

# Agroforestry regional perspective and new dimensions

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**Country Coordinator, CIFOR-ICRAF**





# World Agroforestry (ICRAF) Center for International Forestry Research (CIFOR)

Work in over 40 countries, over 700 staff

Oldest and most globally recognized international research centres in their respective fields of agroforestry and forestry

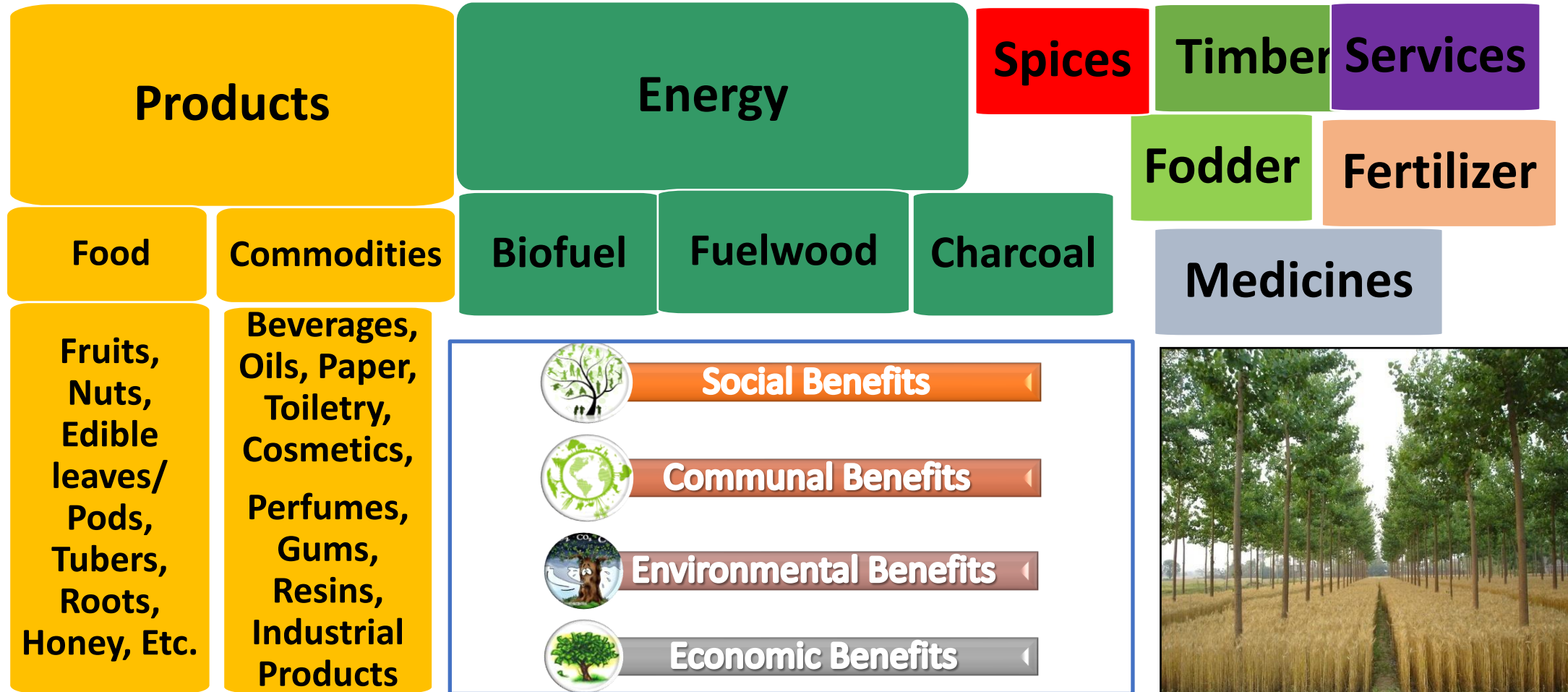
Headquarters in Nairobi, Kenya & Bogor, Indonesia respectively

# Agroforestry

- *Agroforestry is the integration of trees and shrubs with annual crop cultivation, livestock production and other farm activities.*
- **Agroforestry is the practice and science of the interface and interactions between agriculture and forestry, involving farmers, livestock, trees and forests at multiple scales.**
- *Agroforestry is currently practiced by > 1.2 billion people worldwide*



# Agroforestry Benefits



# The right tree for the right place

## 1. Trees for Products



fruit



firewood



medicine



income



sawnwood



fodder

## 2. Trees for Services



soil  
fertility



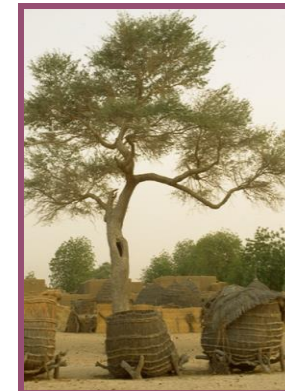
carbon  
sequestration



soil  
erosion



watershed  
protection



shade



biodiversity



# Agroforestry Systems in Africa

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# Agroforestry Systems in South Asia

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# Common Agroforestry Systems



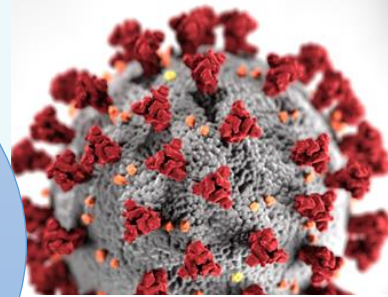
**The Africa and Asia region offers good scope for development of Agroforestry, which will not only supply food, nutrition, fodder, fuel to communities but forms a suitable vegetative cover for ecological maintenance.**



# Looking ahead: worsening trends

**Number of undernourished people should exceed 840 million by 2030.**

(State of Food Security and Nutrition in the World –SOFI – 2020)



**COVID-19**  
CORONAVIRUS DISEASE 2019

a third more people in food crisis (Update Sep.2020 in 11 hotspots)

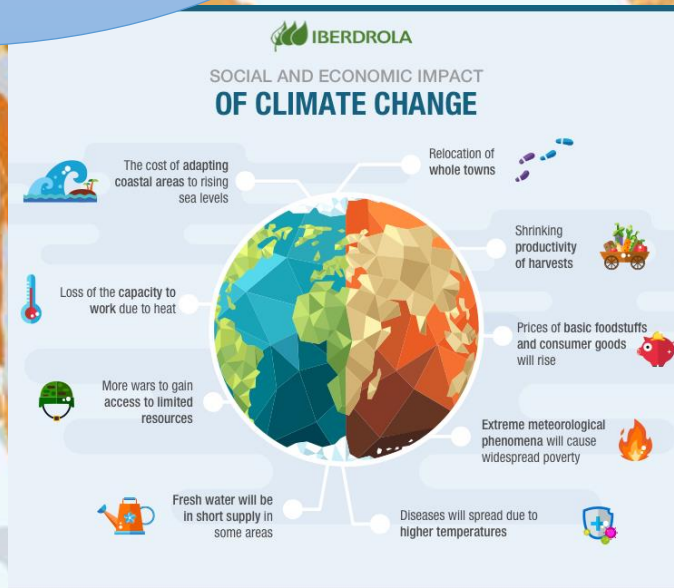


Pacific Ocean

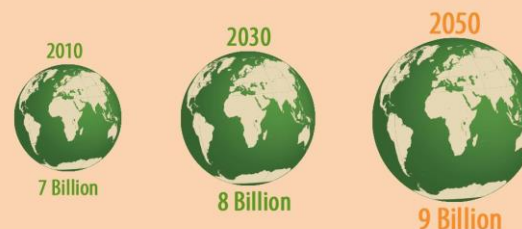
**Land degradation affects over 40% of the Earth's surface**

**Soil degradation**

- Very high severity
- High severity
- Moderate severity
- Low severity
- Stable land, ice cap or non-used wasteland



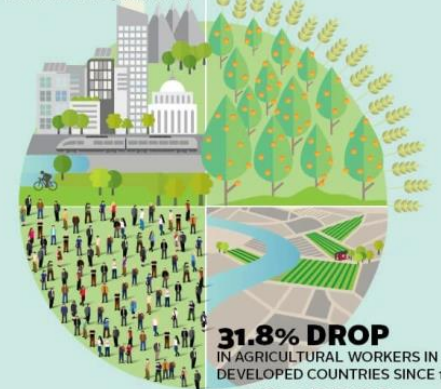
**AGRICULTURE ALSO NEEDS TO PRODUCE 50% MORE FOOD TO NUTRITIOUSLY FEED 9 BILLION BY 2050**



