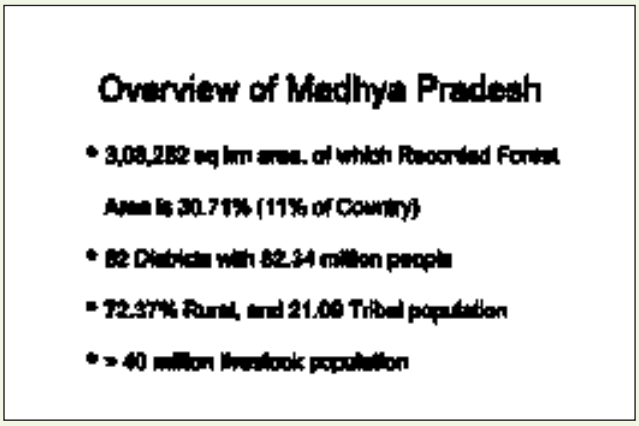

5.
Learnings
Enhancing
Ecosystem
Services
through
Resilient
Watersheds

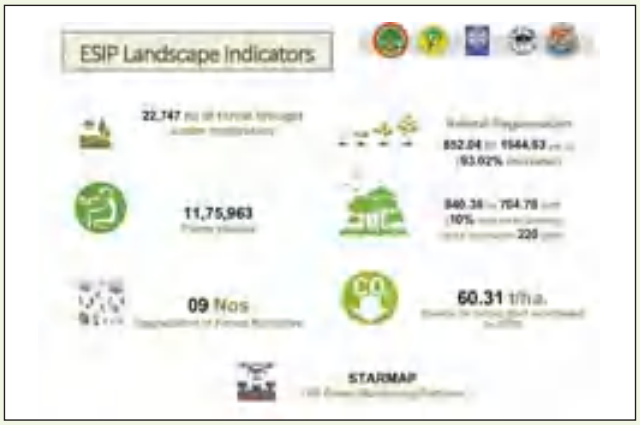

Enhancing Ecosystem Services through Resilient Watersheds


Mantras for Enhancing Ecosystem Services


Thanks!

27. Forest landscape restoration under ESIP – success stories from the state of Madhya Pradesh: Mr. S.P. Sharma, APCCF, Madhya Pradesh Forest Department, Bhopal






ESIP Plantation Geo-tagged Photos
Dec, 2018
Division - North Betul
Range - Bhoura
Compartment No. - 391 PF
Year of Plantation - 2019
Advance Work- Pit Digging
Sept. 2022
Current Status


APRIL 2016

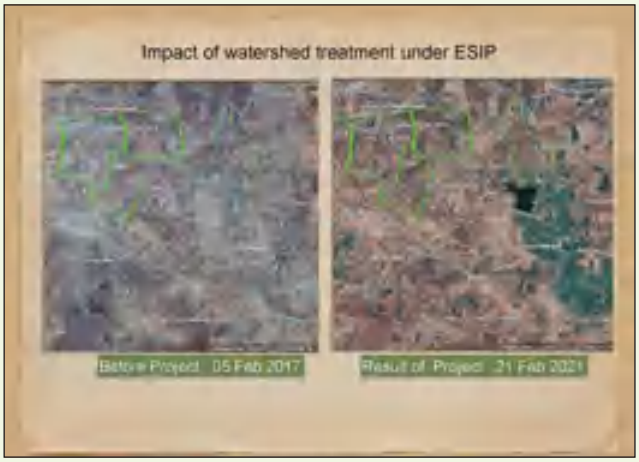

FEB 2019


MARCH 2020


FEB 2021


Change inside the Treated forest Area
21 Feb 2021
05 Feb 2017
Compartment 391


21 Feb 2021
05 Feb 2017


Impact of watershed treatment under ESIP
Before Project - 05 Feb 2017
Result of Project - 21 Feb 2021

Ground water table status in ESIP Landscapes of MP.

S. No.	Name of Division	Range	Ground Water Table				
			Water Resources	Nos.	Average Below Ground Level (in Feet)		Water Table increased (%)
					Oct., 2021	Oct., 2022	
1	Hoshangabad	Banapura	Well	11	3.72	3.58	3.77
		Sukhtawa	Well	14	12.80	12.47	2.56
		Itarsi	Well	16	31.17	26.25	15.79
			Handpump	5	29.53	26.25	11.11
			Tubewell	1	32.81	29.53	10.00
2	North Betul	Bhoura	Well	61	18.21	17.64	3.14
		Shahpur	Well	10		11.29	
3	Sehore	Budni	Well	3	14.07	14.01	0.40
			Handpump	12	28.73	27.20	5.30
			Tubewell	58	27.26	25.89	5.01

Ground water table status in ESIP Landscapes of MP.

