THEME 5

Forests and Climate Change

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Indian Forestry Congress- 2011

Planning Strategy for REDD+: India

New Delhi, 22 November 2011

Jagdish Kishwan

Additional Director General (Wildlife), MoEF
Former PCCF and HoFF, Jammu and Kashmir
Former DG, ICFRE
also
Member, Core Negotiating Group for UNFCCC
Member, Expert Group on Low Carbon Strategy for Inclusive Growth- Planning Commission

Concept and Philosophy of REDD+

- **A national level forest carbon stocks accounting approach**
- **Any scope for project level actions?**

  Yes for learning and experimentation

India: Implementing COP Decisions on REDD+

- **Agreed REDD+ activities contributing to mitigation (para 70 of AWG-LCA)**
  - **Reducing emissions from deforestation**
  - **Reducing emissions from forest degradation**
  - **Conservation of forest carbon stocks**
  - **Sustainable management of forests**
  - **Enhancement of forest carbon stocks**

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India: Implementing COP Decisions on REDD+

- **National REDD+ framework**
  - **National strategy of actions**
  - **National forest reference level**
  - **National transparent forest monitoring and reporting system**
  - **Information system to report on adherence to safeguards**

India: Implementing COP Decisions on REDD+

- **National strategy of actions**
  - **Enhancing and improving forest and tree cover (3 Scenarios of investment)**
    - **NAP (BAU : $ 1.11 bl Yr^{-1})**
    - **NAP+GIM (Accelerated Scenario : $ 2.13 bl Yr^{-1})**
    - **NAP+GIM+Village Forest+Substitution with Wood+Fuel Efficient Wood Stoves (Aggressive Scenario: $ 4.46 bl Yr^{-1})**
  - **Carbon service a co-benefit (rather than overarching benefit) in addition to timber, firewood, fodder, fiber, NTFP, water**

India: Implementing COP Decisions on REDD+

- **National forest reference level**
  - **Based on historical trends of forest carbon stocks**
  - **Embedded with growth trends of population and GDP, and future energy demand**
  - **Open to additional ideas**

India: Implementing COP Decisions on REDD+

- **National forest monitoring and reporting system**
  - **Estimation, monitoring**
    - **FSI+SFDs alongwith responsibility of forest and tree cover assessment**
  - **Reporting**
    - **REDD+ Cell of MoEF**
    - **System on lines of biennial reporting to be developed**

India: Implementing COP Decisions on REDD+

- **Safeguards to be promoted and supported**
  - **Transparent and effective governance**
  - **Rights of indigenous peoples and local communities**
  - **Participation of IPs and LCs**
  - **Conservation of natural forests and biological diversity**
    - **No conversion of natural forests**
  - **Reduce displacement of emissions**

India: Implementing COP Decisions on REDD+

- **Financing options (para 77 of AWG-LCA)**
  - **No tangible progress so far, countries asked to make submissions in Panama**
- **Indian position**
  - **Favours a flexible combination of market and non-market based mechanisms**
  - **Claim for incentivizing**
    - **Baseline forest carbon stocks (fund based)**
    - **Incremental forest carbon stocks (market)**

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India: Implementing COP Decisions on REDD+

- **National strategy: Technological aspects**
  - **Estimation**
    - Move towards more precise estimates
    - Biome and other foreign models good as stopgap arrangement
    - Improve and fine-tune existing methodologies for assessment of forest carbon stocks both biomass and SOC. Use these methodologies for testing and validation of models
    - Use background and knowledge of methodologies to develop indigenous models

India: Implementing COP Decisions on REDD+

- **National strategy: Policy aspects**
- Safeguard legal and traditional rights of local communities (examples- JFM, CFM, FRA)
- No role for private sector, reiterate
- No specific changes in FM for REDD+
- REDD+ incentives bonus in addition to traditional goods and services to local community from forests
- Policy statement endorsing 100% share of REDD+ to local community and no involvement of private companies
- Participation of local community in assessment and monitoring of forest C stocks
- Capacity building

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Forests and climate change

1. Deforestation and land use change contribute to CO_2 emissions
   – IPCC; 20% of CO_2 emissions
2. Forests provide a large potential to mitigate climate change; REDD, A&R, Bioenergy…
   - IPCC; 15 – 20% of CO_2 emissions
3. Forests will be impacted by climate change and are highly vulnerable to climate impacts
   - Need for adaptation to enable forests to cope with climate change
4. CC could impact Carbon sinks, REDD potential

Forest sector is critical in addressing climate change

Forest sector is very contentious in global negotiations

Issues in Climate Change and Forests

1. **GHG Inventory from Forestry or LULUCF sector**
   – IPCC methods; data and models
2. **Mitigation potential assessments at different levels – for land based projects**
   1. **CDM, REDD+, Forest conservation, A&R, etc**
   2. **Barriers and policy options to promote mitigation actions**
3. **Impact of climate change on forest ecosystems, biodiversity and livelihoods**
4. **Adaptation and resilience enhancement; practices**
5. **CDM and REDD+; policy and methodological issues**
6. **International negotiations – India’s position**
7. **Greening India Mission – Information/Data needs**

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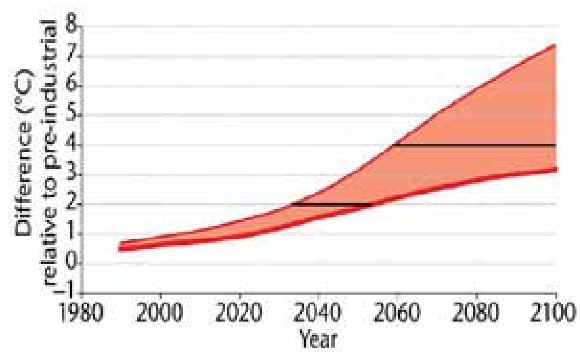
Greening India Mission (GIM)

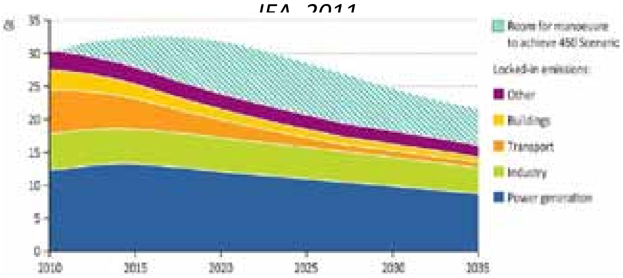
The Mission aims at addressing climate change by

1. **Enhancing carbon sinks in sustainably managed forests and other ecosystems**
2. **Enhancing the resilience and ability of vulnerable species/ ecosystems to adapt to the changing climate**
3. **Enabling adaptation of forest-dependant local communities in the face of climatic variability.**

2°C threshold - Projected temperature rise for A1B & A1F1 scenarios



The door to 2°C is closing, but will we be "locked-in" ? IEA, 2011



Without further action, by 2017all CO2emissions permitted in the 450 Scenario will be "locked-in" by existing power plants, factories, buildings, etc

Figure 1: Forest cover map of India of 2007 (FSI, 2009)

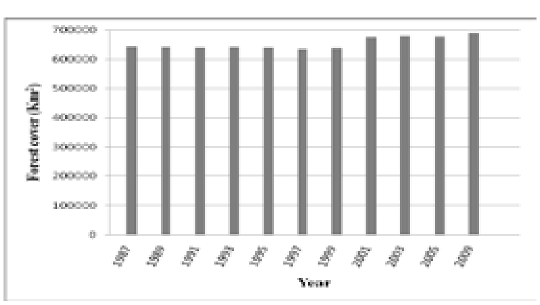


Figure 2: Trends in area under forest over the period 1987 to 2009 (according to FSI reports)

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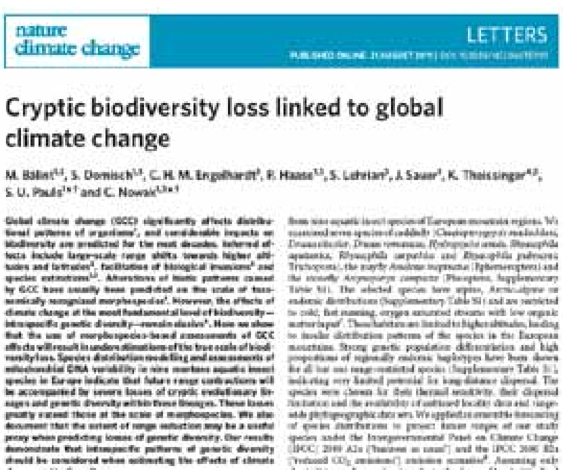
Failure to migrate: lack of tree range expansion in response to climate change , by Kai Zhu, Christopher W. Woodall, James S. Clark, *Global Change Biology, 2011*

Abstract

Tree species are expected to track warming climate by shifting their ranges to higher latitudes or elevations, but current evidence of latitudinal range shifts for suites of species is largely indirect. In response to global warming, offspring of trees are predicted to have ranges extend beyond adults at leading edges and the opposite relationship at trailing edges. Large-scale forest inventory data provide an opportunity to compare present latitudes of seedlings and adult trees at their range limits. Using the USDA Forest Service's Forest Inventory and Analysis data, we directly compared seedling and tree 5th and 95th percentile latitudes for 92 species in 30 longitudinal bands for 43 334 plots across the eastern United States. We further compared these latitudes with 20th century temperature and precipitation change and functional traits, including seed size and seed spread rate. Results suggest that 58.7% of the tree species examined show the pattern expected for a population undergoing range contraction, rather than expansion, at both northern and southern boundaries. Fewer species show a pattern consistent with a northward shift (20.7%) and fewer still with a southward shift (16.3%). Only 4.3% are consistent with expansion at both range limits. When compared with the 20th century climate changes that have occurred at the range boundaries themselves, there is no consistent evidence that population spread is greatest in areas where climate has changed most; nor are patterns related to seed size or dispersal characteristics. The fact that the majority of seedling extreme latitudes are less than those for adult trees may emphasize the lack of evidence for climate-mediated migration, and should increase concerns for the risks posed by climate change.



GHG Inventory from LULUCF Sector

Indian Institute of Science

National Remote Sensing Agency

Forest Survey of India

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GHG-INVENTORY GUIDELINES

1. 1996 Revised IPCC Guidelines for GHG Inventory of LUCF sector – NATCOM- I
2. **Good Practice Guidance for LULUCF Sector IPCC 2003 - NATCOM-II**
3. IPCC- GHG Inventory guidelines, 2006
   - AFOLU – Agriculture, Forest and Other land use Sectors

Greenhouse gas inventory estimates for India

GHG emissions from LULUCF sector for India (Gg) during 2000

Land category	*Sub-category*	*Annual CO_2 emissions/ removals*	*CH_4*	*N_2O*	*Total CO2 eq Emissions*
Forest land	Forest land remaining forest land	-79,918.80	11,600	2,090	-66,228
	Land converted to forest land	**-137,475.00**			**-137,475**
Cropland	Crop land remaining crop land	-15,318.44			-15,318
	Land converted to crop land	-8.87			-9
Grassland	Grassland remaining Grassland	-3,460.77			-3,460
Settlement	Settlement remaining Settlement	-73.13			-73
	Land converted to Settlement	-2.42			-2.42
Total		**-236,257.43**	**11,600**	**2,090**	**-222,567.43**

Limitations of Data on Area, Biomass and Carbon Stock

- **No periodic forest inventory studies in India**
- **Land use change matrix for 6 land categories not available**
- **Carbon pools data not available for different land categories; stocks and changes**
- **Wood extraction; commercial timber and fuelwood extraction data not available**
- **No data on forest degradation**

Mitigation assessment

-CDM projects

-Greening mission

-CAMPA

-JFM / CFM / Social Forestry / NEAB

-REDD plus

-IPCC assessments

Mitigation Options

- Forest Conservation
  - –Halting or reducing Deforestation
  - –Reducing forest degradation
- Afforestation / Reforestation
- Agro-forestry
- Bio-energy plantations

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Models for mitigation assessment

- PROCOMAP
- GCOMAP
- CATIE
- TARAM

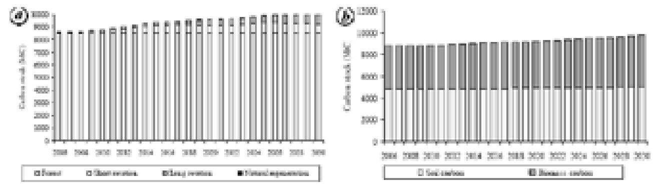
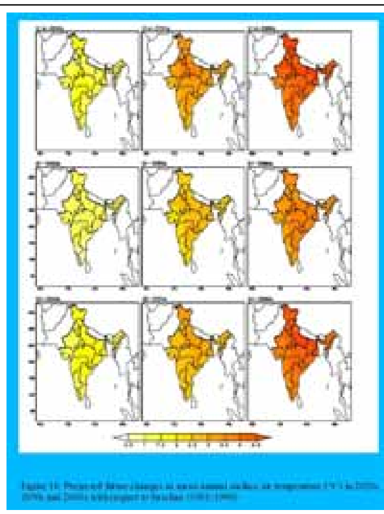


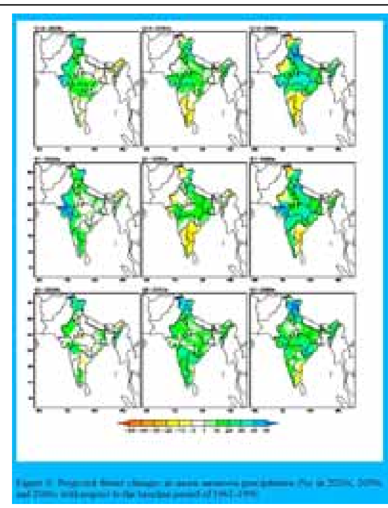
Figure 6. Projected forest carbon stocks. a, Under the current trend scenario for existing forests and area afforested (short- and long-rotation and natural regeneration). b, According to biomass and soil carbon.