## CONFLATING TRENDS SEVERAL TRENDS ARE PUSHING AG-TECH FORWARD

**66% OF PEOPLE WILL LIVE IN CITIES BY 2050** COMPARED TO 54% IN 2014

**50% INCREASE IN FOOD DEMAND BY 2050**



**3 BILLION MORE MOUTHS TO FEED BY 2050**

**31.8% DROP IN AGRICULTURAL WORKERS IN DEVELOPED COUNTRIES SINCE 1950**

**32.8% DROP IN AGRICULTURAL WORKERS IN DEVELOPING COUNTRIES**

SOURCE: FAO

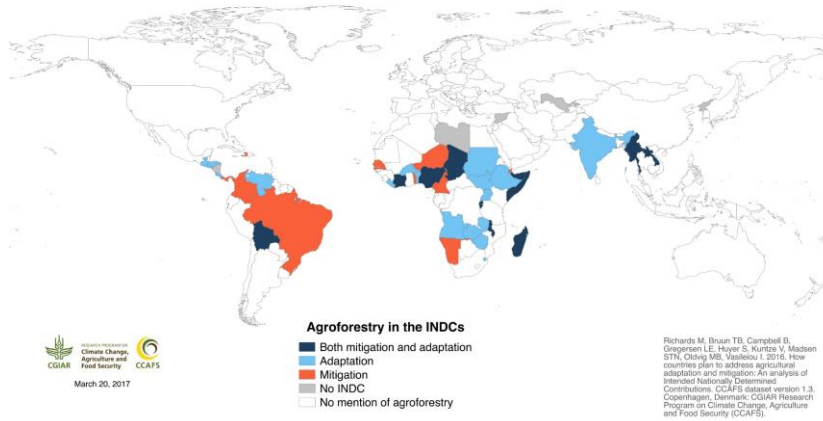
Source: EC presentation, Crabbe

# Agroforestry and SDGs and Global Climate Dialogues

SDG No	SDG Description	Evidence that agroforestry can support
2	Zero hunger	Increasing food production whilst enhancing the environment
3	Good health and well being	Improved quality of drinking water and healthier food
6	Clean water and sanitation	Improved water quality due to tree uptake of pollutants
7	Affordable and clean energy	Woody vegetation in the farmed landscape for bioenergy
8	Decent work and economic growth	Opportunities for added value
11	Sustainable cities & communities	Through the promotion of fruit trees in homegardens
12	Responsible consumption & production	Sustainable production systems
13	Climate action	Enhanced carbon storage on farm land
15	Life on land	Enhanced biodiversity

Kyoto Protocol – 2005	Includes agroforestry as an important sustainable land management approach for climate change adaptation and mitigation
REDD+	Agroforestry potential to support indigenous communities for livelihood benefits while mitigating climate change demonstrated
IPCC Third Assessment Report (2001)	Prospects of AFS for providing solutions to myriad issues while at the same time delivering a variety of social, financial and environmental profits for human well-being acknowledged
IPCC Special report - Climate and Land (2019)	AFS quoted as an emerging vital solution to climate adaptation and mitigation through efficient land management

# Agroforestry and INDC



- **23 countries identify agroforestry as a mitigation strategy**
- **29 countries identify agroforestry as an adaptation strategy**

Source: <https://ccafs.cgiar.org/agricultures-prominence-indcs-data-and-maps#.Wfa1uohx200>

As in NCs, agroforestry is mentioned in many developing country NDCs. Out of 148 NDCs examined, 59 (40%) explicitly mention agroforestry as a measure for climate-change mitigation or adaptation. Mentions include: 71% (36 of 50) of African NDCs, 34% (11 of 32) of Americas NDCs, **21% (9 of 44) of Asian NDCs**, 7% (1 of 14) of Oceania NDCs and 17% (1 of 6) of European NDCs

- Reviews- developing countries' submissions of NCs ( $N = 147$ ) and NDCs ( $N = 148$ )
- Each country/ document examined against criteria indicating whether agroforestry was explicitly or potentially (1) mentioned as a climate action; (2) reported; and (3) what methods were used to quantify and represent

- Of 148 National Communications (NCs) reviewed, 105 either explicitly mention agroforestry or discuss interventions that could include agroforestry ('potential mentions')
- More than 80% of those countries (88 of 105) explicitly refer to agroforestry, with 69% (61 of 88) mentioning it as a solution for mitigation, 72% (63 of 88) for adaptation and 41% (36 of 88) mentioning it for both
- **Interest in agroforestry is particularly evident in Africa, where some 36 of the 50 countries (71%) analyzed include agroforestry as a climate response measure**
- Interest in agroforestry in the Americas, where 34% (11 of 32) of countries mention agroforestry

# Dissemination and promotion of agroforestry

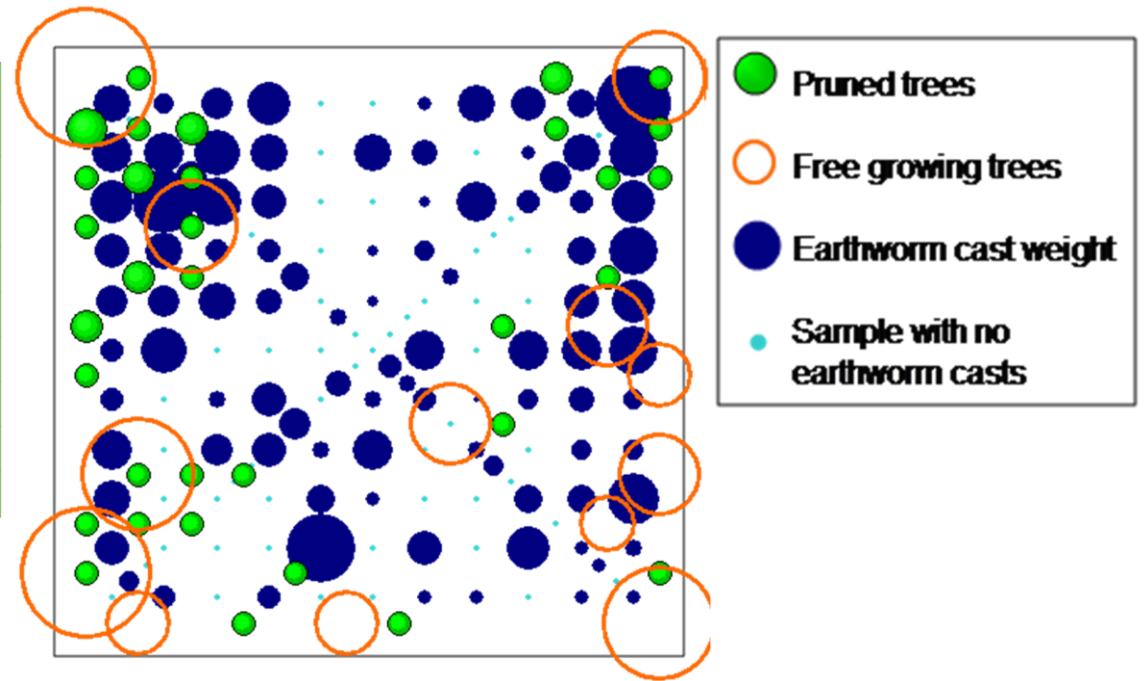
## Benefits of agroforestry to farmers

(outcomes of experiment from farmers' field)

Tree species	Inter crop	Mango yield Kg/ha	Inter crop Yield Kg/ha	Net Return (Rs)	B:C
Mangifera indica (Agroforestry system)	Pineapple	2582	7419	243320	3.56
	Mango ginger	2342	3776	87950	2.35
	Turmeric	1984	4982	74240	1.98
	Arrowroot	2082	8426	98162	2.78
Control	Pineapple		4470	85150	2.06
	Mango ginger		3042	20650	1.41
	Turmeric		3840	16800	1.28
	Arrowroot		5036	20432	1.51

**Income to the farmers in case crop failure**

## Agroforestry increases soil fauna



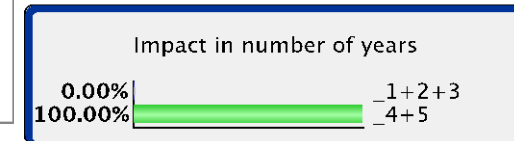
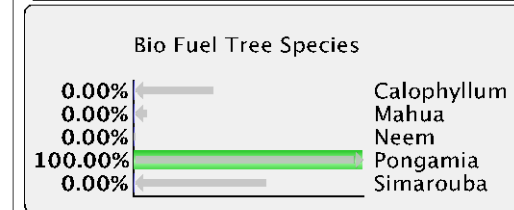
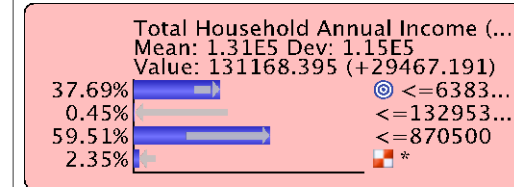
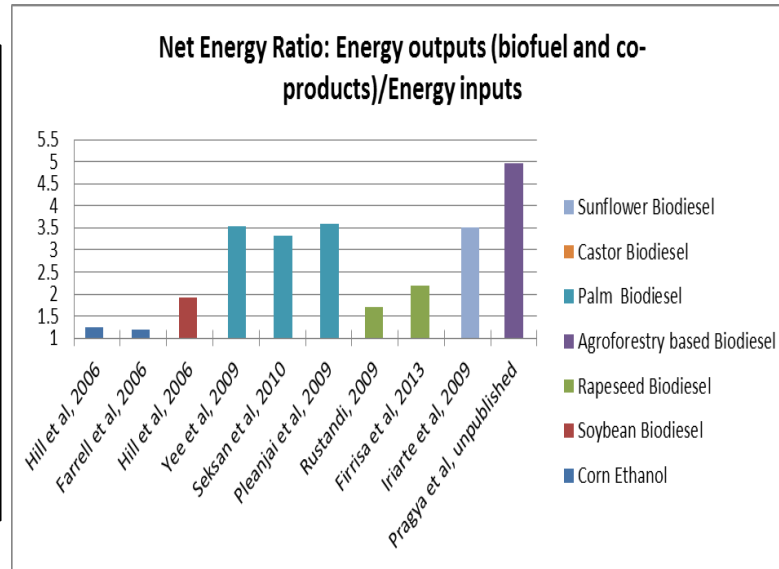
Pauli et al (2010) Pedobiologia 53 127–139

# Breaking the myth of long gestation period of agroforestry



# Smart Agroforestry Systems

## Sustainable Bioenergy Landscapes



- Integrated Food-energy system
- Multiple species: year round supply of feed stocks
- Several co-products: oilcake, SVO
- Livelihood improvements
- Potential GHG savings



**Need to be scaled up and scaled out**

# Livelihood

Development of AFS integrating livelihood option including value addition and income generation for self-reliance among farmers.