S. No.	Name of Division	Range	Ground Water Table				
			Water Resources	Nos.	Average Below Ground Level (in Feet)		Water Table increased (%)
					June, 2021	June, 2022	
1	Hoshangabad	Banapura	Well	11	3.81	3.55	6.68
		Sukhtawa	Well	14	7.31	6.91	5.47
		Itarsi	Well	16	7.47	7.19	3.77
			Handpump	5	12.80	12.80	0.00
			Tubewell	1	12.00	11.00	8.33
2	North Betul	Bhoura	Well	61	16.75	15.09	9.93
		Shahpur	Well	10		25.10	
3	Sehore	Budni	Well	3	43.33	42.80	1.23
			Handpump	12	95.00	93.58	1.07
			Tubewell	58	93.33	91.58	1.87

Rabi Crop in the Landscape after treatment under ESIP / GIM

Miliwatershed	Halka_village	2017-18	2018-19	2019-20	2020-21	2021-22
1	2	3	4	5	6	7

National Skills Qualifications Framework (NSQF Course)	Apparel made-up and home furnishing sector AMH/Q5301
Persons trained	1010
Person Employed	1010
Employment type	Self Employment and Jobs
Average Income	Rs. 3000-5000/- per month
Placement	19 - South Export Pvt Ltd, Bengaluru Salary - 9000/- per month (Work Select)

National Skills Qualifications Framework (NSQF Course)	Helper/ Assistant Electrician CON/ Q601
Persons trained	163
Person Employed	144
Employment type	Self Employment and Jobs
Average Income	Salary Rs. 8700-10000/- per ... own business Rs. 25000-30000/- per

National Skills Qualifications Framework (NSQF Course)	Helper/ Assistant Two Wheeler Repair ASC/Q1401
Persons trained	112
Person Employed	56
Employment type	Self Employment and Jobs

Total Number of Nets Distributed	3405
Nets distributed to the households (nos)	925
Quantity of Mahua Flower Collected (in QTL)	1589.61
Quantity of Mahua Flower Exported (QTL)	27 qtls
Profit to the beneficiaries in INR	2,70,000/-


Mahua Bakery Enterprise Setup, N. Betul

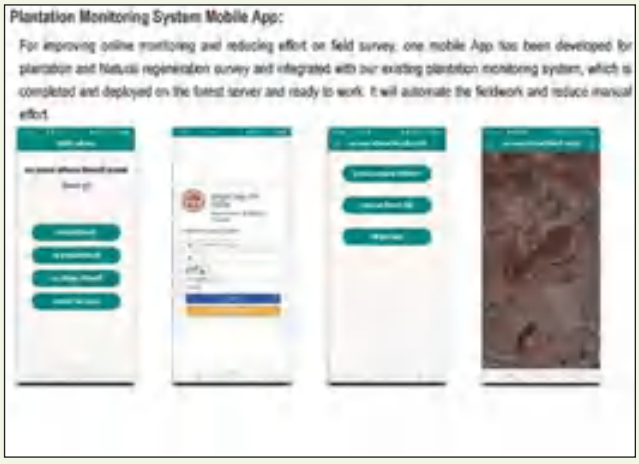

Developing Community Based Model for Sustainable Utilization of NTFPs
Mushroom Cultivation
Persons trained
Person Employed
Employment type
Average income
Self Employment

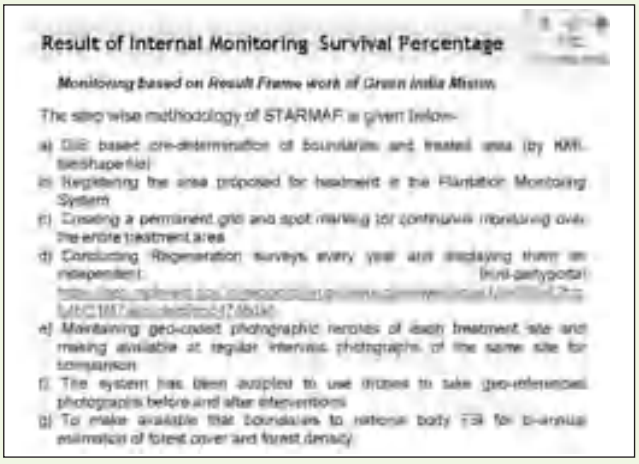

Impact of Watershed level Intervention
Paddy and Maize harvest N. Betul, MP, India


Users Benefited from CPR restoration (numbers)
Activity
Well Repairing (02)
Village
Ranghi & Pipalgota
Range
Itarsi & Banapura
Division
Hoshangabad
Users
728