Assessment of mitigation potential under changing climate

- **Climate change will impact forest ecosystems, dominant species and net primary productivity**
- **Need to assess the impact of climate change on mitigation potential and forest carbon sink**
  - **Will forests become source from sink**
  - **What happens to REDD+ potential?**

Impact of Climate Change on forest ecosystems and Adaptation Needs





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CURRENT SCIENCE

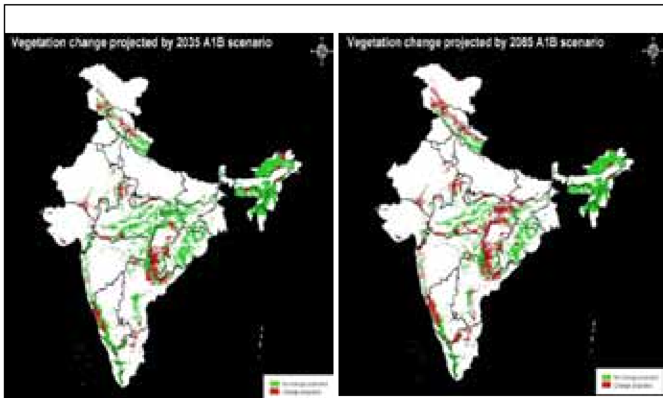
Impact of Climate Change on Indian Forests

Global Vegetation Model:

1. BIOME4: Equilibrium model
2. IBIS (Integrated Biosphere Simulator): dynamic global Vegetation Model
3. Working currently on LPJ & CLM models

Climate Model: GCM and RCM data from

- Hadley HadRM3 data (50x50 km^2)
- In future other GCMs will be used



Red indicates that a change in vegetation is projected at that grid in the time-period of 2035 & 2085 - under A1B scenario
Green indicates that no change in vegetation is projected by that period.

Percentage of FSI grids projected to undergo change, aggregated by the major forested states – A1B Scenario

State	Number of FSI grids in the state	% projected to change by 2035	% projected to change by 2085
Rajasthan	802	61.22	78.18
Jammu & Kashmir	910	57.03	88.35
Chhattisgarh	3292	48.00	75.85
Himachal Pradesh	838	47.49	65.39
Andhra Pradesh	2288	39.20	51.57
Karnataka	1947	38.37	62.20
Tamil Nadu	776	27.45	47.04
Madhya Pradesh	4432	22.59	48.17
Maharashtra	2197	21.21	45.33
Uttaranchal	1203	19.04	31.92
Arunachal Pradesh	2666	12.27	6.90
Orissa	2564	9.71	13.53
Meghalaya	829	7.96	0.00
Assam	1261	5.23	1.11
Jharkhand	1148	0.00	24.30

Percentage of FSI grids projected to undergo change, aggregated by Champion and Seth forest types – A!B

Forest type (by Champion and Seth, 1968)	Number of FSI grids in type	% projected to change by 2035	% projected to change by 2085
Tropical dry evergreen forest	37	70.27	72.97
Subtropical dry evergreen forest	133	54.14	67.67
Himalayan dry temperate forest	106	52.83	76.42
Himalayan moist temperate forest	1144	52.62	88.02
Subalpine and alpine forest	400	49.75	77.50
Tropical thorn forest	1278	41.39	75.12
Tropical semi evergreen forest	1239	30.67	50.36
Littoral and swamp forest	7	28.57	28.57
Tropical dry deciduous forest	9663	25.62	46.73
Tropical moist deciduous forest	11266	22.63	37.88
Subtropical pine forest	1662	20.64	17.39
Subtropical broad leaved hill forest	192	15.10	15.10
Tropical wet evergreen forest	2862	14.61	14.68
Montane wet temperate forest	940	5.64	0.32

Vulnerability Index and Profile Development

Applicable and necessary for
Greening India Mission

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Vulnerability Assessment - Indicators

1. Climate change impact Indicators
2. Bio-physical Indicators
3. Socio-economic Indicators

Criteria & Indicators for Mitigation projects

- **Disturbance index**: **An indication of the human disturbance for a particular forest patch. More the disturbance index, higher the forest vulnerability.**
- **Fragmentation status**: **An indication of how fragmented the forest patch is. More the fragmentation status, higher the forest vulnerability.**
- **Biological richness**: **Indicates the species diversity of the forest patch, a measure of the number of species of flora and fauna, per unit area. *Higher* the biological richness, *lower* the forest vulnerability**
- **Impact of climate change on carbon sinks of forests:** **For estimating climate change impacts, IBIS, which is a dynamic global vegetation model, was used.**

Why Adaptation? When uncertainty in Impact Assessment

- Impacts will be irreversible; e.g.,
  - loss of biodiversity
- Inertia in response to changing climate
- Long gestation period in developing & implementation of adaptation practices
- Waiting for full knowledge – high risk
- Large ecological, economic and social implications

Focus on "win – win" adaptation options

REDD & CDM

- **REDD+ and CDM are likely to become important mechanisms in forestry**
- **Large opportunities for carbon revenue**
- **Policy , institutional and financial issues**
- **Requires rigorous methods for estimating area changes, carbon stock changes**
- **Requires rigorous monitoring, reporting and verification**
- **Requires equitable sharing of carbon revenue with local communities**

Major methodological issues under REDD / CDM

1. **Estimation of deforestation / degradation rates; past, current and projections; spatial and temporal estimates – high accuracy**
2. **Carbon stock change assessment – REDD**
3. **Data on biomass & SOC growth rates for different species & forest and plantation types**
4. **Estimation of emissions from deforestation and degradation**
5. **Baselines/Issue of setting Reference Emissions Levels**
6. **Drivers of deforestation and degradation**
7. **Carbon leakage estimation**
8. **REDD Monitoring and Verification (MRV)**

Research

- Initiate long term monitoring studies vegetation response to CC
- **Enhancing modeling capacity**
- Generate database for forestry CC related analysis and projects
- **Conduct regional level; impact and mitigation studies**
- Developing pilot adaptation project

Addressing Data / Modeling GAPS is most critical for research in the forest sector

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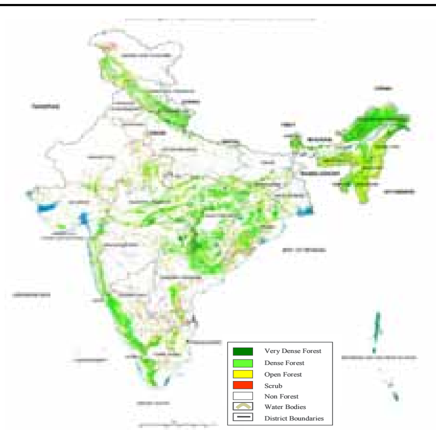
Ministry of Environment and Forests
GOVERNMENT OF INDIA

NATIONAL MISSION FOR A GREEN INDIA

Under the National Action Plan on Climate Change

22nd Nov, 2011

What is at Stake?



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Making of Mission for Green India : Trying to develop an Inclusive approach

<u>**Public inputs in planning (2010-11)**</u>

- Draft document on **website** 23rd May 2010, in **11 languages**
- **7 Regional Consultations; Over 1450 people**; **Thousands of mails received**
- **Revised draft on website in Oct 2010**
- **Deliberations in PM Council & Endorsement of Mission on 22nd Feb;** outlay of 200 crores for Prep Year; with IMG

3

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'Business as Unusual': Key Innovations

1. **Improvement in forests – both qualitative and quantitative** (5mha+5mha)
2. **Focus on a range of ecosystem services**
   – Emphasis on biodiversity, water and improved biomass ;Carbon sequestration as co-benefit
3. **Adoption of Landscape-based Approach**
   – Landscape prioritisation to use a range of criteria
   – Interventions at "scale" (5000-6000 hectares) at a time;
   – Ecosystems including forests, grasslands, wetlands, cold desert, ravines, Jhum, abandoned mining areas , urban and peri-urban, agro ecosystem etc
   – Simultaneous treatment of forest and non forest areas
   – Addressing key drivers of degradation ; convergence principle
   – Capacities/ leadership to manage landscape level

Countries now shifting towards landscape approach for multiple values,

The Reform Agenda and Demand Driven

- **Reform Agenda** as **conditionality**
  - Strengthen Decentralized forest governance ,
  - Centrality of Gram Sabha for improved forest governance; poly centric and nest organisations
  - Second Generation reform in JFM
  - Revamped FDAs
  - Filling of vacancies of frontline staff
  - Easing out of regulatory framework on felling and transit of timber

Mission Details

A. Mission Aim

Respond to climate change by a combination of adaptation and mitigation measures, which would help :
– Enhancing carbon sinks in sustainably managed forests and other ecosystems;
– Adaptation of vulnerable species/ecosystems to the changing climate; and
– Adaptation of forest-dependant communities.

B. Mission Objectives

1. **Increased forest/tree cover** on 5 m ha of forest/non-forest lands and **improved quality of forest cover** on another 5 m ha (a total of 10 m ha)
2. **Improved ecosystem services** including biodiversity, hydrological services and carbon sequestration as a result of treatment of 10 m ha. **(measurements?)**
3. Increased forest-based livelihood income for **3 million forest dependent households**
4. Enhanced annual CO2 sequestration of **50-60 million tonnes** by the year 2022

Mission Details

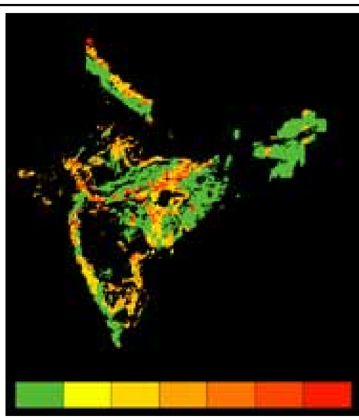
C. Mission Outputs: 5mn ha quality improvement and 5mn ha new forest cover

1. **Qualitative improvement of forest cover/ ecosystems in**:
   – 1.5 m ha dense forests
   – 3.0 m ha of degraded forests
   – 0.4 m ha of grasslands
   – 0.1 m ha of wet lands
2. **Creating new forest cover through eco-restoration/afforestation**
   – 1.8 m ha of scrub, mangroves, ravines, cold desert, shifting cultivation areas, abandoned mining area
   – 0.2 m ha of urban peri urban
   – 3.0 m ha of agro/social forestry; no cultivable land
3. **Improved livelihoods** for about 3 million households
4. **Community institutions manage forests under the Mission**
5. Project area households adopt **fuel wood efficiency and alternative RE devices**

5 sub Missions and Cross cutting interventions

Forest Vulnerability A2 (IIS)

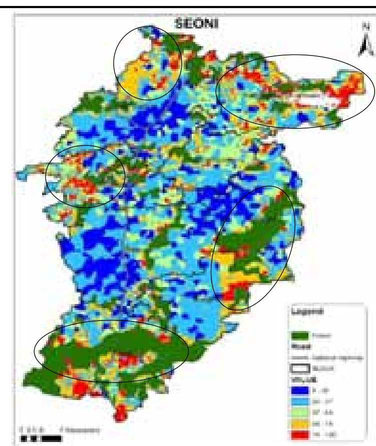
<u>Criteria</u>
Density
Biodiversity
Vegetation type change



Green least vulnerable , yellow to red increasing vulnerability

Delineating priority landscapes using value of forest cover, corridor, BPL and ST population

A total of 294 villages in 5 clusters are given very high priority
(Red)



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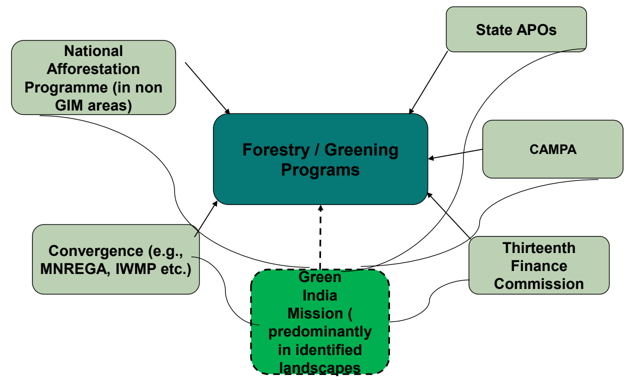
Mission Details