- AFS integrating apiculture, lac, gum, resin, sericulture etc. to augment farmer's income developed.

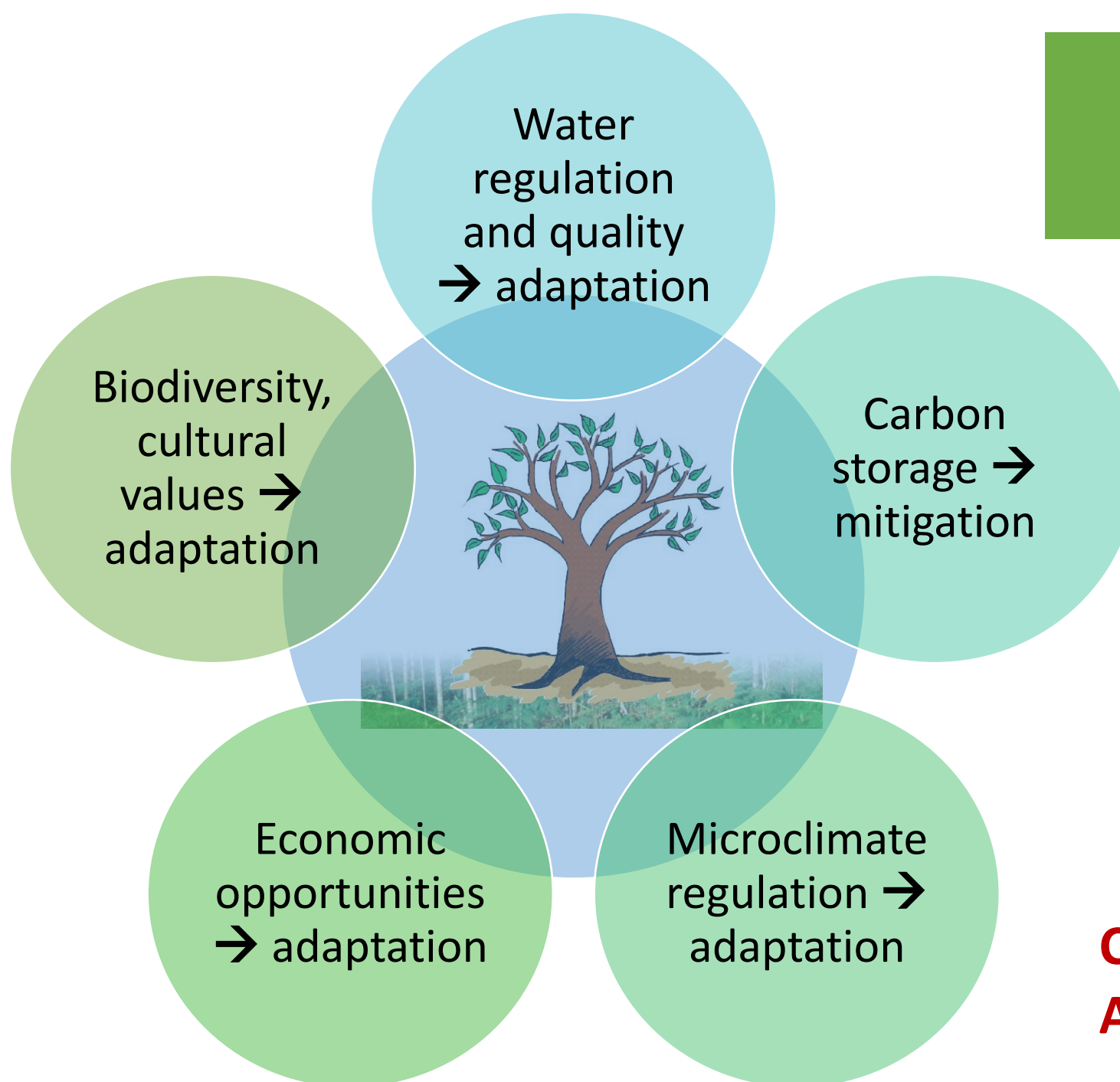


## Suitable trees for gum and resin identified



Different shapes of naturally oozed gum from *Acacia nilotica*

# Trees for climate resilience



- Improve Air Quality
- Manage storm water
- Above and below ground carbon storage
- Provide habitat for animals
- Recycle oxygen
- Conserve Soil and Water

**Case studies from  
Africa and Asia**





# Case studies: Success story from Africa: The Drylands Development Programme (DryDev)

A Farmer-led Program to Enhance Water Management, Food Security, and Rural Economic Development in the Drylands of

Burkina Faso, Ethiopia, Kenya, Mali and Niger



- Over 158,800 farmers (59,000 women) involved in rehabilitation of 87,013 hectare using various watershed treatments, planting of grasses and 1.83 million trees.
- To control run-off and increase water infiltration check dams on streams to manage siltation, sand dams to store underground water, infiltration trenches/pits, and half-moon micro-catchments were promoted





# Case studies: Success story from UAE:

About 30,000 ha plantation in the heart of desert with > 18 million trees





# Case studies:

Problem: Reservoir capacity and siltation

→ Upland erosion & degradation

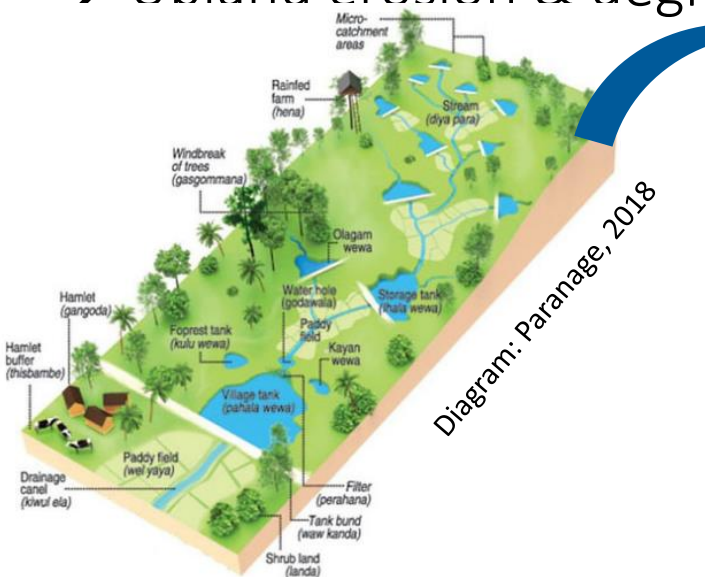
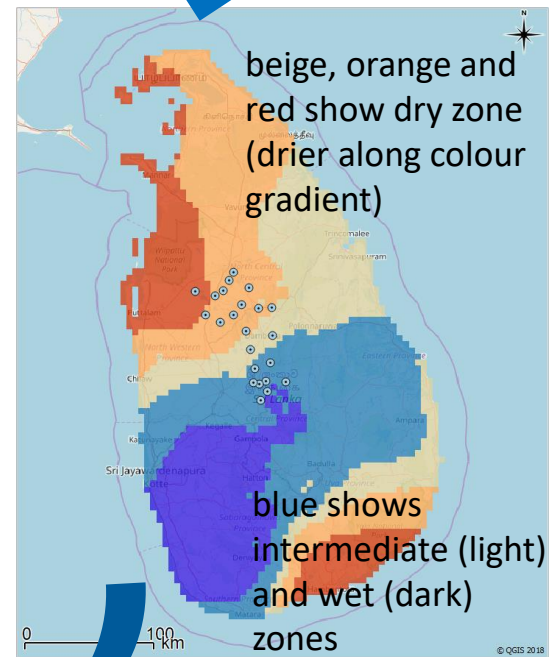


Diagram: Paranage, 2018

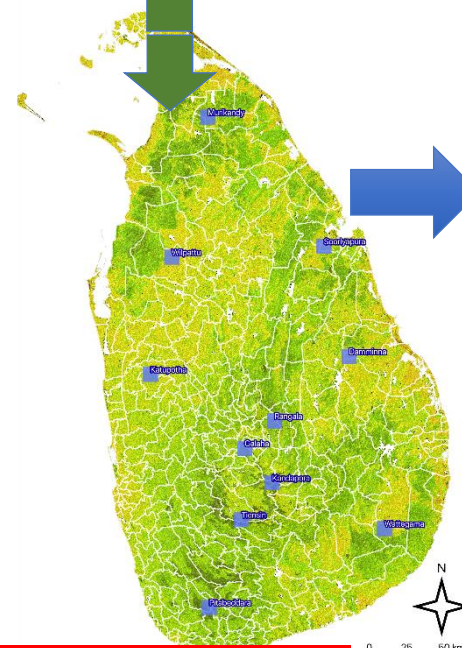
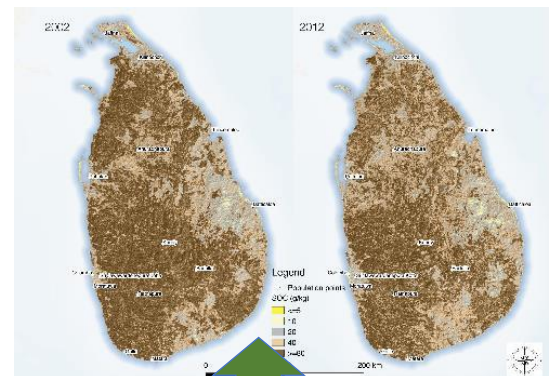