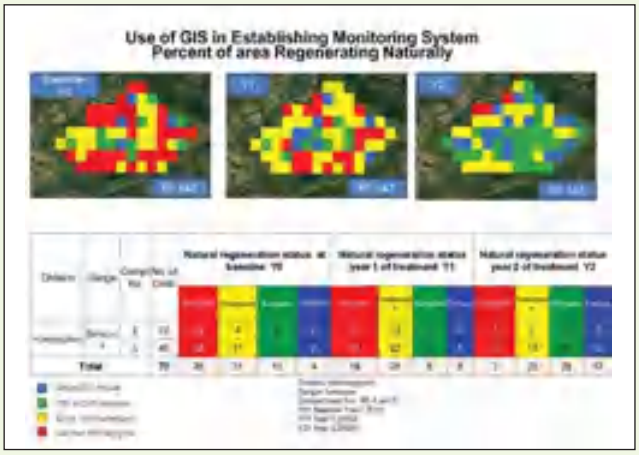

Users Benefited from CPR restoration (numbers)
Activity
Range
Users benefited
497
Impact

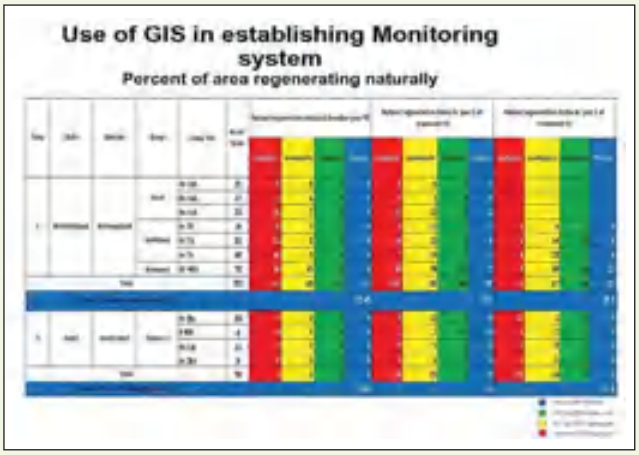

Users Benefited from CPR restoration (numbers)
Users Benefited
125
95
30

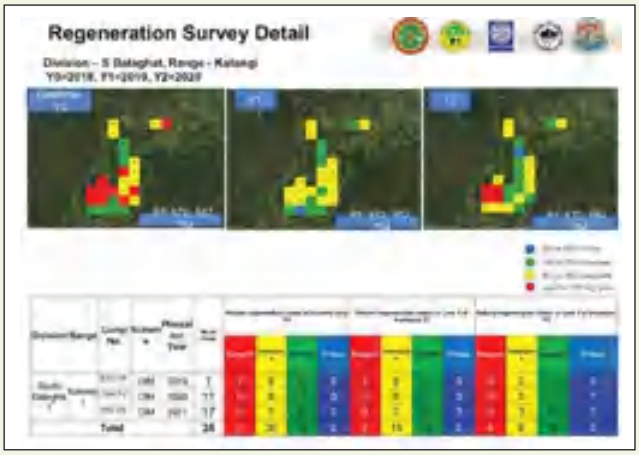

Plantation Monitoring System Mobile App:
For improving online monitoring and reducing effort on field survey, one mobile App has been developed for plantation and Natural regeneration survey and integrated with our existing plantation monitoring system, which is completed and deployed on the forest server and ready to work. It will automate the fieldwork and reduce manual effort.

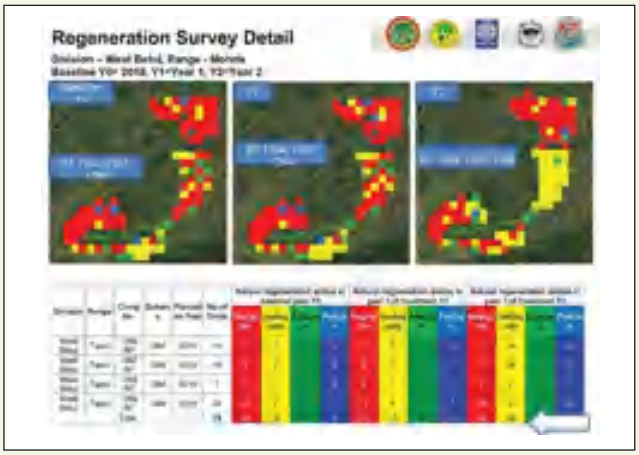

Result of Internal Monitoring Survival Percentage
Monitoring Based on Result Frame work of Green India Mission
The step wise methodology of STARMAP is given below-
a) GIS based pre-determination of boundaries and treated area (by KML files/shapefile)
b) Registering the area proposed for treatment in the Plantation Monitoring System
c) Creating a permanent grid and spot marking for continuous monitoring over the entire treatment area
d) Conducting Regeneration surveys every year and displaying them on independent
e) Maintaining geo-coded photographic records of each treatment site and making available at regular intervals photographs of the same site for comparison
f) The system has been supplied to use drones to take geo-referenced photographs before and after interventions
g) To make available the boundaries to national body FSI for bi-annual estimation of forest cover and forest density