F. Mission Monitoring Framework

- **Improved monitoring at Outcome Level:**
  Monitoring at 4 levels
  – Self Monitoring by community and field staff (appropriator or resource consumer are best placed to monitor)
  – "Eye in the Sky" + GIS (geomatic)
  – Monitoring by third party
  – Monitoring key indicators (long term)
- **Social Audit (learning from MNREGA)**
- **Auditing by CAG/AG**

Positioning Green India Mission Phase I (2012-2014)



Mission Details

Budget & Timeframe

- Total Mission Cost **Rs 46,000 crore over 10 years** (Rs. 34,000cr + Rs. 12,000cr), covering both Centre and States
- Mission to run 2011-2022
  – Mission implementation to coincide with **12th and 13th Five year Plan**
  – Year 1 (2011-2012) to be preparatory year
- The Mission document to lead to formulation of State Action Plans and Plan at local levels

GIM document : Inputs from the PM Council on climate change

- Full range of ES service benefits to be computed, not just carbon
- Must address regulatory regime on farmers lands
- Caveat on agro forestry
- Linkages with the MNRES
- Unlocking of the CAMPA

GIM document : CSO perspective

Banking on Forests : Kanchi Kohli and Manju Menon

- GIM is carbon complaint ; new forest are carbon stocks
- Will GIM really put meaning into participatory forestry or just another rhetoric
- Afforestation will continue to create problem of access for poor
- Where are the commons , particularly wastelands
- De-greening not addressed
- CAMPA and REDD funding

Engendering the climate for Change : Aditi Kapoor

- Weak gender focus ; limited role for women in forest management foreseen; Mission meant for afforestation and Carbon

Preparatory phase: Key Processes & Outputs

- **Operational guidelines ; also revised GIM doc**
- **Institutional & Procedural**
  National (Core Staff; Governing Council; Autonomous Society)
  State : Strengthening of SFDA ;
  MoEF processes: Cabinet note, EFC , IMG proposal , Consultant team
- **Plans** :
  State: One year bridge plan; State Perspective Plan (5-10 years)
- **Local Plan implementation (Institutions; livelihood support; early nursery preps etc)**
- **Communication & Awareness**
- **Research Studies /Assessments**

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Making of Mission for Green India : An Inclusive Approach

Activities in 2011-12

- Activity calendar/Road Map discussed during March Consultation
- April 28th Consultations
- NAEB to anchor the Mission in the preparatory year
- Mail Groups Set up to put up guidelines
- Note for IMG prepared
- Cabinet note prepared and circulated
- IA drafted
- Regional Consultations for selection of landscapes
- Review of progress by PMO and Cab Sect

16

We are we in the preparatory year

- **Limited progress**
- **Key issues :**

process guidelines

Procedural

Institutional issues

Financing the GIM

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Remembering Robert Frost

Woods could be lovely , dark and deep ;
But we have the promises to keep
Miles to go before we sleep.....

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Understanding present and future carbon cycling of forests: Some methodological problems

A.Shvidenko, H.Boettcher

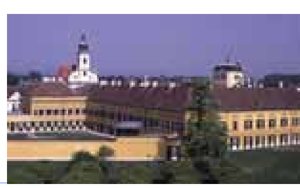
International Institute for Applied Systems Analysis, Laxenburg, A-2361 Austria

Indian Forestry Congress, New Delhi, India, 21-26 November 2011

International Institute for Applied Systems Analysis (IIASA)

Located in a 18th century castle "Schloss Laxenburg" (Habsburg), 30 minutes south of Vienna; founded in 1972

East-West -> North-South -> Global



Two ways of study of carbon cycling

- Pool based approach: NBP=ΔLB+ΔDW+ΔSC
  - LB - Live biomass
  - DW - Dead wood (coarse woody debris)
  - SC - Soil carbon, including on-ground organic layer
- Flux-based approach: NBP=NPP-HSR-DEC-LF-D
  - NPP - Net Primary Production
  - HSR - Heterotrophic soil respiration
  - LF - Lateral fluxes to hydrosphere and lithosphere
  - DEC - Decomposition flux
  - D – Flux caused by Disturbances

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Major principle: integration, harmonizing and multiple constraints of independent methods and results

Landscape-ecosystem approach
Process-based and other models
Flux measurements
Multi-sensor remote sensing concept
Inverse modeling

General philosophy: Need of Verified Full Carbon Account (FCA)

Full: ALL (forest) ecosystems, ALL processes, ALL carbon contained substances – spatially distributed and continuous in time

Verified: reliable and comprehensive account of uncertainties for all modules and at all stages of the account, to a possible extent – reliable and comprehensively

Uncertainty is an aggregation of insufficiencies of outputs of the accounting system, regardless of whether those insufficiencies result from a lack of knowledge, intricacy of the system, or other causes

But

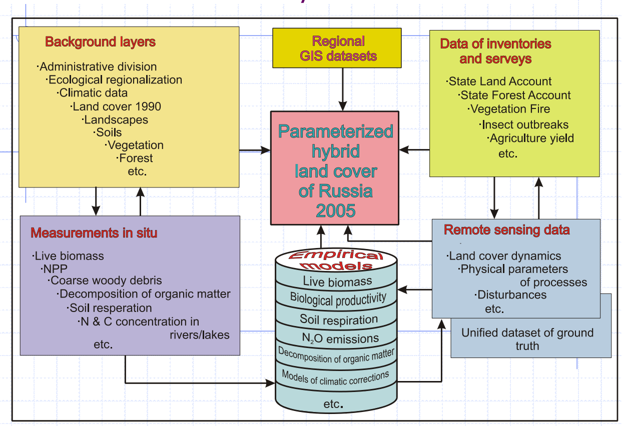
FCA is underspecified task (fuzzy, full complexity, or ill–defined problem), which cannot be verified by strict formal methods

Approach: As comprehensive as possible following the principles of applied systems analysis

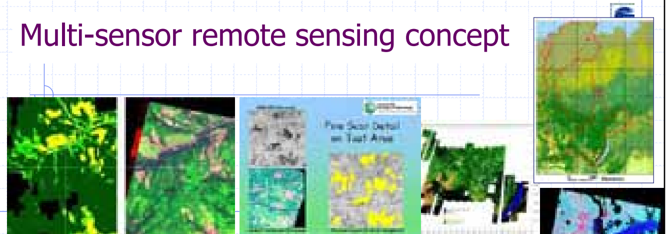
Landscape-ecosystem approach: an empirical (semi-empirical) background of FCA

- As comprehensive as possible following the requirements of the applied systems analysis
- Relevant combination of flux- and pool-based approaches
- Strict mono-semantic definitions and proper classification schemes; harmonization of these with other approaches
- Explicit intra- and intersystem structuring: optimization of input data; explicit algorithmic form of accounting schemes, models and assumptions
- Spatially and temporally explicit distribution of pools and fluxes
- Correction of many year average estimates for environmental and climatic indicators of individual years
- Assessment of uncertainties at all stages and for all modules of the account – intra-approach uncertainty
- Comparative analysis with independent sources, harmonizing and multiple constraints of the intermediate and final results

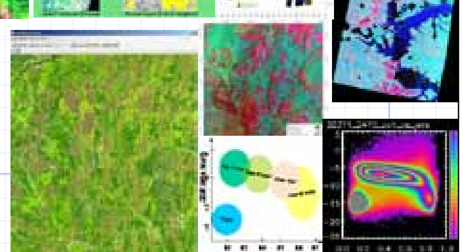
Information Background of FCA – Integrated Land Information System of Russia



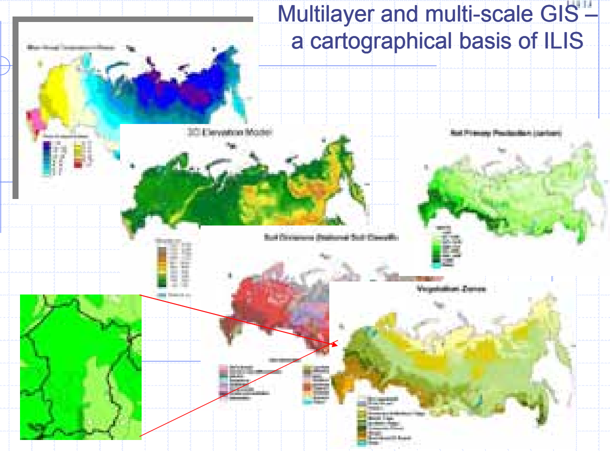
Multi-sensor remote sensing concept



- NOAA AVHRR
- MODIS
- GLC-2000
- MODIS-VCF
- LANDSAT TM
- ENVISAT MERIS
- ENVISAT ASAR
- JERS
- ERS-1 and ERS-2
- ALOS PALSAR



Multilayer and multi-scale GIS – a cartographical basis of ILIS



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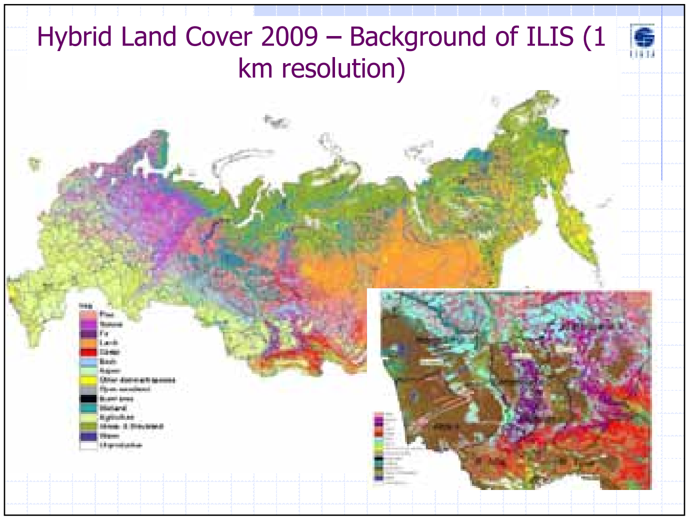