Photo: Ada Derana



Paranage 2018, Water 10(10), 1402; doi:[10.3390/w10101402](https://doi.org/10.3390/w10101402)

# Using Science to enable multiple functions in Sri Lankan uplands



Exploring assessments of land health in Laikipia

- Soil organic carbon SOC
- Soil inorganic carbon (IP) percent and
- Fractional vegetation cover

Land health status/summary, Vegetation cover status and time, Land degradation, Soil inorganic (IP) - 2017, Fractional vegetation cover - 2017, Fractional vegetation cover - 2009, Fractional vegetation cover - 2015, Fractional vegetation cover - 2009

Add MIR Photo

Explore the CIFOR-ICRAF Spectral Lab:  
<https://worldagroforestry.org/sd/landhealth/soil-plant-spectral-diagnostics-laboratory>

# Case studies:

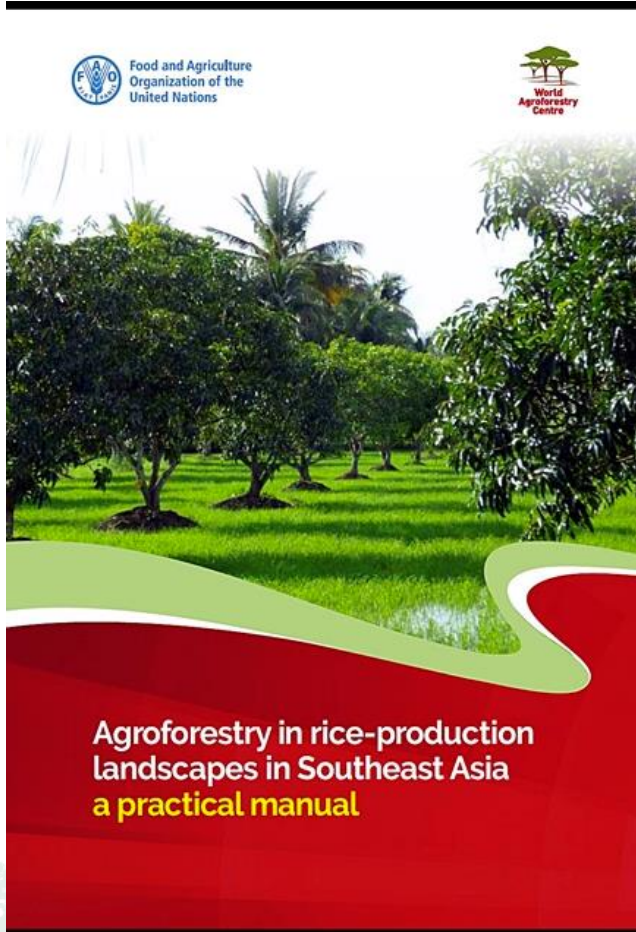
## Rehabilitation of Degraded Lands- India

- Regulated grazing, bunding, gully plugging, anicuts, afforestation and fodder grass / legume (*Cenchrus ciliaris* and stylo) seeding applied
- Controlled and Rehabilitated fields monitoring in Odhisa (24 sites in Angul and Dhenkanal), Rajasthan (36 sites in Udai Pur, Bhilwara and Jaipur), Assam (3 sites in Dhemanjhi) and Madhya Pradesh (2 sites in Morena and Bhind)
- Soil physical, chemical and hydrological properties, and vegetation frequency was measured



A project site-in Bhilwara with a stone wall constructed by the community to capture rainwater and prevent runoff and soil erosion in 1998 (left), and regeneration of vegetation in the stone wall enclosed area in 2007 (right)

# Agroforestry systems for climate adaptation and mitigation



- Impacts of trees on crop temperatures, yield, flowering, pest and disease incidence to adapt to a changing climate
- Opportunities to store more carbon in soils, vegetation and grow sustainable fuelwood on farms
- For key staple and commodity crops:
  - rice, wheat, teff
  - coffee, cocoa
- Diversification as a resilience strategy