Online plantation monitoring-MPFD
Internal Monitoring


Use of GIS in Establishing Monitoring System
Percent of area Regenerating Naturally


Use of GIS in establishing Monitoring system
Percent of area regenerating naturally


Regeneration Survey Detail


Regeneration Survey Detail


Thank You

28. ESIP initiatives in restoration of degraded forests in Chhattisgarh: Mr. Arun Kumar Pandey, APCCF, Chhattisgarh Forest and Climate Change Department, Raipur

International Workshop
'Enhancing Ecosystem Services by Improving Forest Quality and Productivity, and SLEM Knowledge Dissemination'

ESIP initiatives in restoration of degraded forests in Chhattisgarh

Arun Kumar Pandey IFS
APCCF (JFM)

Background

- Chhattisgarh is one of the youngest states f India, carved out of Madhya Pradesh in the year 2000. It is the seventh largest state of the country in terms of area.
- The total geographical area of the State is around 135192 sqm which constitutes 4.11% of the total geographical area of the country
- Land use pattern in Chhattisgarh-

S. No.	Land use types	Area (in 000' ha.)
1	Total Geographical Area	13,519
2	Forests	6331
3	Reporting area for land utilization	13,790
4	Not available for land cultivation	1027
5	Culturable wasteland	394
6	Permanent pastures and other grazing land	882
7	Land under misc. tree crops	1
8	Land available for cultivation	351
9	Fallow lands other than current fallows	254
10	Current fallow land	260
11	Net area sown	468

Vulnerability Assisment

Based on vulnerability and risk assessment report under climate change cell, Dr. N.H. Ravindranath and team identified following top five indicators-

1. Crop, livestock, and fish yield variability
2. Percentage net area cultivated under Hrticulture.
3. Percentage of available water resources under fish culture.
4. Forest dependence of rural tribal communities.
5. Number of approved Minor Forest Produce (MFP) Micro Enterprises.

All this indicators pointing towards water and soil conservation with forest restoration.

ESIP in Chhattisgarh

- The Landscapes have been selected in the five Forest Divisons of four Forest Circles Durg, Bilaspur, Kanker and Sarguja of previously selected GIM landscape of the State.
- So that due importance is given to the various ecosystems and the associated flora and fauna in these landscapes.
- The selected landscapes are chosen because of their susceptibility to Androgens factors of degradation and indicators of vulnerability assessment.

Area of the ESIP Landscapes

SN	Division (L2)	Forest Area (ha)				Revenue Area	Total Area of landscape
		Very Dense	Mod. Dense	Open	Total		
1	Kawardha	0.00	2525.75	3011.91	5537.66	2450.03	7987.69
2	Marwahi	0.00	1961.14	2804.01	4765.15	4735.91	9501.06
3	Katghora	1055.90	2989.90	519.18	4564.98	2144.16	6709.14
4	Balrampur	1107.74	1140.10	1980.20	4228.04	2910.69	7138.73
5	Kanker	0.00	1146.10	2405.87	3551.97	4265.67	7817.64
Total		**2163.61**	**9763.02**	**10721.17**	**22647.80**	**16506.46**	**39154.26**

Special Innovation

- Biodiversity Assessment by highly qualified team in all the five landscapes. (Component –A & B)
- Rare endangered and threatened Species mapping is done in Kanker Division, work in Kawardha division is on progress . (Component – B)
- Social Impact analysis of Project activates in villages is on progress. (Component – D)
- Prepared Environment Management Plan of Balrampur ESIP Landscape (Draft Report sent to MoEF)
- Carbon Measurement and Carbon Credits trading (Proposed)- (Component – B)

Special Innovation

Plantation Activities In ESIP Landscape

(Improving Forest Quality in selected landscapes)

SN	Division	SMC Work (ha.)	Plantation Area (ha.)
1.	Kawardha	510	720
2.	Marwahi	1133	1173
3.	Katghora	500	750
4.	Balrampur	500	750
5.	Kanker	1460	370
	Total	**4103**	**3763**

PLANTATION WORK

Plantation work in - Balrampur Division

PLANTATION WORK

Plantation under ESIP : Marwahi Division

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PLANTATION WORK

Plantation under ESIP : Kawardha Division

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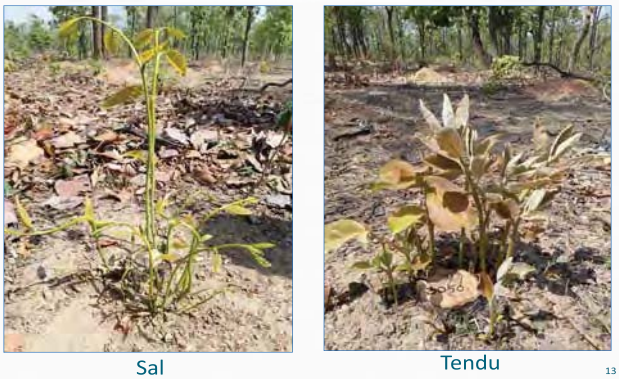
PLANTATION WORK