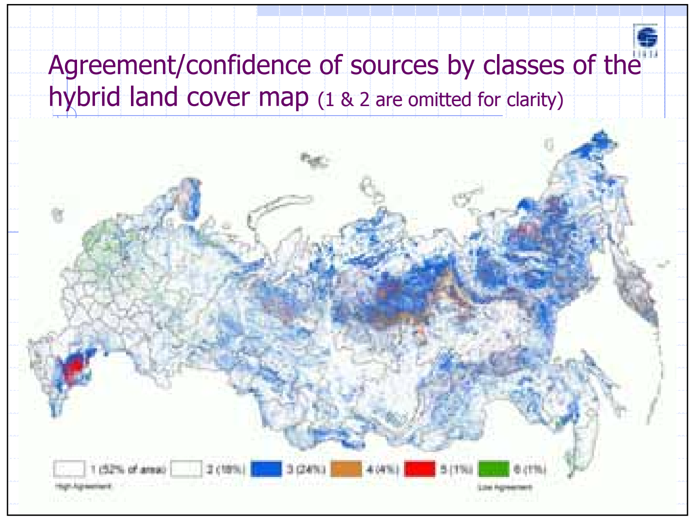

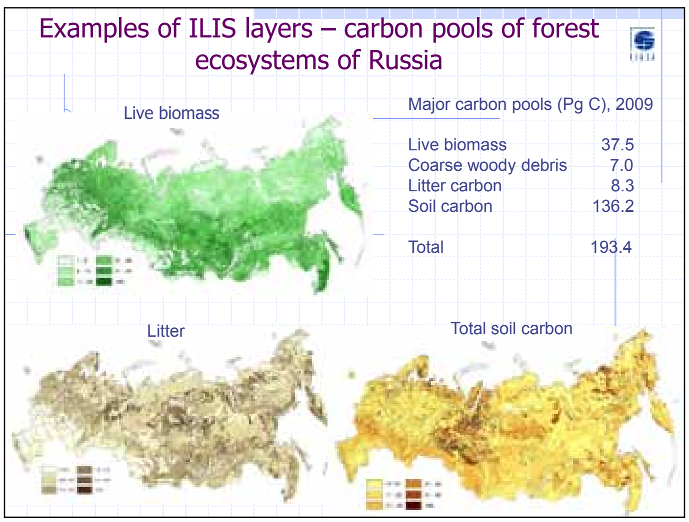

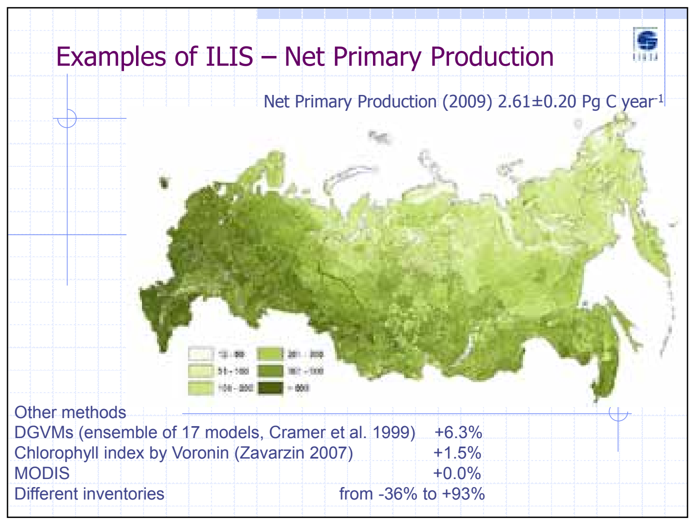

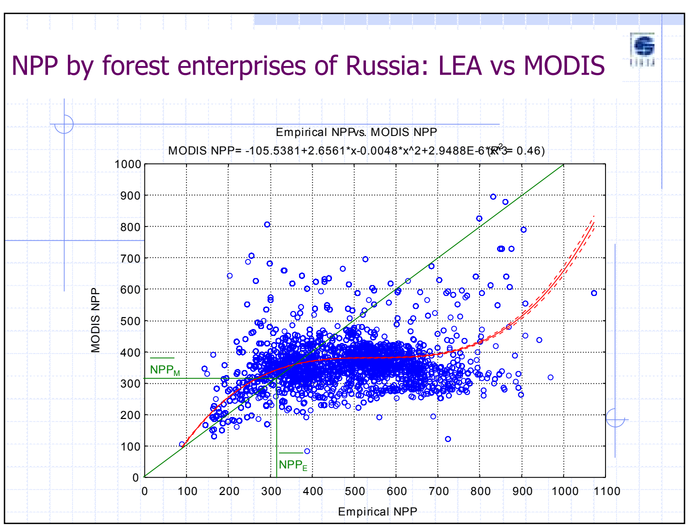

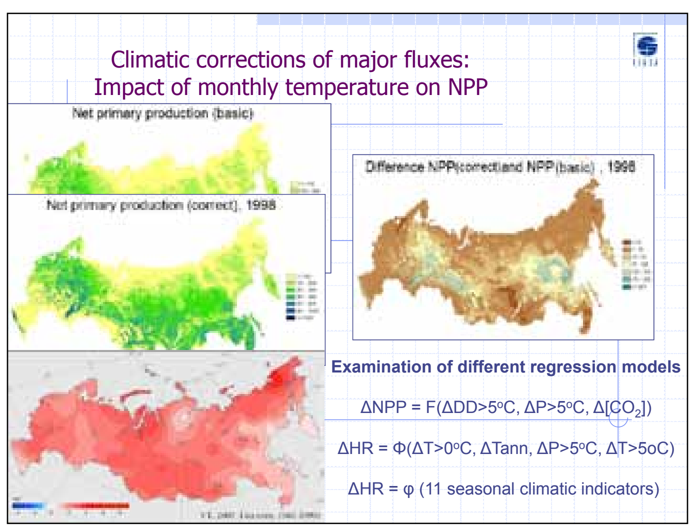

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Heterotrophic soil respiration: Initial data

- Soil map of the Russian Federation 1:2.5 Mio (Fridland, 1988)
- Hybrid land cover (Schepaschenko et al., 2010)
- Database of measurements of organic carbon in soils of Russia (1068 records-Kurganova, Mukhortova, Schepaschenko)
- Global database of soil respiration (3592 records)
- Map of bioclimatic zones (Stolbovoi, McCallum, 2002)
- Administrative map

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Method of estimation of HSR

- Regression models of total soil respiration (SR) on climate by soil types
- Modification of models by region/bioclimatic zone, vegetation type and disturbance
- Model of share of autotrophic respiration in total SR by soil types
- Regression correction of SR by level of Net Primary Production

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Modification of SR by regions/bioclimatic zone, vegetation type, land-use and disturbance

$$C_i = \frac{\bar{R}^{measured}_{S\,i}}{\bar{R}^{mod}_{S\,i}}$$

Corrections are made by the ratio between average measured SR ($R^{measured}$) to SR, calculated by climatic models (R^{mod}) for each region, zone, vegetation type, land-use and disturbance

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Heterotrophic soil rspiration

(g C m^{-2})

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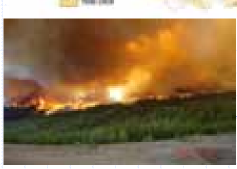
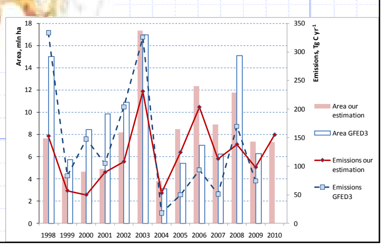
Burnt areas and direct fire emissions in Russia in 1998-2010

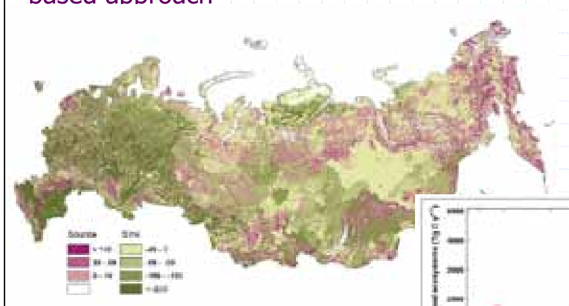
Average area of wildfire in 1998-2010 гг. Is estimated at 8.2 Mio ha and carbon emission121 Tr C год$^{-1}$

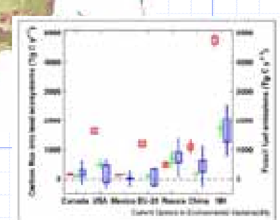




Source: Shvidenko et al. 2011

Full carbon account for Russia in 2009 – flux-based approach





All ecosystems of Russia in 2000-2010 served as a net carbon sink at 0.5-0.7 Pg per year
Of this sink, ~90% was provided by forests
Source: Shvidenko et al. 2011

Source: Ciais et al. 2010

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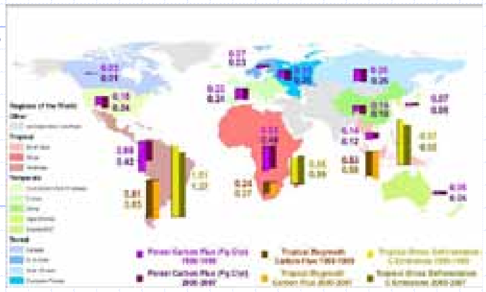
Change of carbon stock in boreal ecosystems in 1990-2007: net sink at 0.5 Pg C year^{-1} or 21% of established forests (Pan et al. 2011)

including (Tg C yr^{-1})

Asian Russia	259
European Russia	170
Boreal Europe	48
Canada	19
Total	496



Goodale et al. (2002) – ~500 Tg C yr-1

Inverse modeling

- Estimates for Eurasia, Pg C year^{-1}

Fan *et al.*,1999, *Science*	+0.1±0.7
Bousquet *et al.*, 1999, *JGR*	-1.8±1.0
Rodenback *et al.*, 2003, *AChPh*	+0.2±0.3
Gurney *et al.*, 2004, *GChB*	-0.7±1.0

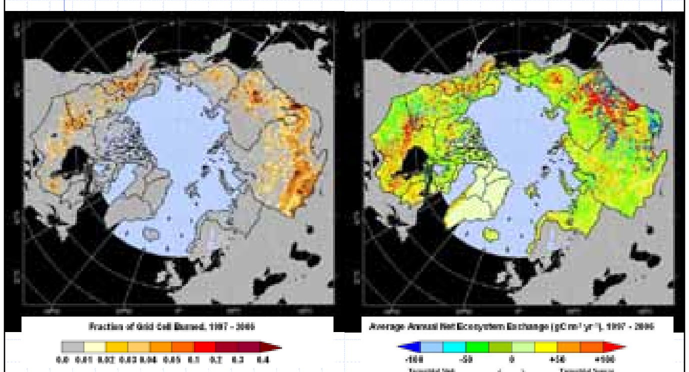
- Estimates for boreal Asia, Pg C year^{-1}

Maksyutov et al., 2003 (1992-1996)	-0.63±0.36
Gurney et al.,2003 (1992-1996)	-0.58±0.56
Baker et al. (1988-2003)	-0.37±0.24
Patra et al., 2006 (1999-2001)	-0.33±0.78

- Estimates for Russia, Pg C year^{-1}

Ciais et al., 2010 (2000-2005), 4 dif. Inv.	-0.65±0.12
Shvidenko et al., 2010 (2003-2008), LEA	-0.57±0.26

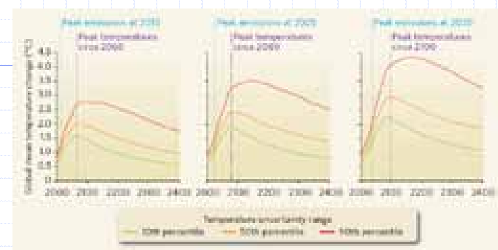
TEM – Terrestrial CO_2 Exchange



Sink 302 Tg C yr−1 = NPP (3260)−HR(2958); fire 255 [178 in soil]

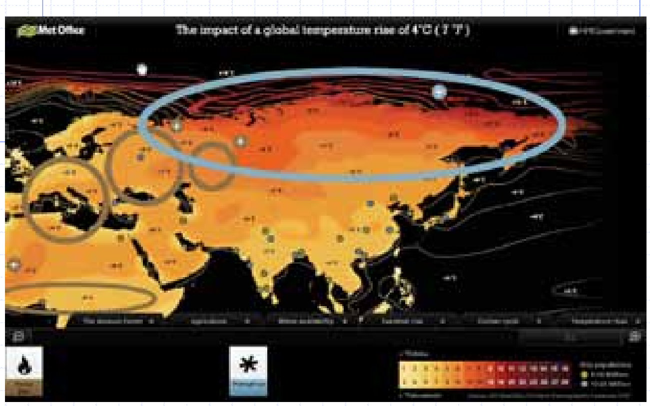
McGuire et al. 2010

We should be planning to adapt to at least 3-4°C of global warming



Global average surface temperature scenarios for peak emissions at three different dates with 3%-per-year reductions in greenhouse gas emissions. Source: Parry et al. Nature 458, 30 April 2009

Northern Eurasia under +4°C globally



http://www.actoncopenhagen.decc.gov.uk

Planning adaptation and mitigation strategies in forestry and forest sector

(1)Again this is a typical case of *full complexity [fuzzy, underspecified]* problems – ill-defined and quasi-manageable task, i.e.

- Structurally, functionally and dynamically intricate
- Non-separable from context, observation and interest
- Multi-objective/subjective
- Inherently uncertain due to fragmentary knowledge and the lack of any proper validation

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Planning adaptation and mitigation strategies in forestry and forest sector

(2) Future is very uncertain and complex

- Climatic projections by AOGCMs are not consistent
- Ecological, social and economic developments are hardly predictable
- Complexity, non-linear responses and feedbacks
- Need to take decisions for dynamic fuzzy system under uncertainty
- Needs to derive minimum mitigation standards from the limits of adaptation
- Relevancy to consider multiple strategies that integrate mitigation and adaptation measures in no-regret and win-win fashion

Planning adaptation and mitigation strategies in forestry and forest sector

(3) Our current knowledge is often not satisfactory

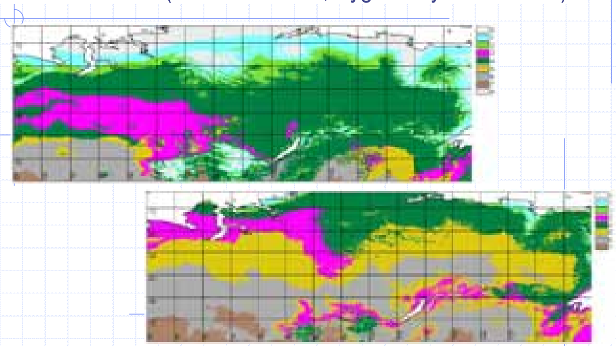
- How much stable is the direct stimulation of photosynthesis and NPP by the environmental change?
- How are terrestrial ecosystems functioning under dynamic conditions of multiple limitations for life resources?
- To what extent do the limitations bound CO2 fertilization effect and how long?
- How much nitrogen deposition is able to eliminate lack of available nitrogen in high latitudes?
- How do all these changes interact with the hydrological cycle, particularly with water stress?
- How will destruction of permafrost impact forest ecosystems of high latitudes?
- What is future governance of environment and natural resources?

Planning adaptation and mitigation strategies

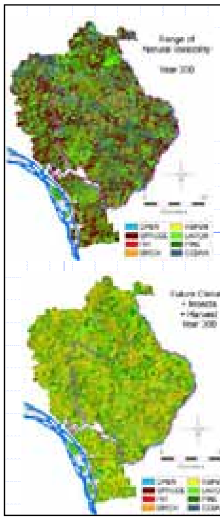
(4) Robust policies – a background of the planning which should:

- ensure long-term stability of systems against multiple events within the sustainable forest management paradigm;
- include ecological, economic, and social dimensions;
- account for extreme events;
- consider uncertainties in a holistic way;
- allow for flexibility a diversity of decisions dependent on associated risks and costs;
- include safety criteria, constraints, and performance indicators of involved agents; and
- allow to minimize losses if the alternative scenario is realized

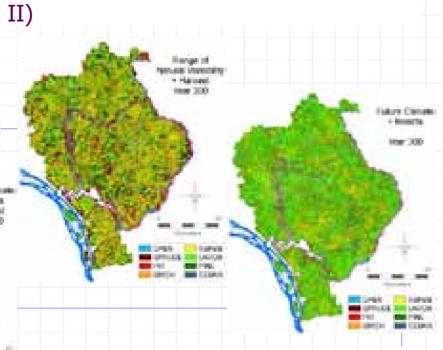
Distribution of bioclimatic zone in Northern Asia under current (a) and 2090 climate (model SibClim3, Vygodskaya et al. 2007)



Water (0), tundra (1), forest tundra (2), dark coniferous (3), light coniferous (4), forest steppe (5), steppe (6), desert (7), polar desert (8).