**New Initiatives**

# Enhancing water infiltration through bunding

Approx. 1.5 Km road

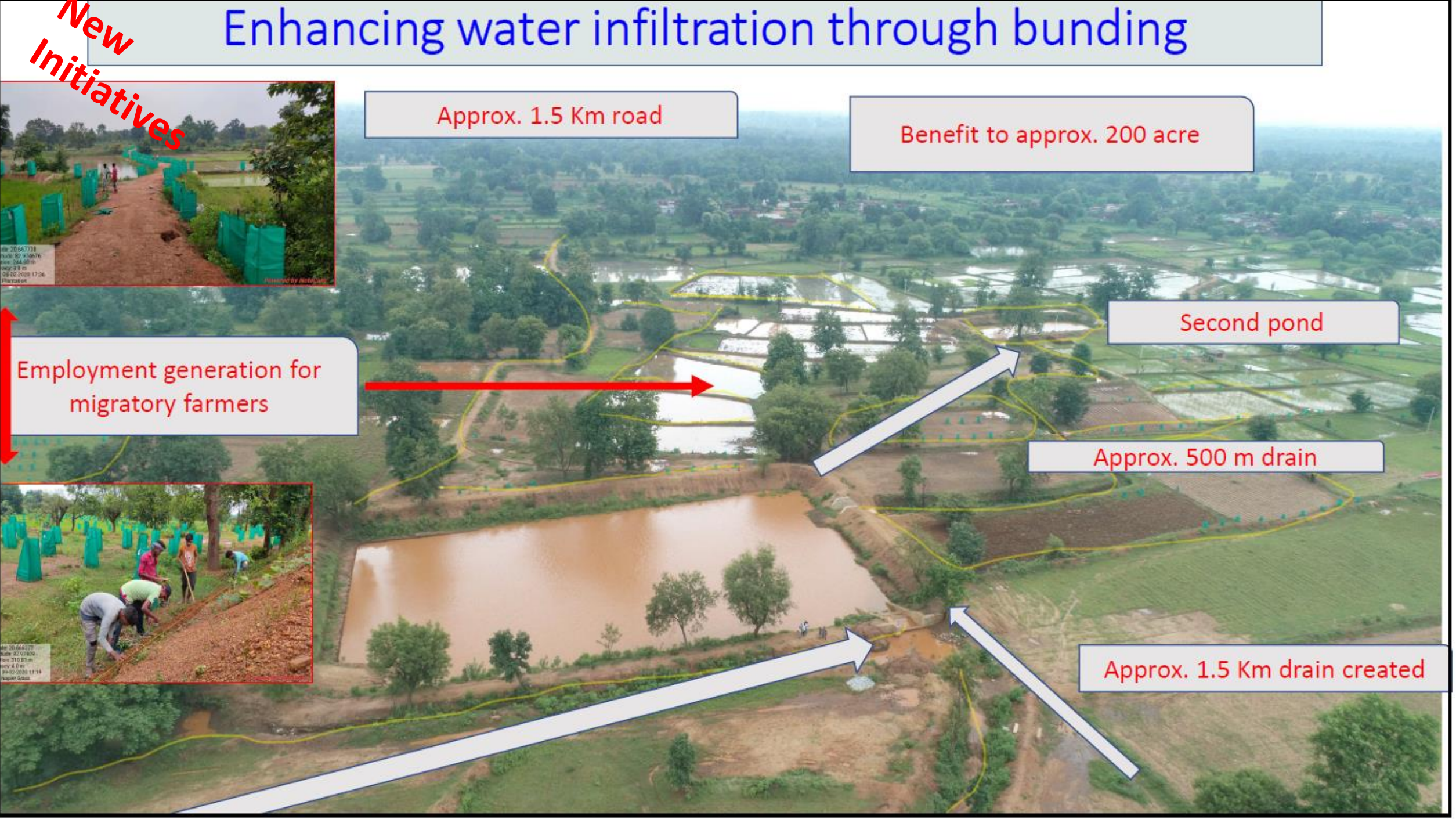
Benefit to approx. 200 acre

Second pond

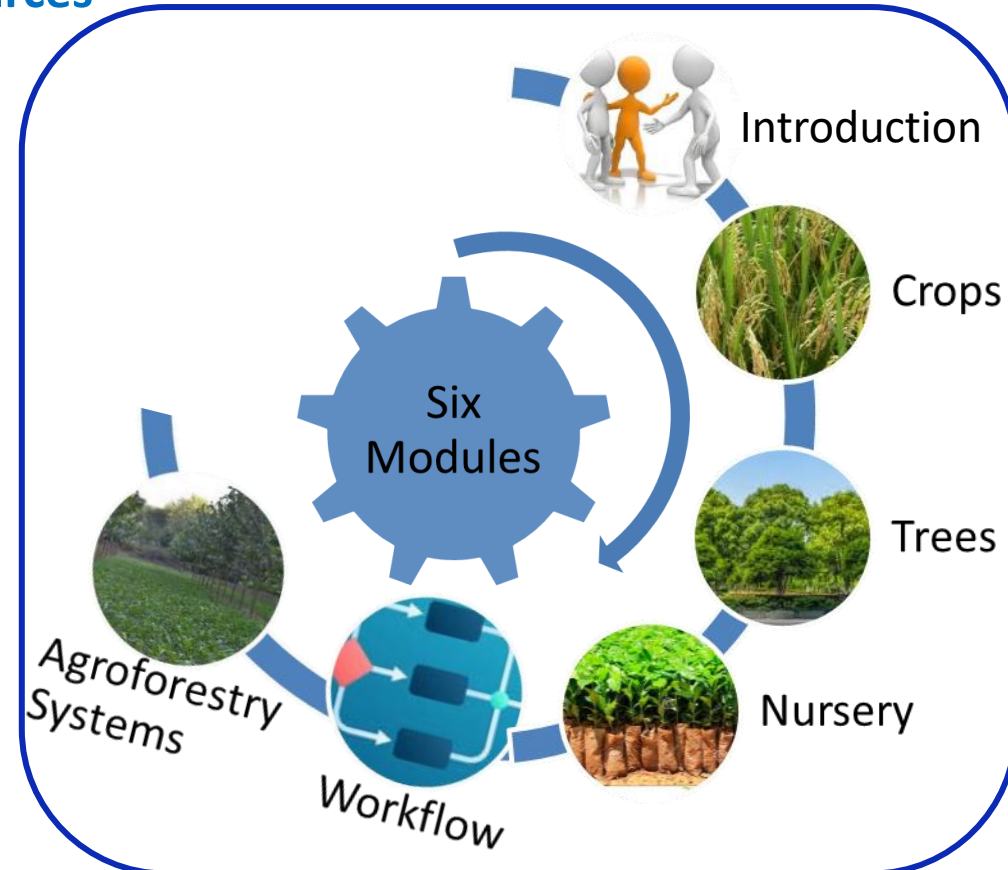
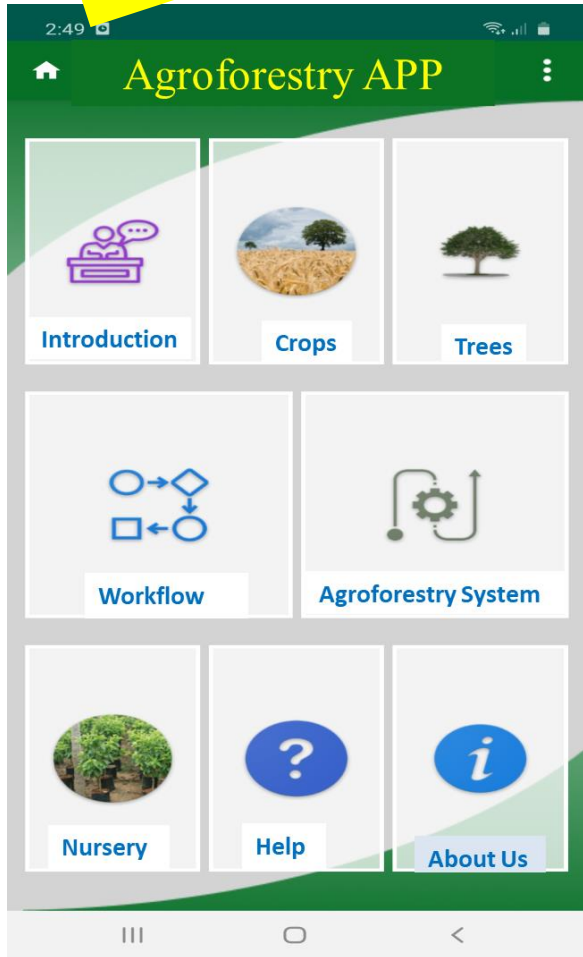
Employment generation for migratory farmers

Approx. 500 m drain

Approx. 1.5 Km drain created



System approach : crop & plants  
 Best practices  
 Quality Planting material sources



**Data dissemination tool**

# Tree Crops Improvement: Genomics for Climate Adaptation

**New Initiatives**

**Genebank**- germplasm collection and characterization

**Pre-breeding**: Primary selections, trait homogenization at population level to make orphan crops adaptable for crop husbandry practices, **domestication**

**Organized breeding and selection**: Breeding populations, directional selections, quantifiable gains

## Genomics for:

- Germplasm characterization
- Diversity analysis
- Material prioritization
- Germplasm diversity = **Climate resilience**

## Genomics for:

- Preselection of genetically diverse material for exploration and (**climate**) suitability mapping, primary range-wide selections interbreeding and population improvement
- Ecological genomics to understand **climate adaptation**

## Genomics for:

- Understanding gene-basis of traits such as yield, stature, phenology, biotic and abiotic stress tolerance, nutrition etc (**climate related**).
- Selection of parents for crossing

## African Orphan Crops Consortium (AOCC) Partnership of 28 core partners

- The 101 species being sequenced
- 8 genomes published (Faidherbia, Moringa, Scelrocarya, Bambara nut, lablab bean, jackfruit, breadfruit, African eggplant))
- 4 genomes in the pipeline (shea, yam, cleome, finger millet)
- 20 genomes by partners

Genomics to breed for climate resilience, nutrition and yield using different genomics-based approaches

Current Issue | October 2020

nature.com/ng October 2020 Vol. 52 No. 10

## nature genetics

Comment | Published: 23 March 2020

### Enhancing African orphan crops with genomics

Ramni Jamnadas, Rita H. Mumm, Iago Hale, Prasad Hendre, Alice Muchugi, Ian K. Dawson, Wayne Powell, Lars Graudal, Howard Yana-Shapiro, Anthony J. Simons & Allen Van Deynze

Nature Genetics 52, 356–360(2020) | Cite this article

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Volume 224, Issue 1 | October 2019



### New Phytologist

The role of genetics in mainstreaming the production of new and orphan crops to diversify food systems and support human nutrition

Ian K. Dawson, Wayne Powell, Prasad Hendre, Jon Bandić, John M. Hickey, Roeland Kindt, Steve Hoad, Iago Hale, Ramni Jamnadas

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Volume 8, Issue 3<sup>20</sup> | March 2019



### (GIGA) SCIENCE

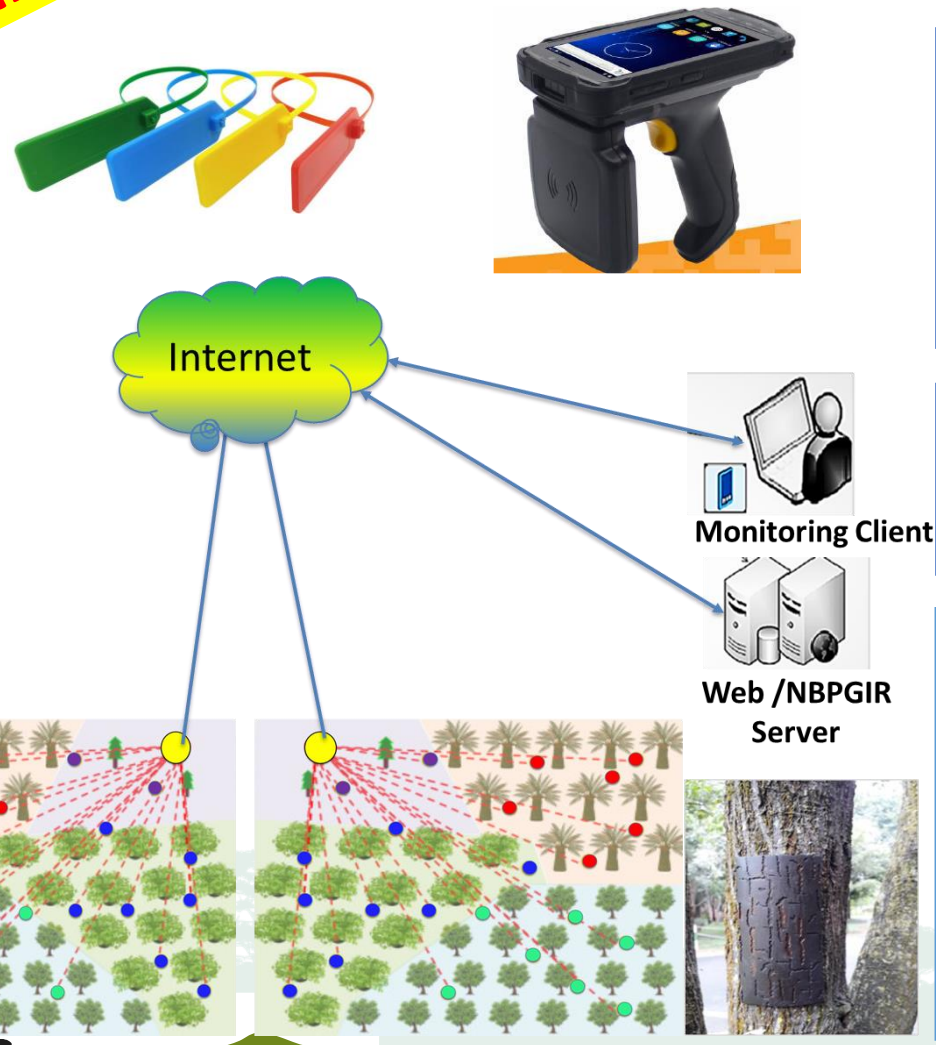
The draft genomes of five agriculturally important African orphan crops

Yue Chang, Huan Liu, Min Liu, Xuezhong Liao, Sunil Kumar Sahu, Yuan Fu, Bo Song, Shifeng Cheng, Robert Kariba, Samuel Muthemba, Prasad S Hendre, Sean Mayes, Wai Kuan Ho, Anna E J Yssel, Presidor Kendabie, Sibow Wang, Linzhou Li, Alice Muchugi, Ramni Jamnadas, Haorong Lu, Shufeng Peng, Allen Van Deynze, Anthony Simons, Howard Yana-Shapiro, Yves Van de Peer, Xun Xu, Huanming Yang, Jian Wang, Xin Liu

# Exploring Chip-based technology for real time monitoring of important AF species in field gene banks

**New Initiatives**

**Team:** NBPGR, CAFRI, IIHR, ICRAF, NRM, ICRAF



**Passive tags:** Semi-automated low-cost RFID technology-information exchange through “Handheld RFID Readers” – Stores passport data and hand-held reader communicates with tags within a certain distance.