Plantation work in Kawardha Division

COPICE REGENERATION: BALRAMPUR



Sal Tendu

13

COPICE REGENERATION: BALRAMPUR

Lendia

14

COPICE REGENERATION

Sal Katghora Division Saja

15

PLANTS ADOPTION

Katghora Division

JFMCs & Population in ESIP Landscapes

S. N	ESIP Project Area	Villages Under ESIP	Population	Number Of Families
1	Balrampur	07	14485	2997
2	Marwahi	06	8343	1780
3	Katghora	08	3533	792
4	Kawardha	08	6519	1416
5	Kanker	09	11222	2804
	Total	**38**	**44102**	**9789**

S.N.	Forest Division	Schedule Caste (%)	Schedule Tribe (%)	O.B.C. (%)	General (%)
1	Balrampur	2.0	77.50	20.20	0.30
2	Marwahi	6.3	70.0	23.50	0.20
3	Katghora	12.50	86.00	1.0	0.50
4	Kawardha	-	98.90	1.10	-
5	Kanker	3.70	95.00	1.15	0.15
Total (%)		**4.90**	**85.48**	**9.39**	**0.23**

Capacity Building (HRD Development)

SN.	Name of Division	No. of Meeting, Training/Workshop	Beneficiaries		
			Male	Female	Total
1	Kawardha	16	1180	790	**1970**
2	Katghora	20	595	573	**1168**
3	Marwahi	21	333	314	**647**
4	Balrampur	10	170	138	**308**
5	Kanker	3	40	28	**68**
Total		**60**	**2318**	**1843**	**4161**

State Level Workshop and Brain Storming Sessions




Bilaspur

Training on Carbon & Biodiversity Measurement

Carbon & Biodiversity Assessment Workshop - Kawardha Division

Training on Carbon & Biodiversity Measurement

Training in Field- Kawardha Division

TRAINING AND WORKSHOPS

Training in Field- Kawardha Division

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TRAINING AND WORKSHOPS


Kanker Division


TRAINING AND WORKSHOPS


SOCIAL SURVEY & PRA IN ESIP LANDSCAPE VILLEGES

JFMCs Meeting

Kawardha Division

Marwahi Division

LIVELIHOOD SUPPORTS FOR NTFP USER GROUPS, WOMENS SELF HELP GROUPS

Livelihood Generation in ESIP Landscape

SN	Name of Division	Name of Activity/Training	No of Beneficiaries
1	Marwahi (10 Villages)	Vermi compost, Lac Production, Lac Bengal Making, Bamboo Articles, Custard apple Ice cream, Dhenki Rice Processing, Dona Pattal Making, Washing Powder making	4240
2.	Kawardha	Lac Production, Char Seed Collection, Poultry Farming	525
3.	Katghora	Dhenki Rice, Lac Production, Poultry Farming, Cloth Sewing, Fishery, Improved Agriculture	590
4.	Balrampur	Poultry Farming, Fishery, Improved Agriculture, Vermi compost Production, Lac Production, Lac Bengal Making, Kosa Cultivation	1894
5.	Kanker	Livelihood Generation, File pad making, Bamboo Processing	68
	Total		7317

Capacity building supports for NTFP user groups- Balrampur



Lac Palan, Vill.- Babhani, Nawgai Benefiecery - 210

Vill.- Girwani, Vinash Viheen Vidohan Prashikshan

34

Capacity building supports for NTFP user groups, women, self help groups (SHG)


Balrampur Division

Value addition investments to traditional NTFP resources



Katghora Division

VARIOUS INCOME GENERATION ACTIVITIES UNDER ESIP

No of Beneficiaries - 18

Average Monthly Income – Rs. 2000/- to 2500/-

Tailoring work by SHGs : Marwahi Division

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SITAFAL PROCESSING

No of Beneficiaries - 3300

FISH FARM UNDER ESIP

No of Beneficiaries - 102

Fish Farming : ESIP Kawardha

FISH FARM UNDER ESIP


No of Beneficiaries - 102

Fish Farming : ESIP Katghora

Balrampur Division


No of Beneficiaries - 62


Preparation for Kosa Palan

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VARIOUS ACTIVITIES UNDER ESIP