Adaptive forest management: climate change *vs* management (LDSM Landis – II)



Northern Forest Enterprise of Irkutsk oblast
Source Gustafson, Shvidenko et al. 2008

Climate change research at IIASA

World Population: 6.8 bn (2009) Projected 9.1 bn (2050)

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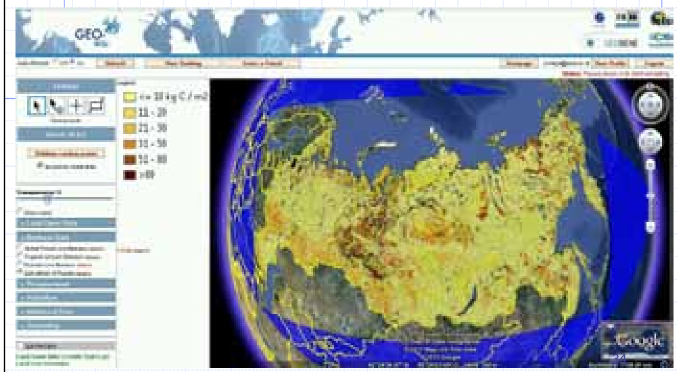
On-line tool for visualization and validation of land cover http://biomass.geo-wiki.org



Projection of the future EU forest CO_2 sink as affected by recent bioenergy policies

Hannes Böttcher1
Mykola Gusti 1,2
Petr Havlik 1
Giacomo Grassi 3

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3) European Commission - Joint Research Centre, Institute for Environment and Sustainability Climate Change and Air Quality Unit - TP 290 - Via Fermi, 21027 Ispra (VA), Italy

Background

- EU climate policy has set **emission reduction targets of 20% below 1990 levels in 2020** to be achieved through measures implemented by MS
- This target does **not** include LULUCF (land use, including forest management) although EU forests are significant sink
- EU climate policy has set renewable energy and **biofuel targets for 2020** to be implemented by MS
- Increased demand for bioenergy from forests can either be met through increased imports or increased domestic wood extraction in the EU

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Research questions

- How long will the current sink of EU forests be maintained in the near future?
- Potential conflict between carbon storage in forests and the increased use of forest bioenergy?
- What is the order of magnitude for a given policy scenario?

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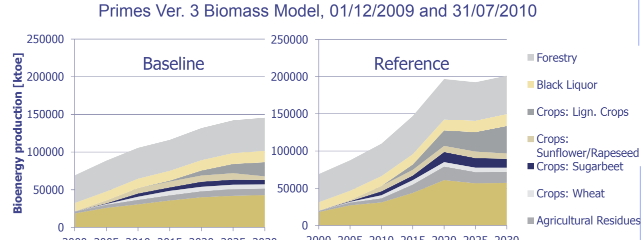
Driver: Bioenergy production in EU

Primes Ver. 3 Biomass Model, 01/12/2009 and 31/07/2010



Includes current trends and policies including the recent economic downturn and takes into account bioenergy markets

Includes the **baseline +** the Climate and energy package i.e. the renewable target of 20% in 2020 in the EU

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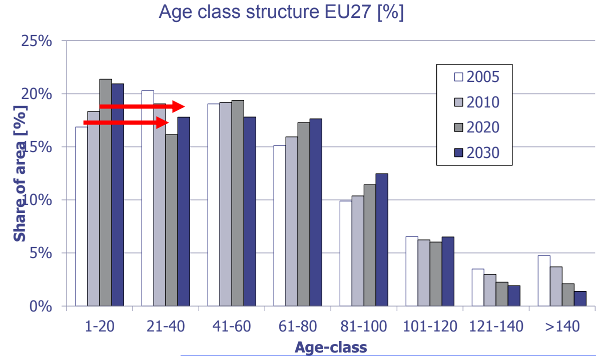
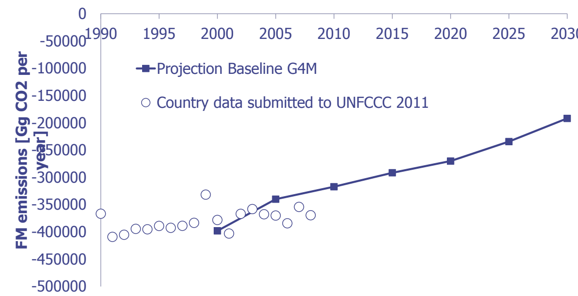
Driver: European forest age class structure



Results: Baseline development

Forest biomass only. Results calculated by Global Forest Model **G4M** Developed by IIASA

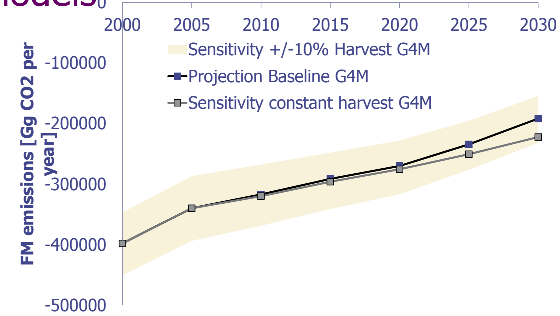


Results: Impact of increased bioenergy use on EU forest sink

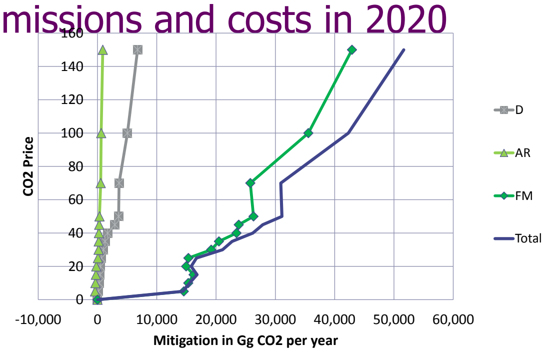
Absolute and relative differences of reference scenario to baseline for harvest volume and forest management CO_2 sink in Mm^3 (harvest) and Gg CO_2 (sink).

	2010	2015	2020	2025	2030
Harvest	5.3	10.5	15.8	4.7	-6.4
	1%	2%	3%	1%	-1%
Sink G4M	0	**-4,400**	**-11,600**	**-2,500**	16,100
	0%	**-1%**	**-4%**	**-1%**	8%

Results: Sensitivity of forestry models



Mitigation potential of baseline emissions and costs in 2020



Conclusions

- Forest sink in EU (excl. afforestation) expected to decline by 15% in 2020 and 25-40% in 2030 compared to 2010
- Drivers are:
  - the demand for wood for energy and material use that is projected to increase further in the future
  - shifts in the forest structure towards an older forests that lower the strength of forest carbon accumulation
- Impact on EU forest carbon stocks depends on whether the demand growth will be met by internal production or increased imports – indirect effects!

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Thank you !

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Article accepted at GCB Bioenergy

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The Possible Contours of Mitigation and Adaptation in Forestry Sector in India in the Coming Decade

Dr Promode Kant

A "large and persistent" carbon sink

- Globally, forests are the single largest agent of mitigation of climate change
- "large and persistent" carbon sink of 2.4 ± 0.4 Gt C/yr averaged over two decades beginning 1990
- This is 27% of the current levels of annual anthropogenic carbon emissions
- Larger than the oceanic intake of about 2.3±0.4 Gt C/year

India's performance since independence

- India reversed deforestation and led its forests into net carbon sink.
- Constitutional changes and FCA played crucial role
- Between 1995 to 2005 C stocks in Indian forests increased from 6245 to 6622 Mt - annual increment of 38 Mt of C or 138 Mt of CO2 enough to neutralize 9.31 % of the total of India's emission of the year 2000.
- Compounded annual growth rate of GHG emissions in CO2e is 4.2% (Kishwan et al., 2009), emissions in 2020 will be 95% higher than in 2000

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GHG emission offsets by forests over the years

- 1990 - 13.98%*
- 1994 – 11.25%
- 2000 – 9.31%
- 2010 – 6.53%
- 2020 – 4.87%
- This is not good enough. Much more is possible.

Comparison with China

- Forest cover in 1950 barley 8.5%, rose to 12% in early 1980s and 13.92% in early 1990s,
- Now stands at 18.21% covering 180 Mha of land.
- Over the past two decades an average of four million hectares planted annually.
- Now 54 million hectares of man-made forest with stock volumes of about 1.505 billion m^3.
- Total biomass in forests and other wooded lands of China including the deadwood biomass rose from 11883 Mt in 1990 to 14029 Mt in 2000 and 14961 Mt in the year 2005 (FAO 2005).
- Average annual increase was 205 Mt of biomass or about 301 Mt CO_2-e more than double of India's 138 Mt CO_2-e

Role of TOF in China

- Increase within forests while biomass in "other wooded lands" (corresponding to TOF in India) decreased from 993 Mt in 1990 to 982 in 2000 and 934 Mt in 2005
- Trend is similar to India where TOF stock came down from 1616 to 1599 Mm^3 between 2005 to 2007 though TOF area increased from 2.79 to 2.82 % of geographical area.
- Shorter rotation harvesting in TOF
- Availability of large number of well distributed TOF reduces pressure of demand on public forests
- Ecological demand over TOF is limited – can be harvested as per need – contributes more to CC mitigation
- Greater utilization of TOF biomass implies slower increase in fossil energy consumption when biomass is used as bioenergy or as partial replacement for steel, aluminium, cement that are very energy intensive.

China's determined use of forests to offset its industrial GHG

- In 2009 China announced plans to reduce emission intensity / unit GDP in 2020 by 40 - 45 % against 2005 levels
- Planting additional 40 Mha and increase the stock volumes by 1.3 billion m^3 from 2006 to 2020.
- Can they do it?
- Yin et al (2011) - in a comparable period between 1990 and 2005 China's forest area increased by 40 Mha and stocking by 2.77 billion m^3, which is equivalent to 2910 Mt of biomass or 1450 Mt of Carbon or 5321 Mt CO_2.
- India's case is a contrast – more a question of approach and resolve

Is Green India Mission ambitious enough?

- Enhanced annual CO2 sequestration of 50-60 Mt by 2020 offsetting 6 % compared to 4.87 % in the absence of the Mission
- Increase in forest and tree cover would be mostly in agroforestry and SF (3 Mha), shifting cultivation areas, abandoned mining lands, mangroves, ravines (1.8 Mha) and (0.2 Mha) in urban
- Improvement in forest cover over degraded forests (3 Mha) and dense forests (1.5 Mha) grasslands (0.4 Mha) and wetlands (0.1 Mha)
- Annual Outlay of Rs 8,500 cr increased by 4600 cr

Greater potential lies in Intensive Forest Management

- We seem to be practising 'do nothing' management
- Filing court cases of illegal felling and encroachments
- Rare working of forests, harvesting only dead trees
- Even JFMCs only expected to stop illegal felling
- Very intensive management with high investment not only in plantations but also in natural forests
- Intense Assisted Natural Regeneration and appropriate harvesting for enhanced productivity
- Leading to increased C sequestration and storage both in forests and in harvested products
- And production of biomass based energy

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Diameter class-wise stock position in temperate and tropical forests

	10-30 cm		30-50 cm		50+ cm		
	Stems Millions	Vol Mm^3	Stems Millions	Vol Mm^3	Stems Millions	Vol Mm^3	
Temperate	831.65	126.54	283.90	265.26	134.55	542.57	
Tropical	10896.73	1524.63	1726.88	1612.71	536.33	2305.70	

Possibilities in temperate forests

- Assuming 30 years to grow to next dia class - harvesting possibilities of 543 Mcum in 30 years or 19 Mcum annually.
- Keeping 50% mountain forests inviolate for preserving biodiversity, steep slopes, sensitive ecosystems etc would mean 9.5 Mcum/yr
- This is twice the timber imported by India in 2008 at average price of $274/cum or $2.6 Bn
- 40% additional non-timber biomass usable as fuel

Larger opportunities in tropical and subtropical

- Assuming 20 years to grow from one class to next
- Possibilities of an increase of 2305 Mcum in tropical forests over 20 years or 115 Mcum/yr
- An intensive management system with intense ANR, sustainable harvesting, keeping forests vigorous
- Can natural forests be worked at all?
- Harvesting before 1950s caused little damage
- Damage due to failure in governance and management, not because natural forests are beyond working