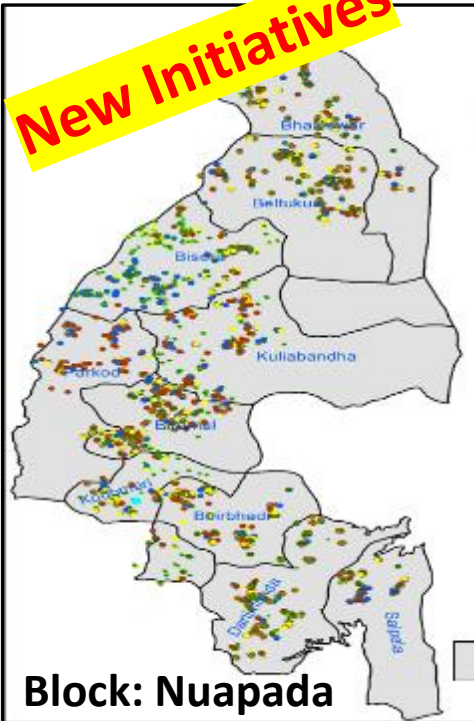
**Pilot sites:**  
NBPGR, New Delhi; CAFRI, Jhansi and IIHR, Bengaluru

**IoT Sensor Tags (RTS):** Sensors fixed on trees detect vibration and tilt and automatically communicate to computer and/or mobile phone of site manager. Sensor can differentiate between impacts of wind, livestock/wildlife and any cutting device; and alerts the site manager.

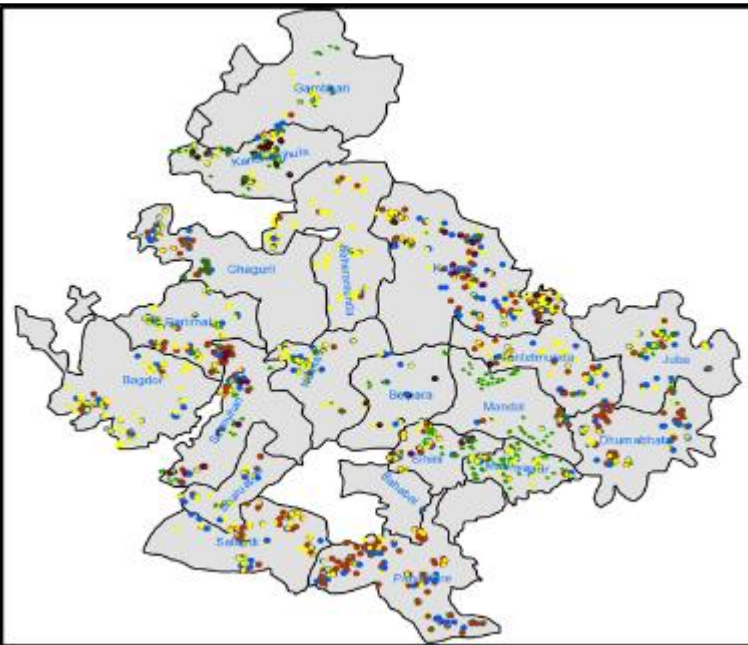
# Geotagging & Monitoring Agroforestry Interventions

**New Initiatives**

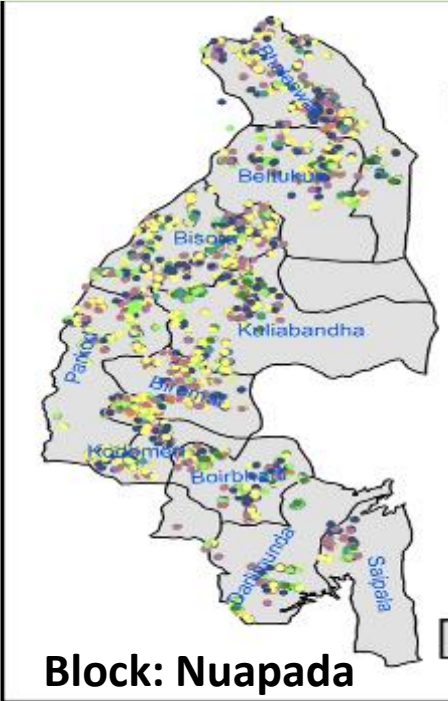
2019-20 and 2020-21



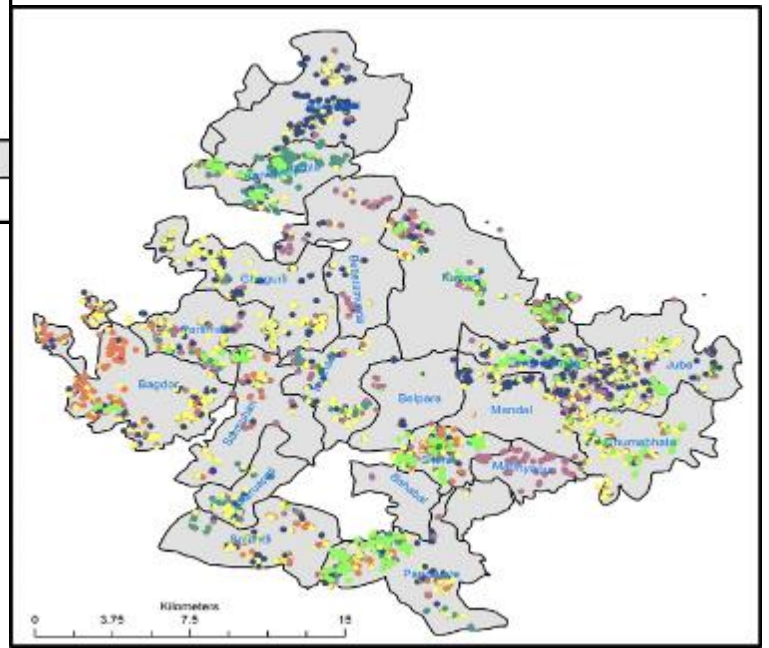
**Block: Nuapada**



**Block: Belpada**



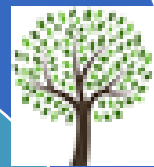
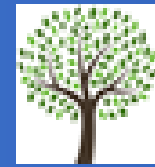
**Block: Nuapada**



**Block: Belpada**

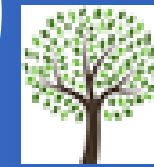


Intercropping with bio-fortified staple food crops



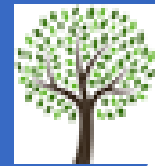
Trees

Vegetables



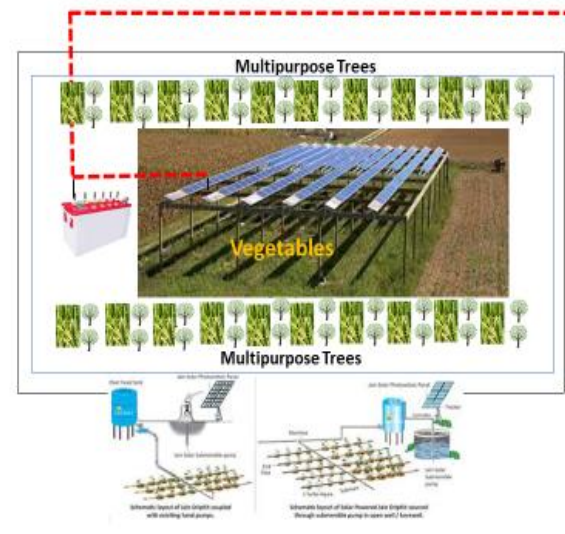
New Initiatives

Agro-voltaic system



Innovative Agroforestry Practices

### Agrivoltaic system



# Evidence-based soil-plant health assessment

## Spectral Technology – rapid, reliable, low cost



New Initiatives

### Mid-infrared spectrometer (MIR)

- Soil health mapping
- Farm level soil testing services
- Monitoring plant nutrition
- Soil carbon inventory

+



### Handheld x-ray fluorescence analyser (pXRF)

- Mining reclamation
- Agri-input quality analysis & certification (fertilizers, manures)
- Agri-product quality analysis