Vegetable Cultivation:
Kawardha Division

No of Beneficiaries - 12

Average Monthly Income –
Rs. 5000/-

Mustard Cultivation:
Balrampur Division

VARIOUS ACTIVITIES UNDER ESIP

Cassia tora Collection :
Balrampur Division

No of Beneficiaries - 32

erage Monthly Income –
Rs. 1800/- to 2000/-

MFP Marketing:
Kawardha Division

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Exposure Visit of SHG Members

Marwahi Division

Marwahi Division

Marketing Support for NTFP based Product

Marwahi Division

MARKETING SUPPORT FOR NTFP BASED PRODUCT UNDER ESIP

Inauguration of MFP Value Addition
Centre
Marwahi Division
Date- 06.01.2021

By Hon'ble C.M.
Shri Bhupesh Baghel

MARKETING SUPPORT FOR NTFP BASED PRODUCT UNDER ESIP

Rice Processing through Theki : Marwahi Division

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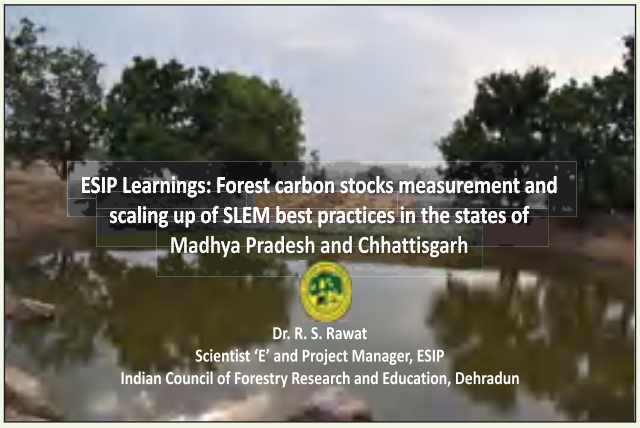
Thanking you
for Patient Listening

29. ESIP Learnings: Forest carbon stocks measurement and scaling up of SLEM best practices in the states of Madhya Pradesh and Chhattisgarh: Dr. R. S. Rawat, Project Manager, ESIP, ICFRE, Dehradun



Background

- Sustainable Land and Ecosystem Management - Country Partnership Programme (SLEM-CPP) was a joint initiative of the Govt. of India and GEF with 7 projects implemented in different parts of the country.
- ICFRE implemented GEF/ World Bank funded project titled 'Policy and Institutional Reform for Mainstreaming and Scaling-up of the Sustainable Land and Ecosystem Management' from 2009 to 2014 as a Technical Facilitation Organization under SLEM-CPP.
- Provided technical supports, capacity building, documentation of success stories and best practices on SLEM and mainstream them into the policy environment in the country.

- Published 'SLEM Baseline Report', 'SLEM: Some Best Practices from India' and 'M&E Indicator Framework for DLDD'

Ecosystem Services Improvement Project

- ESIP supports the goals of the Green India Mission by demonstrating models for adaptation-based mitigation through scaling up of SLEM and livelihood benefits.
- Overall objective of ESIP is to improve forest quality, land management and non-timber forest produce benefits for forest dependent communities.
- ESIP is introducing new tools and technologies for management of natural resources, including biodiversity and carbon stocks.
- ESIP is targeting 10,000 ha area for forest quality improvement and 25,000 ha area for scaling up of SLEM practices in common property resource and private lands in the selected landscapes of MP and CG.

Project Components

Component 1: Strengthen capacity of government institutions in forestry and land management programs in MP and CG

1. Capacity-building of staff and JFMC (SFD of CG and MP)
2. Forest carbon stock measurement, monitoring -capacity-building (ICFRE)

Component 2: Investments for improving forest quality and n selected landscapes

1. Enhancing and restoring carbon stocks in forestlands (SFD of CG & MP)
2. Developing community-based models for sustainable utilization of NTFP (SFD of CG & MP)

Component 3: Scaling up SLEM in selected landscapes (ICFRE)

1. Scaling-up of SLEM best practices
2. Building national capacity for land degradation and desertification monitoring
3. Development and implementation of a national knowledge network

Component 4: Project Management (MOEFCC, SFD of CG & MP and ICFRE)

ESIP Areas in the States of MP and CG

Component 1: Strengthen capacity of government institutions in forestry and land management programs in Madhya Pradesh and Chhattisgarh

Sub-component 1.2: Forest carbon stocks measurement, monitoring and capacity building

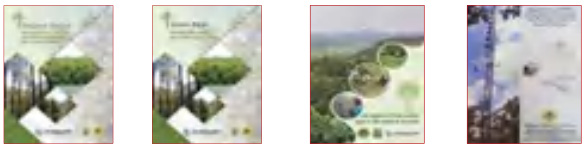
- Baseline reports of forest carbon stocks of ESIP areas of MP and CG

Total Forest Cover: 20016 ha
Total Forest Carbon Stocks: 1.17 million tonne
Average Carbon Density: 59.87 tonne/ ha