Significant increase in GHG offset

- possible to have an annual accrual of 134 M cum of commercial wood from the temperate and tropical forests combined which is equivalent to 142 Mt of biomass or 71.1 Mt of Carbon or 261 Mt of CO2e.
- **A different strategy for the PAs, steep slopes and Biodiversity rich forests: c**omplete preservation
- Assuming 20% forests (50% in temperate + 10% elsewhere) fall under this category - annual accrual would be 20% less or about 209 Mt CO2e.
- Adding contribution of NGIM it become 269 Mt CO2e/yr – double of present levels

Increased Role of TOF

- TOF critical because it gives enormous flexibility to forest management
- Enhanced agricultural productivity and agri-reforms needed for making marginal agri lands available for tree cultivation
- Upto 10% of least productive agri-lands – 17 Mha - could come under tree without affecting food security
- Making smallholder forestry attractive,
- Rethink on timber transit rules
- PES for smallholders

Economic contribution is a key requirement of sustained political support

- Bigger advantage of this approach is that it creates jobs.
- Nair and Rutt, 2009, - in forestry sector annual expenditure of $ 1 million creates between 500 to 1000 full time jobs
- Highest creation of new full time jobs is in A/R, desertification control, conservation, fire, indigenous forest management, watershed, improvement in productivity of existing planted forests, agro forestry, urban and peri-urban forestry and skill improvement in forestry sector.
- Also in conservation activities like demarcation of boundaries, maintenance of inspection paths and roads and creating and managing nature education centers
- Recreational activities

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Sustainable Forest Management

- Keeping forest capital stock and productivity intact over succeeding generations
- But capital stock is not natural forests alone
- Total Forest Capital (TFC)= Natural forest capital (NC)+ Man made forest capital (MC)+ Forest related Institutional capital (IC)
- SFM should be seen as keeping intergeneration TFC intact with NC not falling below $NC_{critical}$
- Institutional capital is high in India, capable of recreating forests given adequate support

Critical NC

- That NC which, if destroyed, has profoundly damaging consequences
- Difficulty lies in finding which is critical and what is the level beyond which the damage is profound
- Strong sustainability stays far above critical NC whereas weak sustainability must be guarded against crossing threshold
- Market has no inbuilt safeguards – regulatory regime needed

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MC enhances the utility of NC

- An important part of SFM is to meet the local forest based needs
- Plantations may give higher levels of satisfaction to the local stakeholders
- If harm to biodiversity is not serious and irreversible then a good proportion of MC might actually be in the interest of SFM
- Leaving a good stock of commercial timber for next generation might serve the purpose of SFM over a larger area
- Over a longer term, and managed judiciously, plantations permit natural ecosystems to replace them

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- Bequeathing next generation zero MC may be as unwise as bequeathing zero NC
- If a particular NC is abundant a part of it substituted by MC can actually complement NC because together they provide higher satisfaction to society
- And if scarce then conserving more NC will bring greater satisfaction

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Summarizing Role of Forests in CC Mitigation

Increased C sequestration and storage subject to

- Non-declining welfare over time from the forests
- Non-declining levels of consumption of forest goods and services over time
- Constant or increasing stocks of all forest capital (natural+ plantation+ human) over time with natural capital not dipping below critical levels for any ecosystem

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Adaptation

- Ecosystems are expressions of climate and geography , as climate changes ecosystems will exhibit commensurate changes.
- Response of ecosystem constituents – flora and fauna - to these changes would be in accordance with their genetic resilience, phenological plasticity and the possibility and range of mobility.
- Generally speaking the fauna and shorter lived plants may show altitudinal or latitudinal migration
- Adaptation programme needs to be designed differently from the normal developmental programme.
- It must look at what would be available in greater measures under the changing climate and then convert that into a useful product.
- Simultaneously, it must assess what would be available less as the globe warms up and initiate efforts to conserve the same.

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Adaptation

- early days yet for adaptation - not yet clear what would be the likely changes and what the adaptation measures should try to achieve in the immediate, medium and long term.
- Best use of funds in the short term may be for skill enhancement and developmental activities that increase adaptive capacity among the government and non-government institutions as it would be of crucial importance for an efficient, effective and equitable adaptation, and yield immediate benefits irrespective of how and at what pace the climatic changes occur (Fankhauser and Burton , 2011).
- For adapting to the changing climate in the forestry sector the immediate need is for research into vulnerability assessment of critical ecosystems and of key species of flora and fauna.
- Higher investments and induction of technology in forest fire and disease control management are required.

Forestry is more than ecological management

- Keeping millions of hectare of forest lands allowing trees to die of age and disease, creating no employment and little incomes, can not earn people's support for keeping one third of land under forest cover.
- A forester's job has to be much more comprehensive - must use land appropriately both ecologically and economically
- Enhancing productivity as important as ecologically sound management.
- A balance has to be found which may not always be achievable in every bit of forests but can perhaps be achieved over larger landscapes.
- Need to bring the focus back to comprehensive forestry in which economic productivity is not an abusive word.
- The increasing demand for mitigation of climate change through carbon sequestration might perhaps cause the changes needed in our forestry practices.

References

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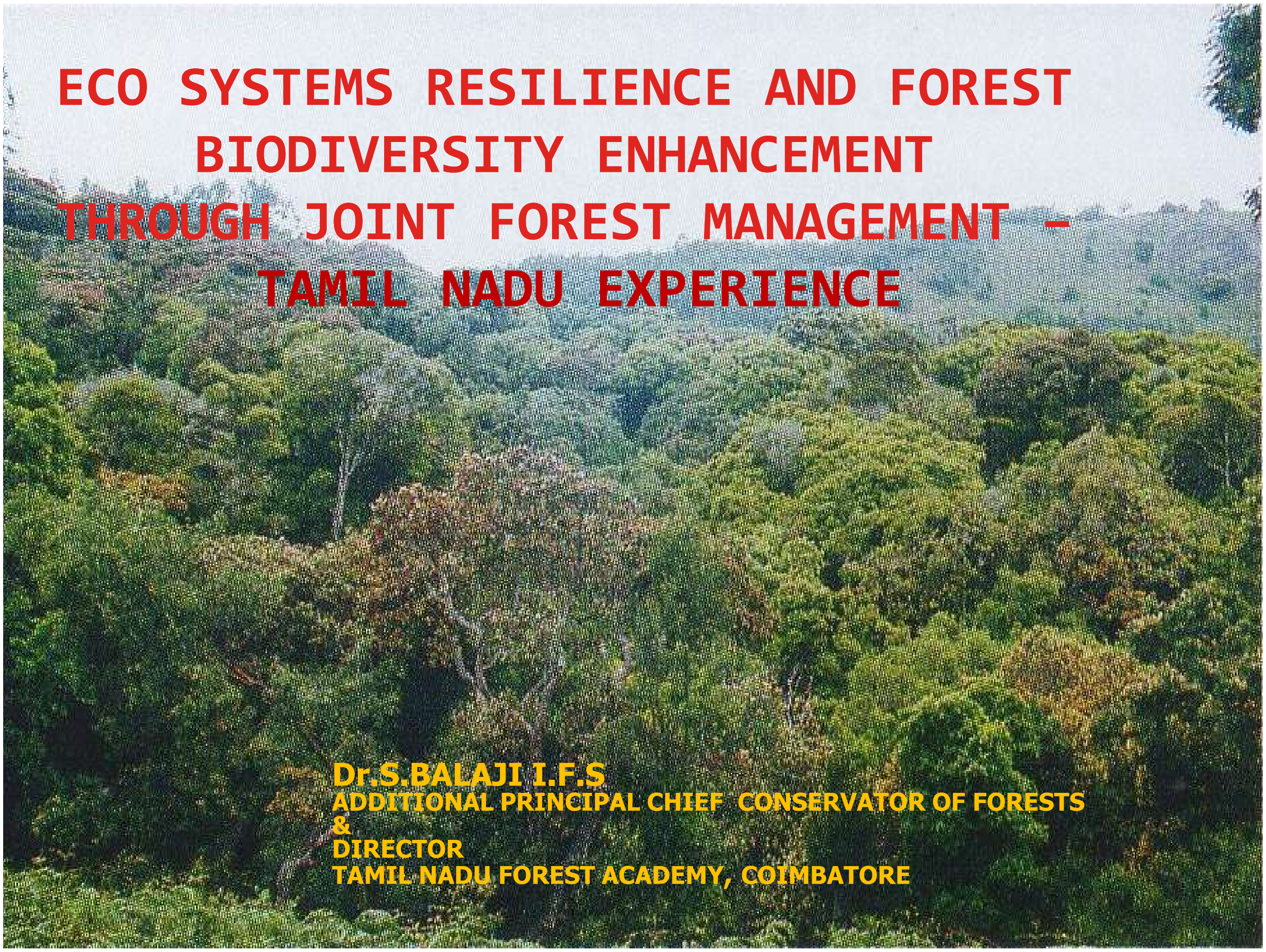
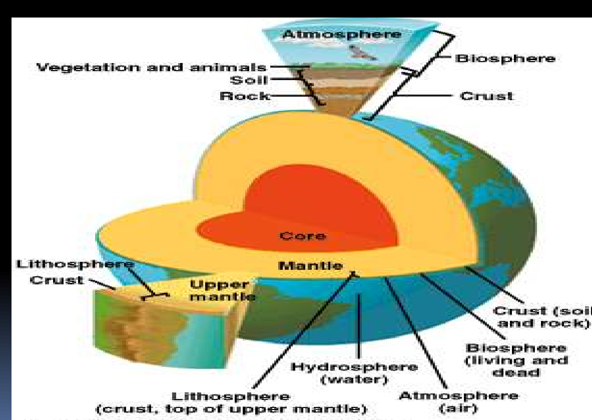


Ecosystems

- Study of how organisms interact with each other and with the biotic environment
- Organism -> species-> population -> community -> ecosystem
- Each species has a range of tolerance – physical/ chemical environmental, biotic/ abiotic factors
- Purpose of an organism – to reproduce successfully, ensure offspring reproduce successfully with genetic variation as the lowest energy cost.
- Adaptations – chemical / physical / behavioral changes to increase survival rates
- **ECOSYSTEMSTRUCTURE-**
- **PRODUCER-CONSUMER-DECOMPOSER**
- GEOMORPHOLOGY
- ENDEMISM — FRAGILE ECOSYSTEM
- EXTINCTION VERTICES — FOREST TYPES
- FLORISTICS — SPECIES RECOVERY
- MOLECULAR ECOLOGY — POPULATION BIOLOGY
- LANDSCAPE ECOLOGY — GIS STUDIES

GEOMORPHOLOGY



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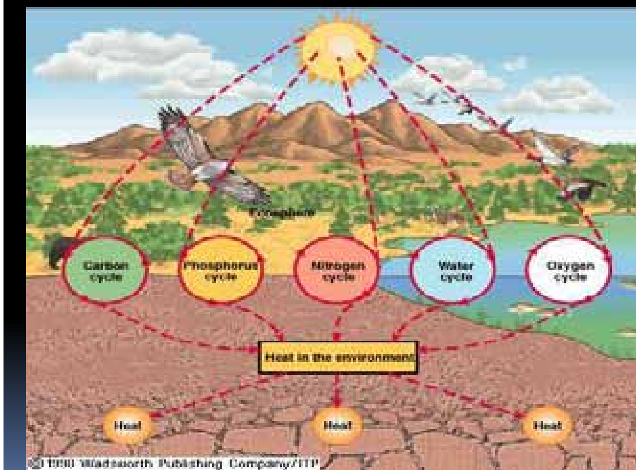
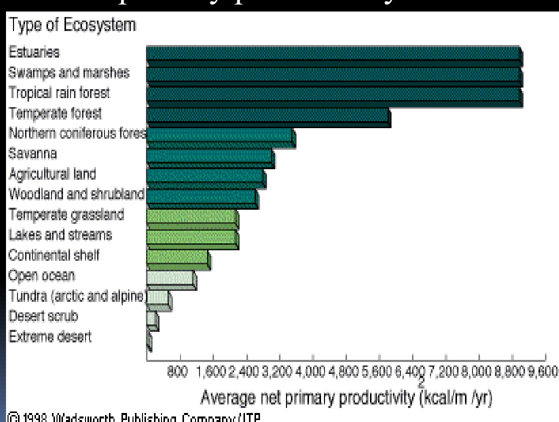
Principles of Ecosystem Functioning

- Life on earth is sustained by
  - Solar energy
  - gravity
  - water cycle
  - Primary productivity
  - Energy flow
  - Trophic levels
  - Nutrient cycling
- Ecosystems run on solar energy.
- Nutrients are recycled in an ecosystem.
- Ecosystems cannot support large numbers of top consumers
  - Energy is lost as heat and is used to keep consumers alive so the amount of energy available decreases as we move up the food chain



The net primary productivity of biomes



TAMIL NADU PROFILE

Total geographical area	:	130,058 Sq. kms.
Total Forest area	:	22,870 Sq. kms.
% of Forest area	:	17.584%
Total annual average rainfall	:	900 – 1200 mm.
Total population	:	62.11 Million
Total No. of villages	:	17,272 villages