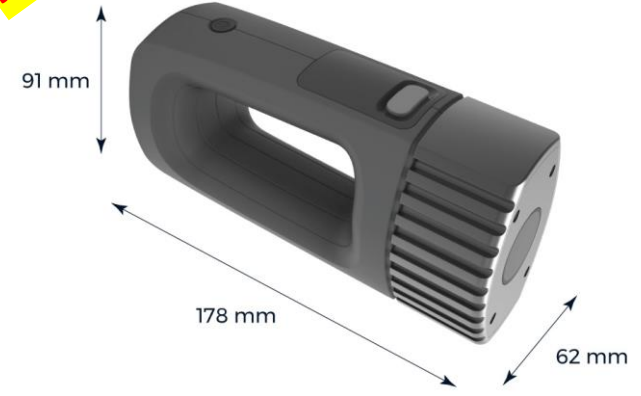
**New Initiatives**

# Test and validate handheld soil analyzer

Test AR-IISS-ICRAF

## (Neo-spectra scanner)

Portable scanning tool to test Indian soils



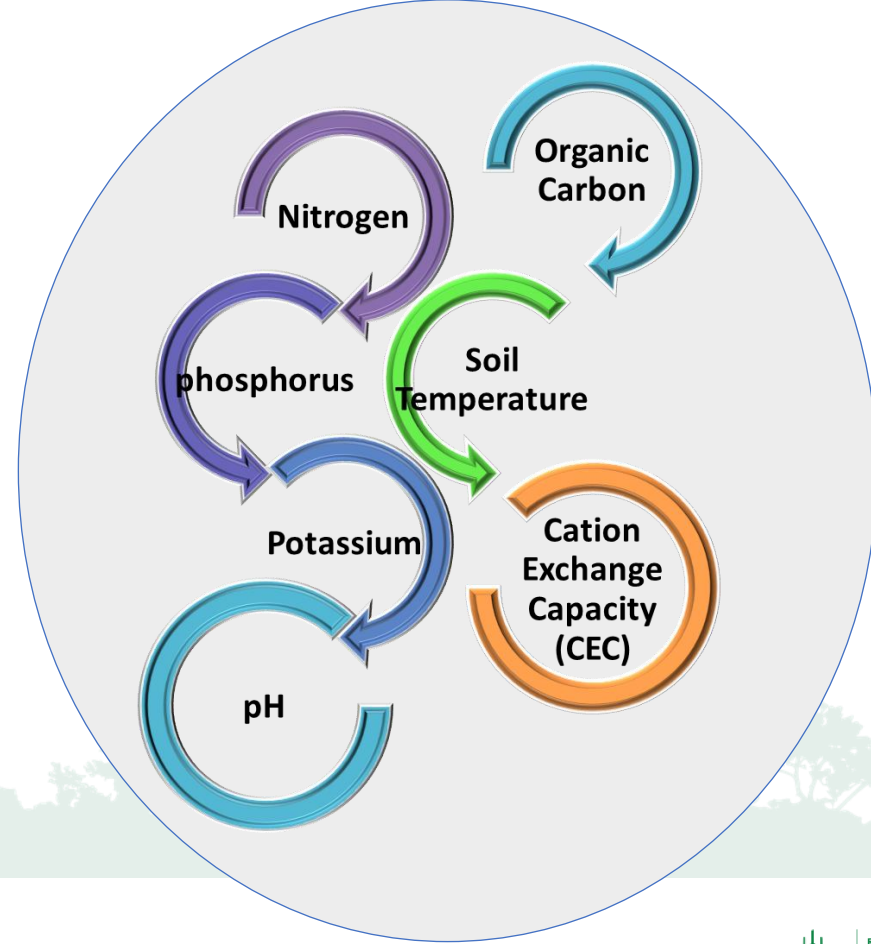
**Above the Scanner**  
o Set the scanner on a flat surface  
o Place samples on top



**Point & Shoot**  
o Hold scanner in hand  
o Point and shoot at samples



**Below the Scanner**  
o Place samples on a flat surface  
o Set the scanner on top



- Soil scanner uses electro-magnetic radiation in the NIR region (1350-2500 nm)
- Scanned about 1700 soil samples
- Provide predictions for Soil Texture (Clay, Sand), Soil Organic Carbon, pH, Cation Exchange Capacity, Total Nitrogen, Total Phosphorus, and Exch. Potassium



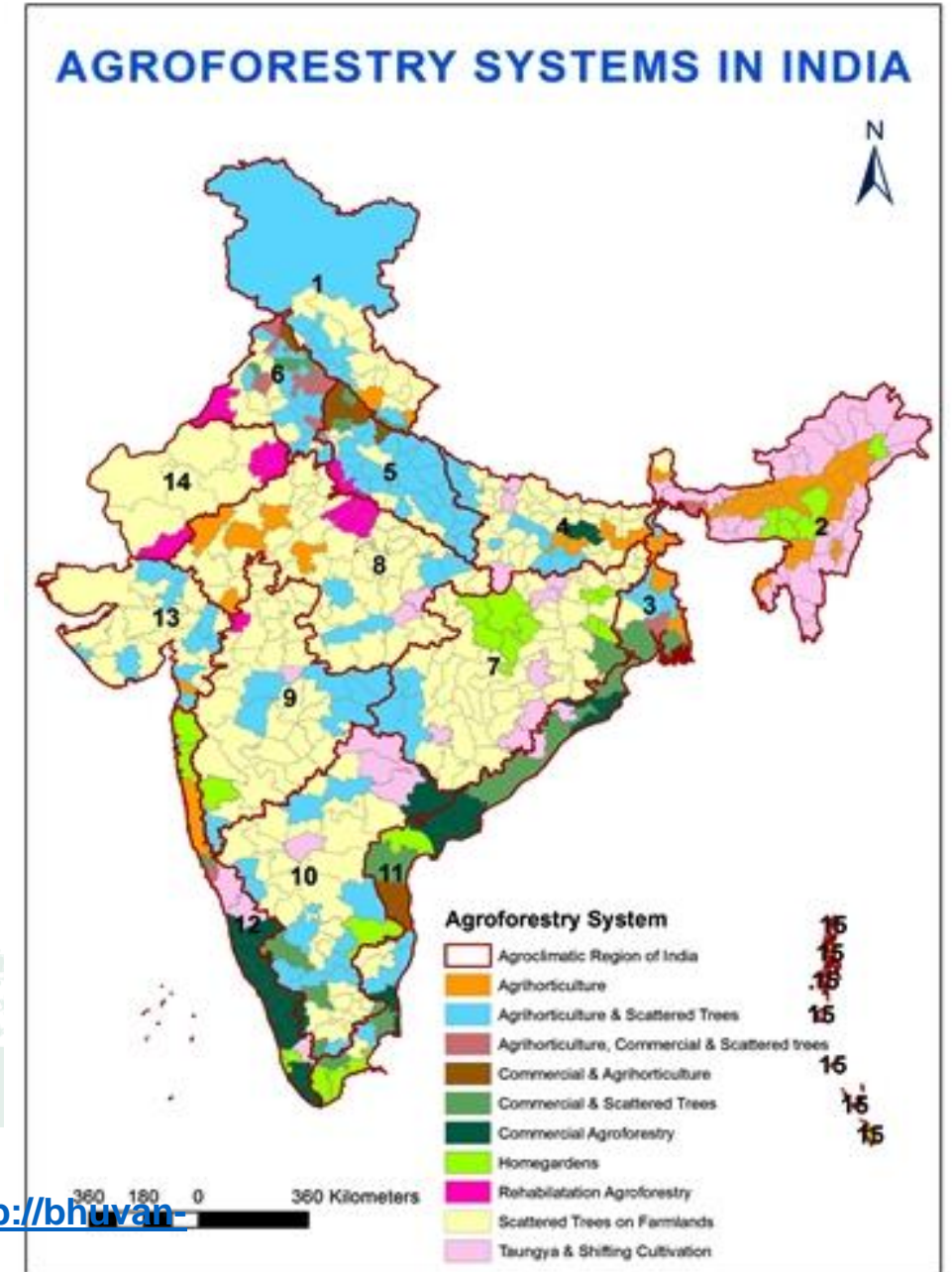
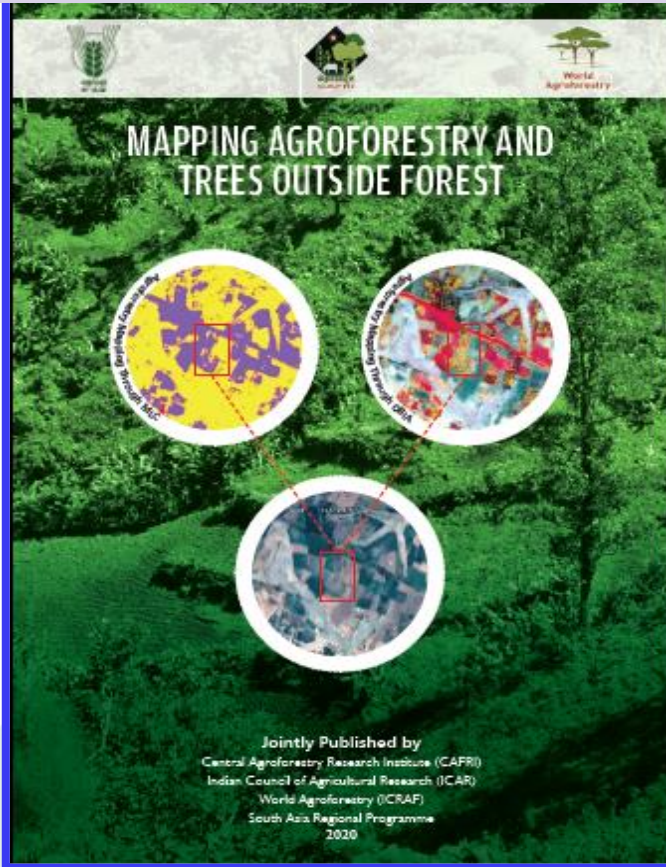


## Estimated Area under Agroforestry in 15 ACZs

- ICRAF and ICAR-CAFRI completed mapping agroforestry area in all the 15 agroclimatic zones using geospatial technology
- **28.25 million hectares**

## Investigate spectral signatures of dominant AF species

- Development of spectral library,
- Data seasonal collection
- Initiated for 20 species mentioned in NAP- 6 completed
- Then cover state exempted AF species
- **Initiate proof of concept for use of drones in AF**



# **Agroforestry Contribution to National Economy & Climate Resilience: India case Study**

# National Commitments and Strategy

- **GoI seeking to boost forest and tree cover in India to 33% (NFP 1988)**
- **Key 2030 commitments:**
- **Sequestration of 2.5-3 billion tons of additional Green House Gases (CO2 equivalent)**
- **Restoration of 26 million ha of degraded land**