Total Forest Cover: 18780 ha
Total Forest Carbon Stocks: 1.22 million tonne
Average Carbon Density: 74.11 tonne/ ha

Knowledge Products on Forest Carbon Measurement

- Resource Manuals on Measurement of Forest Carbon Stocks for Capacity Building of SFDs
- Brochure on Measurement of Forest Carbon Stocks for capacity building of JFMCs
- Resource manual on Application of Eddy Covariance Technique for Measurement of Forest Carbon



3. Capacity buildings of SFDs and JFMCs on measurement of forest carbon stocks

S. No.	Year	No. of trainings organized	Total no. of participants	SFDs	JFMCs
1	2018-19	2	123	166	-
2	2019-20	6	267	267	-
3	2020-21	12	488	66	365
4	2021-22	18	790	350	494
5	2022-23	30	1439	83	1356
	Total	68	3107	1032	2215

Trainings on Measurement of Forest Carbon Stocks for SFDs

Trainings on Forest Carbon Stocks measurement for JFMCs

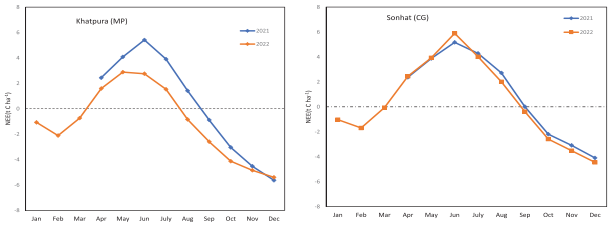
Eddy Covariance Flux Towers established by ESIP

EC Flux Tower Khatpura

Site	Khatpura forest beat	Sonhat forest beat
Location	Budhni Forest Range, MP	Raghunathnagar Forest Range, CG
Terrain type	Flat	Flat
Slope	<2 degree	<2 degree
Fetch	500-700m	500-700m
Vegetation type	Northern mixed deciduous forest	Southern mixed deciduous forest
Canopy height	12-15m	25-28m
Measurement height	22m	32m
Sampling frequency	10Hz	10Hz
Tree Species	*Tectona grandis, Pterocarpus marsupium, Butea monosperma, Terminalia arjuna, Terminalia bellirica, Sacopetalum tomentasum, Holoptelea integrifolia, Terminalia tomentosa, Buchanania cochinchinensis, Chloroxylon swietenia, Anogeissus latifolia, Lannea coromandelica, Diospyros melanoxylon*	*Holoptelea integrifolia, Lagerstroemia parviflora, Diospyros melanoxylon, Boswellia serrata, Anogeissus latifolia, Cassia fistula, Shorea robusta, Soymida febrifuga, Buchnania lanzan, Acacia catechu, Caseario tomentosa, Bombax ceiba*

EC Flux Tower at Sonhat

Cumulative Net Ecosystem CO_2 Exchange



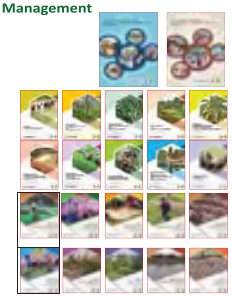
Net CO_2 uptake from the atmosphere was 5.40 and 4.84 t C ha^{-1} respectively in the year 2021 and 2022 at Khatpura.

Net CO_2 uptake from the atmosphere was 4.09 and 4.45 t C ha^{-1} respectively during the year 2021 and 2022 at Sonhat.

Component 3: Scaling up Sustainable Land and Ecosystem Management

3.1 Scaling-up of SLEM Best Practices

1. Baseline reports of socio-economic status
2. Knowledge Products on SLEM best practices
   - Lac Cultivation for livelihood generation and biodiversity conservation
   - Aonla based agro-forestry
   - Rehabilitation of degraded bamboo forests
   - Eco-restoration and institution strengthening
   - Wadi system – A tree-based farming system
   - Rain water harvesting and augmentation of water resources
   - Integrated farm development for sustainable land productivity
   - System of rice intensification
   - Chauka system- A water conservation practice
   - Climate proofing fish farming
   - नीमास्त्र, अमृत पानी, बीजामृत, ब्रह्मास्त्र, दसपर्णी अर्क, जीवामृत, केंचुआ खाद, नाडेप खाद



4. Capacity building of the local communities on scaling up of SLEM practices

S. No.	Year	No. of trainings organized	No. of participants
1	2018-19	1	60
2	2019-20	12	606
3	2020-21	65	4664
4	2021-22	68	5263
5	2022-23	65	5200
	Total	211	15793

Trainings on Upscaling of SLEM Best Practices for Local Communities of CG

Training on Upscaling of SLEM Best Practices for Local Communities of MP

Scaling up of SLEM practices in ESIP areas of CG and MP

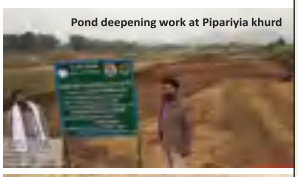
Scaling up of SLEM practices in ESIP areas of CG and MP