Shola forests and montane grasslands

Tropical Wet evergreen forests, Muthukuzhivayal

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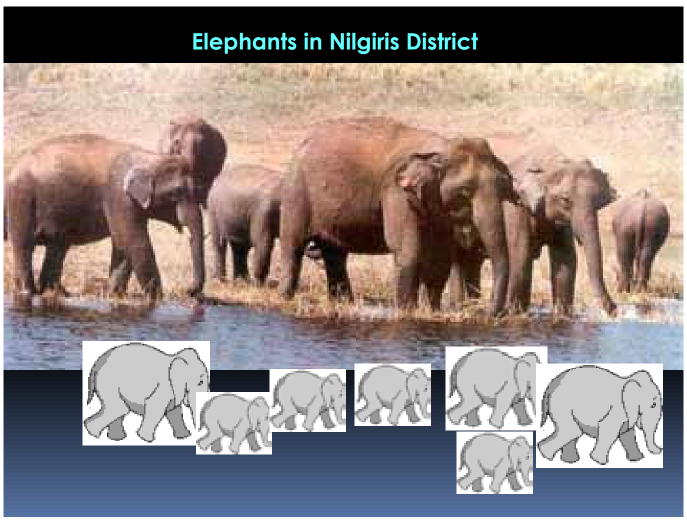

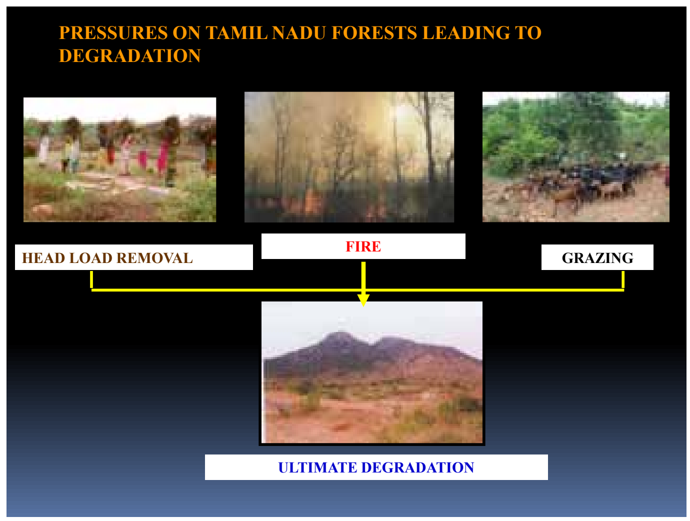

TAMIL NADU AFFORESTATION PROJECT

- A JFM based project.
- Eco-restoration with watershed development approach.
- Aimed at reducing the poverty level of the forest dependent people.
- Participation of line departments / agencies in the holistic development of forest fringe people.
- Infrastructure development and HRD to enhance capability of TNFD.

TAP PHASE-I (1997-98 to 2004-05)

ACTIVITIES	ACHIEVEMENTS	
Afforestation	4.80 lakh ha.	
Water harvesting	Check dams Nos.	23,454
	Percolation ponds Nos.	2,201
	Storage capacity million cft.	817.53
Formation of VFCs	: 1367 Nos.	
Formation of SHGs	: 3891 Nos. (60,097 Women beneficiaries)	
Project expenditure	: Rs. 688 crores (17330 million Yen)	

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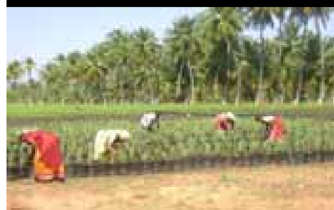
TAP PHASE-II

ACHIEVEMENT FROM 2005-06 TO 2009-10

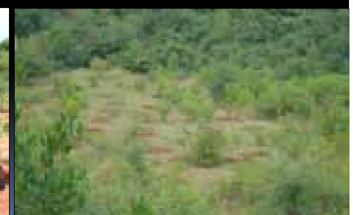
ACTIVITY	Total
No. of villages covered	800
No. of VFCs formed	800
Afforestation (in ha.)	177500
Water harvesting structures (Nos.)	
Check dams	4666
Percolation ponds	1428
Capacity (in million cft)	897
No. of SHGs formed	3283
Women beneficiaries	44879
Community development (No. of works)	2397
Employment generation (lakh mandays)	176.23
Office buildings, Quarters and Rest Houses (Nos.)	667
Project Expenditure upto 2009-10 (Rs. In crores)	484.16

AFFORESTATION


Nursery in 2008-Nochipatty TAP village of Salem circle


Plantation work in upper zone of 2006-Nedium TAP village of Chennai circle

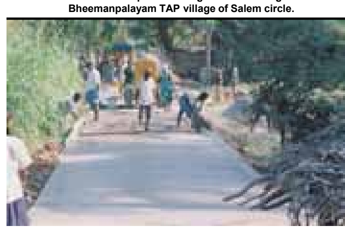

A view of 2006-Thadaganachiarpuram TAP plantation of Madurai circle


A view of 2007-Kallipattu TAP plantation of Villupuram circle

COMMUNITY DEVELOPMENT WORKS


Part-time ration shop functioning in VFC building in 2005-Bheemanpalayam TAP village of Salem circle.


Supply of benches, desks to Government Middle School at 2006-Thullukutti Nayakkanoor TAP village of Virudhunagar circle


Formation of cement concrete road 2005-Kangkuppam Duraimoolai TAP village of Vellore circle.


School compound wall in 2007-Singadivakkam TAP village of Chennai circle

SOCIO-ECONOMIC STUDY OF TAP

- TAP has reached to 47% of the under-privileged sections of society (24% ST & 23% SC)
- 93% of the beneficiaries are landless and marginal farmers.
- 45% of beneficiaries households belong to Below Poverty Line (BPL).
- 30% of beneficiaries took up new economic activity from TAP micro-credit.
- 32% of beneficiaries improved their existing economic activities.
- 77% reported an incremental annual income upto Rs.10,000/- and 17% reported an increase between Rs.10,000 to Rs.15,000/-

Study conducted by **Economic Perspectives, Chennai-18.**

Total No. of villages studied – 30 villages in 7 Agro-climatic zones

Study period – 2008.


T.N. PUDUKUDY VILLAGE – TIRUNELVELI DIVISION – DURING 1999


T.N. PUDUKUDY VILLAGE – TIRUNELVELI DIVISION – DURING 2006

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BIODIVERSITY ASSESSMENT

Ecologists and Taxonomists are concerned with diversity of plants and animals and interaction within and between ecosystems and landscapes e.g. alpha, beta and gamma diversity (Whittaker, 1973; Magurran, 1988).

α diversity is the diversity of species within a particular habitat or community. It measures species richness within an area giving equal weight to each species. It could be expressed as species richness per unit area.

β diversity is a measure of the rate and extent of change in species. Jaccard's index of similarity and similarity and dissimilarity index to study improvement in forest structure.

γ diversity along a gradient from one habitat to another is dependent on both (α) alpha diversity and (β) diversity and is the diversity of species within a geographical area.

Silvicultural measures

Girth class of distribution of trees
Increased stand volume
Canopy density

SHANNON-WIENER INDEX

Shannon-Wiener index is $H' = -\sum p_i * \ln p_i$
Where H' is = diversity
P is = proportion of I th species

This index is strongly influenced by species richness but the effect of sample size is low.

The Shannon–Wiener index (1963) and Simpson's Index (1949) are currently used to measure the species richness and diversity. increasing sample size (Carpentier *et al.*, 1998).

They take into account not only the number of species but also the relative abundance. The Shannon Wiener Index is based on information theory while the Simpson's index (Simpson, 1949) is based on probability theory.

Shannon Wiener index – Different forest types

Forest type	Plant Density (No. tree/ha)	Species richness No. of species / ha	Shannon-Wiener Index Tree
Dry Dipterocarp Forests	554-789	35-37	3.6-4.0
Mixed deciduous forest	253	14	3.5-3.9
Teak forests	262-395	21	2.9
Pine forests	145-280	22-34	3.3-4.0
Dry evergreen	731	57	3.5-4.9
Hill evergreen	726	56-70	5.0-5.1
Tropical rainforest	818-1540	69-109	5.0-6.2

Shannon –wiener index in Restored Forests in 5 Agro climatic zones of Tamil Nadu in 4 years (Study conducted by SSFRDT, Chennai)

- WESTERN ZONE : 2.33-2.47
- CAUVERY DELTA ZONE : 1.52-2.01
- HIGH RAINFALL ZONE : 0.94-1.13
- SOUTHERN ZONE : 0.75-1.19
- NORTH EASTERN ZONE : 0.84-0.91

STATISTICAL ANALYSIS

Species Richness

	Climatic Factors	Soil Parameters	Bioindicators
Correlation	NS	All significant pH and B.D –ve K, pH and N **	All + ve except Bact
Path analysis	Rainy days	P , pH and N	Butterflies Birds
Regression	NS	pH, K and N	Butterflies Fungi

STATISTICAL ANALYSIS

Total Plant Population

	Climatic Factors	Soil Parameters	Bioindicators
Correlation	All significant Temp. -ve	All significant PH and B.D –ve P, pH, N, B.D **	Birds and Butterflies
Path analysis	Rainy days	O.M, N and P	Birds, Actino. and Fungi
Regression	Temp. and RF	N, O.M	Birds Butterflies

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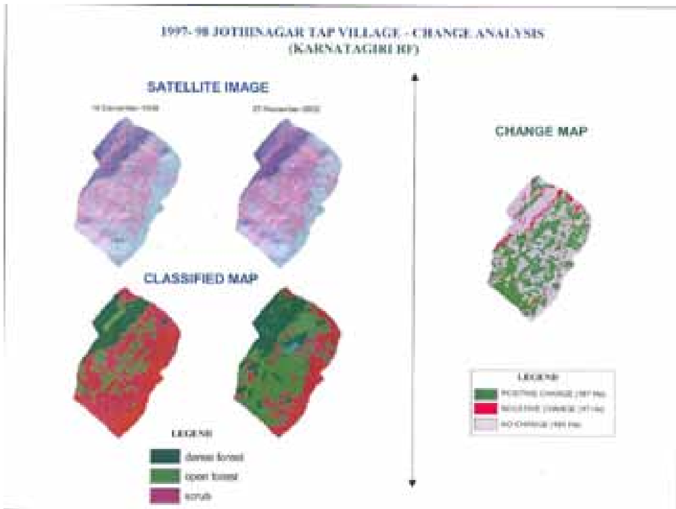

Uses	Jalluthupatti
1. Fuelwood	1. *Acacia planifrons* 2. *Albizia amara*, 3. *Drypetes sepiarea*, 4. *Erythroxylon monogynum*, 5. *Euphorbia antiquorum*, 6. *Ficus bengalensis*, 7. *Ixora pavetta*, 8. *Jatropha curcus*, 9. *Ziziphus jujuba*.
2. Small timber	1. *Acacia leucophloea*, 2. *Albizia amara*, 3. *Azadirachta indica*, 4. *Chloroxylon swietenia*, 5. *Dichrostachys cinerea*, 6. *Harwickia binata* 7. *Ixora pavetta*, 8. *Manilkara hexandra*, 9. *Santalum album*.
3. Ornmantal trees	1. *Cassia occidentalis*, 2. *Cassia fistula* 3. *Stereospermum personatum*,
4. Fodder	1. *Hardwickia binata* 2. *Lepisanthes tetraphylla*
5. GML	1. *Clausena dentata*, 2. *Tephrosia purpurea*
6. Edible fruits	1. *Fluggea lecopyrus* 2. *Opuntia elatior*, 3. *Phonenix sylvestris*, 4. *Randia uliginosa* 5. *Zizyphus jujuba*, 6. *Zizyphus oenoplia*, 7. Sudali, 8. Kavalakilangu.
7. Medicinal plants	1. *AndrograpHis serpyfolia*, 2. *Asparagus racemosus*, 3. *Blumea virens* 4. *Cassia fistula* 5. *Erythorxylon monog* 6. *Evolvulus alisinoides* 7. *Jatropha curcas* 8. *Justicia tranquebarensis*, 9. *Kleinia grandiflora* 10. *Phyllanth amarus*, 11. *Totalia asiatica*, 12. Vettuvaithazhai.
8. Cultural uses	1. *Tarenna aisatica*

GLOBAL FORESTS and CLIMATE CHANGE

- An increase of (CO_2e) of GHGs from 430 Parts per million (ppm) now to 550 ppm by 2035 is expected
- Forests are the single "large and persistent" carbon sink with a size of 2.4±0.4 Gt C/year averaged over two decades beginning 1990.
- This is about 27% of the current levels of annual anthropogenic carbon emissions (Pan *et al* .2011).
- The carbon storage of Global Forests is 638 Gt
- GHG emission from deforestation is 17.4%.
- CoP 16 of UNFCCC held in Cancun approved REDD + (Reducing Emissions from Deforestation and degradation)
- as a new approach to conserve the existing Forests.