## GoI's Two-pronged Strategy



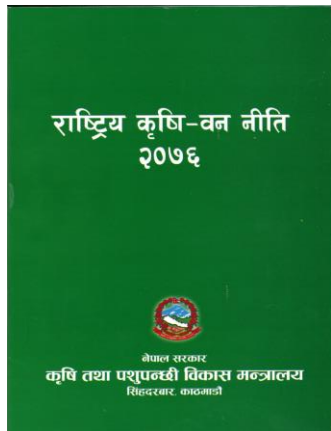
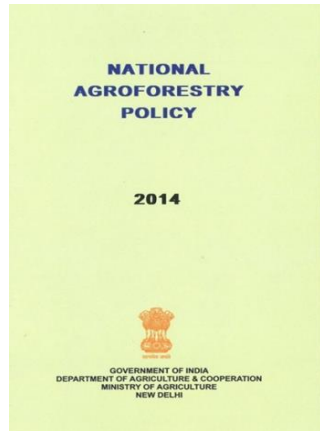
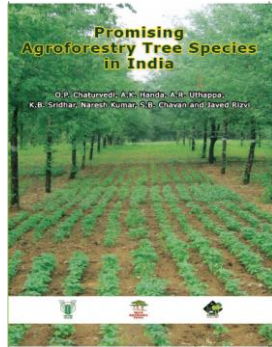
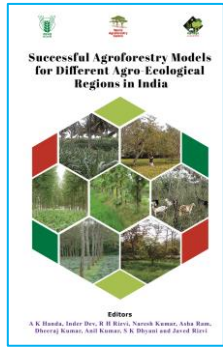
**Restore degraded forests**  
(60% NDC target)

**Scale up Trees Outside Forests**



# Mainstreaming agroforestry

Knowledge dissemination



Policy Support

Agroforestry technologies

Inputs (QPM and Others)

Credit

Absence of Guidelines

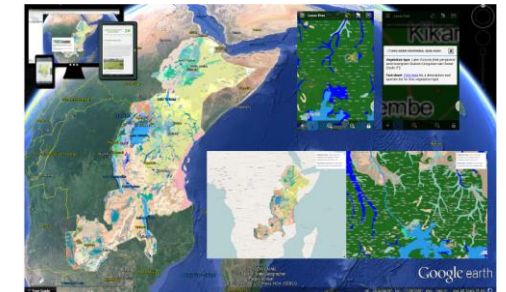
Guidelines to Produce Quality Planting Material of Agroforestry Species

Efficient Linkages Not Available

Forward and backward linkages to market

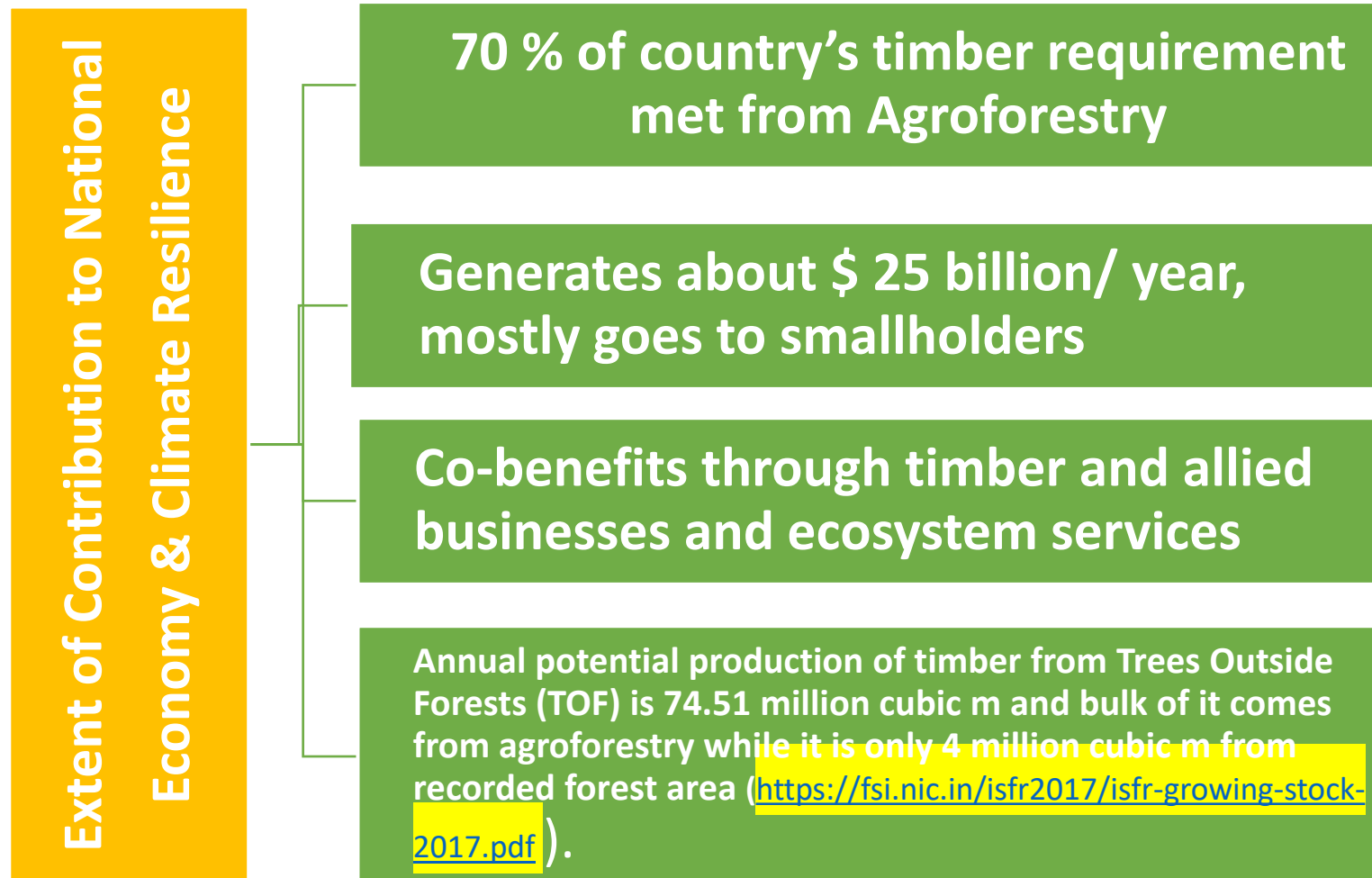
Insurance

Strong Extension Services



- Agroforestry contributing significantly in land use and farm income diversification, natural resource management and meeting the demands of fuel, fodder, timber, thus helping in economic transformation of farmers.
- Agroforestry sector fulfilling most of the wood as well as fuelwood demands in India (Plywood: 80%, Paper: 60%, fuelwood 50%...)
- Agroforestry Mission established
- GOI revised CSR rules to include agroforestry in the CSR portfolio
- Bamboo grown on private land exempted from obtaining permission for felling and transit
- 27 States of India relaxed felling and transit rules for farm grown trees
- Agroforestry Mission established 327,350 nurseries in 5 years

# National Agroforestry Policy helps to accelerate momentum...



# Public-private sector linkages

- WIMCO [now ITC] seedlings Ltd. – Poplar
- ITC Bhadrachalam Paper Board Ltd. - *Eucalyptus*, *Casuarina*, *Leucaena*
- West Coast Paper Mills Ltd. - *Acacia mangium* x *A.auriculiformis* hybrid
- Hindustan Paper Mills Ltd. – Bamboo
- Annual productivity of clonal Eucalyptus range from 20-58 m<sup>3</sup>/ha/yr, while the productivity of seed raised plantation is hardly 4-5 m<sup>3</sup> /ha/yr.
- Clonal *Eucalyptus* plantations benefited 2285 farmers who planted 10.86 million clonal saplings in 5616 ha. during 1992 to 2002 (ITC, A.P.)



# Timber from Agroforestry- value addition: India case study



Photo Credit: CIFOR-ICRAF

# Agroforestry and industries

**26,500 Wood-based industries in the country**

- Saw-mills 23220
- Plywood mills [large & medium] 62
- Plywood mills [small] 2500
- Pulp and paper mills 660
- **Employment generation in AF 53 and 108 days in the farm and non-farm sector.**



**Basketry and furniture from Salix- J&K**



**Yamunanagar city 'country's plywood capital'- biggest market of farm-grown wood in country**

1. About 3.5-4.0 million tonnes of timber worth about US\$19-24 million is being traded annually, of which about US\$ 10-12 million is going back to farmers
2. The city now has heavy concentration of wood-based units, which manufacture wood products worth US\$76-80 million annually and provide direct and indirect employment to about 100,000 people
3. The district alone produces about 45% plywood of the country,
4. **Turnover of Plywood industries= US\$ 747,000 per day**



# CHALLENGES & WAYFORWARD

1. The poverty is very significant in South Asia, South-east Asia and Africa and it is more pronounced in rural area, where majority of the people/farmers live.
2. They have weak socioeconomic condition and largely depending on agriculture practices for their livelihood which is threatened due to the impact of climate change.
3. *Adopting agroforestry by the farmers is a sensible solution for achieving sustainability by optimizing the farmland diversification for meeting the demand of food, nutrition, energy, employment.*
4. This can be achieved by focusing on following areas,
  - Utilization of abandoned agriculture and other land for agroforestry
  - Agroforestry targeting increasing livelihood, reducing poverty, create local employment, increase income for women and youth and reduced migration,
  - Agroforestry for women empowerment, changing role of women from ‘employee” to “employers”, reduced drudgery for women and children,
  - Agroforestry for promotion of small businesses, value chains, and sustainable development
  - Ecosystem services, increased green cover, climate resilience, improved quality of life

*To realize the full potential and benefits of agroforestry, there is an urgent need and demand to sensitize the policy makers, and strengthen their capacities for mainstreaming agroforestry in their country’s development agenda.*

# Thank you

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