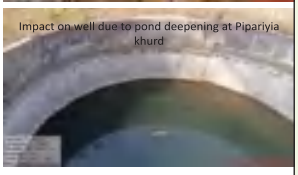
S. No.	Scaling up of SLEM best practices/ activities	States	No. of Household targeted	No. of direct beneficiaries	Area coverage (ha)
1	Rainwater harvesting and augmentation of ground water resource Climate proofing fish farming	CG	76	228	48
		MP	245	735	399
2	Lac cultivation for livelihood generation and biodiversity conservation	CG	2454	4914	1638
3	Vermi-composting	CG	2443	7329	1642
		MP	2579	7737	2180
4	Improved Cook Stoves	CG	8848	26544	-
		MP	4245	12735	-
5	Biopesticides & biofertilizers application for productivity enhancement	CG	8958	26874	8000
		MP	4051	12153	7000
6	Improved Vegetable Seeds (Kharif and Rabi Season)	CG	9000	27000	90.00
		MP	4100	12300	41.00
7	WADI: A tree-based farming system	CG	8735	26205	87.35
		MP	4274	12822	42.74
8	SRI: System of rice intensification Azolla broadcasting in Rice Fields Azolla cultivation	CG	93	93	19.63
		CG	4700	14100	4700
		MP	2300	6900	2300
9	Gravity-based Drip Irrigation System and Portable Sprinkler Irrigation System	CG	2214	6642	22.14
		MP	1859 1216	9225	18.59 486.40

Scaling up of SLEM Best Practice

Rain water harvesting and augmentation of water resources for sustainable land and ecosystem management

Area	Beneficiaries
447 ha	321 HH





Distribution of ICS for SLEM

Scaling up of SLEM Best Practice

Lac cultivation for livelihood generation and biodiversity conservation

Area	Beneficiaries
1138 ha	2454 HH

Brood lac distribution, inoculation and harvesting

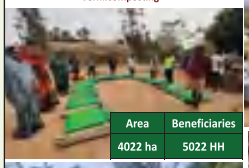
Vegetable Seeds for IFD



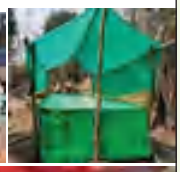


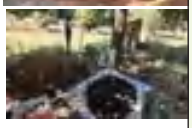

Vermicomposting

Area	Beneficiaries
4022 ha	5022 HH





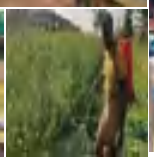




Upscaling of SLEM Best Practice
Biopesticides Preparation for sustainable land management

Area	Beneficiaries
15000 ha	13009 HH





Upscaling of SLEM Best Practice
WADI for sustainable land management

Area	Beneficiaries
130.09 ha	13009 HH

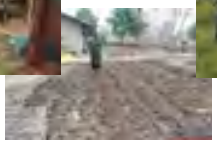

SRI and Azola Farming

Area	19.63 ha	Beneficiaries	93 HH


Distribution of Drip irrigation system and Sprinkler irrigation system

State	Number of Beneficiaries of Drip irrigation system	Number of Beneficiaries of Sprinkler irrigation system
Chhattisgarh	2214	-
Madhya Pradesh	1859	1216
Total	4073	1216





Building National Capacity for Land Degradation and Desertification Monitoring


Development of an online national reporting portal for capturing trends and status of key indicators on land degradation, desertification and drought

SLEM Knowledge Sharing and Reporting System: https://nrdp.icfre.gov.in/

Evaluation of the Working/ Effectiveness of Forestry Extension System through the Van Vigyan Kendras and Recommendations for its Strengthening

Developed national database on SLEM practitioners for the development of institutional and individual networks (National database on 361 SLEM practitioners)

India is the first country to include LiFE (Lifestyle for Environment) in its NDCs under the Paris Agreement and propagate a healthy and sustainable way of living based on its traditions and the values of conservation and moderation, including through a mass movement for LIFE as a key to combating climate change.

Scaling up of SLEM best practices is supporting the LiFE mission, and contributing in achieving the NDC, LDN and SDGs (SDG 1: No Poverty, SDG 3: Good Health and Well Being, SDG 6: Clean water and sanitation, SDG 7: Affordable and Clean Energy, SDG 8: Decent Work and Economic Growth, SDG 13: Climate Action and SDG 15: Life on Land).

SLEM best practices need to be scaled up across the country for addressing the issue of land degradation, desertification and climate change.

Thanks a lot for kind attention !

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WORKSHOP GLIMPSES








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INTERNATIONAL WORKSHOP

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