INDIAN FORESTS

- The carbon stock in Indian forests is estimated to be 6622 million tonnes.
- Sequestration of Indian forests is showing an annual increase of 138 million tonnes of CO_2 while that of China is showing an annual increase of 301.23 million tonnes of CO_2
- Over 50% of the forested grids in the country in BIOME 4 will be impacted due to global warming.
- Maylead to altitudinal and latitudinal shift of species.
- Increased occurrence of fire, invasive species;
- the Change in species assemblage may lead to enhanced vulnerability.
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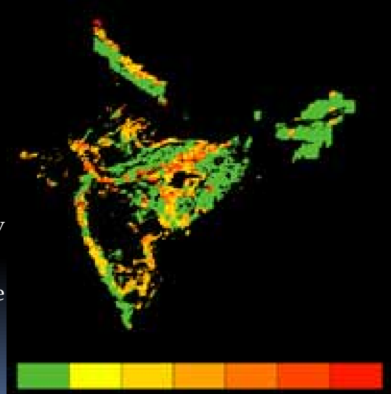
Forest Vulnerability A2 (IIS)

Criteria

Density

Biodiversity

Vegetation type change



Green least vulnerable , yellow to red increasing vulnerability

GREEN INDIA MISSION

- Government of India has embarked on Eight Missions to check the ill effects of Climate Change including the Green India Mission to improve Forest density and increase Green cover .
- **Increased forest/tree cover over on 5 m ha.**
- **improved quality forest cover 5million ha.**
- **Improved ecosystem services including bio diversity, hydrological services and carbon sequestration**
- **Increased forest based livelihood income of 3 million households living in and around forests.**
- **Enhanced CO2 sequestration by 50 to 60 tonnes.**

CONVENTION ON BIOLOGICAL DIVERSITY (CBD)

Sustainable use of components and fair and equitable sharing of benefits arising out of the utilization of genetic resources including by appropriate access to genetic resources and by appropriate transfer of relevant technologies taking into account all rights over those resources and technologies and by appropriate funding - Article 1 of CBD

OUTCOME AFTER A DECADE OF JFM

Sustainable conservation	Vegetation has visibly increased in degraded forests Biotic pressure considerably reduced. Ensured better community protection.
Sustainable participation	VFCs given legal backup by registration under Societies Act. VFDF placed at the disposal of VFC for development.
Economic sustainability	Income level of households has increased. Loan recovery amount credited into VFDF to maintain flow of funds. SHGs have accessed institutional finance Fines, MFP sale revenue added to the VFDF Deep-rooted inter sectoral linkage

CHALLENGES IN JFM

- Sustainability of JFM
- Maintaining Sustained interest of People
- VFC Management by Gram Sabha
- Implementation of Forest Rights Act 2006
- Supreme court ban on cutting Naturally grown Trees
- Augmenting Tangible Benefits from Forests such as thinned poles, NTFP etc. on sustainable basis.
- Revolving SHG loan amount effectively-KMTR Model.
- Inter-Sectoral Linkage for sustainable Rural Livelihood
- Social Silviculture

SUSTAINABILITY:
SWIM to keep JFM afloat

- 6.88 lakh ha. Adjoining 2317 villages restored under TAP.
- Periodical monitoring of forest restoration for Biodiversity enhancement
- Assessing improvement in carrying capacity for wildlife and cattle
- Sustainable Forest Management includes keeping Forests productive and Healthy
- SOCIAL SILVICULTURE: Sustainable use of bamboo, NTFP for better livelihood.
- SWIM-Sustainable Social Silviculture,
- Water Harvest,
- Inter sectoral Devt,
- Microcredit

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India and REDD+: Opportunities and Challenges of Implementation

23 November2011
Indian Forest Congress 2011, New Delhi

Dr. Renu Singh
Head, Biodiversity and Climate Change Division
Indian Council of Forestry Research and Education, Dehradun

Outline

1. Forests and Climate Change Mitigation
2. REDD+ under the UNFCCC: Scope for India's Forests
3. The Cancun Agreements and Opportunities of Implementation in India
4. Issues and Challenges of Implementation for India

Forests and Climate Change

- Forests are both sources and sinks of carbon
- Total C content of forest ecosystem estimated about 652 GtC, which is more than the entire atmosphere
- Global deforestation rate – 13 million hectares per yr leading to about 17.4% of global GHG emissions (5.8 Gt CO_2/yr)
- In the period 2005-2010, carbon stocks in forest biomass decreased by 0.5 Gt of carbon annually
- Forests provide ecosystem goods and services to communities to cope up with climate change

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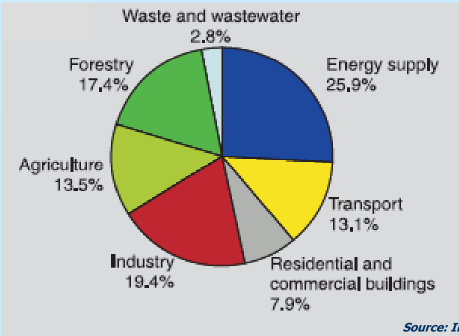
Share of Different Sectors in Total Anthropogenic GHG Emissions in 2004 in Terms of CO_2-eq.



Source: IPCC, 2007

Development of REDD under UNFCCC

(Reducing emissions from deforestation and degradation in developing countries)

- **Attention on high deforestation in Brazil, Indonesia, Bolivia**
- **Deforestation requires same focus as other sectors like energy, industry and transport to check GHG emissions**
- **New agenda item *(Reducing emissions from deforestation in developing countries)* proposed by Papua New Guinea and Costa Rica at COP 11 in Montreal in 2005**

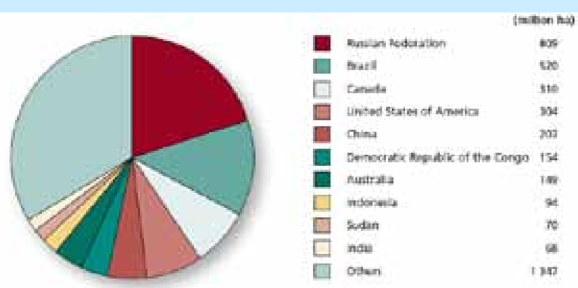
REDD under UNFCCC Contd...

- **COP 11 invited parties for submission of views on the agenda**
- **SBSTA initiated work related to technical issues**
- **Developing countries to participate voluntarily in forestry based mitigation actions; developed countries to provide compensation/incentives**

Policy Approaches Negotiated

1. **Compensated Reductions: Proposed by a group of Brazilian NGOs. Argues for compensation for reducing current deforestation rate.**
2. **Stabilisation of Forest: Stressed by Cameroon, Gabon, and other Congo Basin countries. Asks for compensation for stabilizing forest cover.**
3. **Compensated Conservation: Proposed by India. Argues for compensation for conserving and increasing forest cover.**

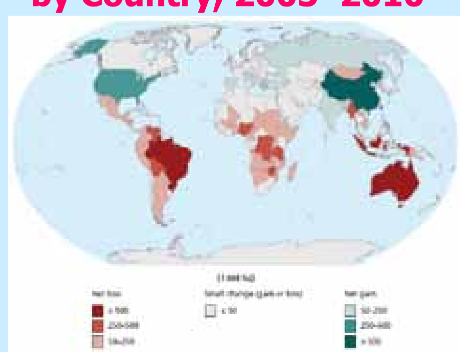
Ten Countries with the Largest Forest Area, 2010



Account for two-thirds of total forest area

Source: FAO 2010, FRA

Annual Change in Forest Area by Country, 2005–2010



Ten Countries with Largest Annual Net Gain in Forest Area, 1990–2010

Country	Annual change 1990-2000		Country	Annual change 2000-2010	
	1000 ha/yr	%		1000 ha/yr	%
China	1 986	1.20	China	2 986	1.57
United States of America	386	0.13	United States of America	383	0.13
Spain	317	2.09	India	304	0.46
Viet Nam	236	2.28	Viet Nam	207	1.64
India	145	0.22	Turkey	119	1.11
France	82	0.55	Spain	119	0.68
Italy	78	0.98	Sweden	81	0.29
Chile	57	0.37	Italy	78	0.90
Finland	57	0.26	Norway	76	0.79
Philippines	55	0.80	France	60	0.38
Total	**3 399**	**0.55**	**Total**	**4 414**	**0.67**

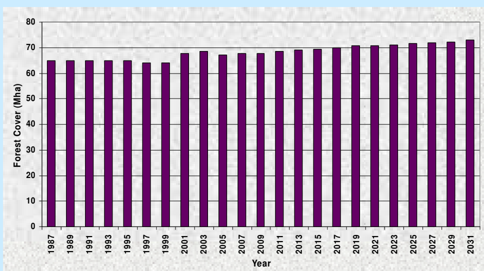
Source: FAO 2010, FRA

Ten Countries with Largest Annual Net Loss of Forest Area, 1990–2010

Country	Annual change 1990-2000		Country	Annual change 2000-2010	
	1 000 ha/yr	%		1 000 ha/yr	%
Brazil	-2 890	-0.51	Brazil	-2 642	-0.49
Indonesia	-1 914	-1.75	Australia	-562	-0.37
Sudan	-589	-0.80	Indonesia	-498	-0.51
Myanmar	-435	-1.17	Nigeria	-410	-3.67
Nigeria	-410	-2.68	United Republic of Tanzania	-403	-1.13
United Republic of Tanzania	-403	-1.02	Zimbabwe	-327	-1.88
Mexico	-354	-0.52	Democratic Republic of the Congo	-311	-0.20
Zimbabwe	-327	-1.58	Myanmar	-310	-0.93
Democratic Republic of the Congo	-311	-0.20	Bolivia (Plurinational State of)	-290	-0.49
Argentina	-293	-0.88	Venezuela (Bolivarian Republic of)	-288	-0.60
Total	-7 926	-0.71	Total	-6 040	-0.53

Source: FAO 2010

Projected Trend in India's Forest Cover and C Stocks under the Current Trend Scenario



Projections of forest carbon stocks – Increase from 8.79 GtC in 2005 to 9.75 GtC in 2030

(Source: IISc., 2006)

SNC estimates- 7.29 Gt in 2005 to 7.33 Gt in 2007

India's Case for Compensated Conservation

- **Project Compensated Conservation as an alternative to Compensated Reduction**
- **Practically no clearfelling/deforestation in India, forest cover stabilized**
- **Best option: Conservation Approach**

REDD in the Bali Conference (COP 13)

Discussions focused on

- **Inclusion of conservation and enhancement of forest carbon stocks (proposed by India and supported by China, Columbia, Bhutan, Pakistan, Bangladesh, Congo Basin countries, and Philippines; opposed by Brazil, Japan, the EU, and some of the Latin American countries)**
- **Consideration of deforestation in the context of discussions on long-term cooperative action under the UNFCCC**

COP 13: Decision on REDD

Para 7(a) of Decision 2/CP.13

"...Inviting Parties to submit, by 21 March 2008, their views on how to address outstanding methodological issues including, inter alia, assessments of changes in forest cover and associated carbon stocks and greenhouse gas emissions, incremental changes due to sustainable management of the forest..."

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Bali Action Plan

Para 1b (iii) of BAP

"...Policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries..."

Save Carbon

RED

Reducing Emissions from Deforestation

Save Carbon

REDD

Reducing Emissions from Deforestation and Forest Degradation

Save+Add Carbon

REDD+

Reducing Emissions from Deforestation, forest Degradation, conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries

Implication for India

REDD+ policy approach provides possibility of seeking incentives for compensation for pro conservation approach and sustainable management of forests resulting in the increase of forest carbon stocks

The Cancun Agreements and Opportunities of Implementation in India

COP 16 (Cancun) Decision on REDD+

- **Aims to slow, halt, and reverse forest cover and carbon loss**
- **Scope: Countries to undertake following activities according to their respective capabilities and national circumstances**
  - Reducing emissions from deforestation
  - Reducing emissions from forest degradation
  - Conservation of forest carbon stocks
  - Sustainable management of forest
  - Enhancement of forest carbon stocks

COP 16 Decision Contd...

Provision of adequate and predictable support in terms of finance and technology to develop the following elements:

- A national strategy or action plan
- A national (interim measure- subnational) forest reference emission level and/or forest reference level
- A robust and transparent national forest monitoring system for MRV of the activities
- A system for information on safeguards assurance in implementation of the activities

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COP 16 Decision Contd...

Countries to address

- Drivers of deforestation and forest degradation,
- Land tenure issues,
- Forest governance issues,
- Gender considerations
- Effective participation of relevant stakeholders
- Safeguards

COP 16 Decision Contd...

• Safeguards

Activities

- To be consistent with the objective of environmental integrity
- Parties' national sustainable development needs
- Consider multiple functions of forests and other ecosystems
- Supported by adequate and predictable financial and technology support including capacity-building
- Promote sustainable management of forests
- Promote conservation of natural forests, biological diversity, and enhance social and environmental benefits

COP 16 Decision Contd...

Implementation in Phases

❖ Phase I

- Development of national strategies,
- Policies and measures,
- Capacity-building,
- Economic assessment of finance needed

❖ Phase II

- Implementation of national policies and action plans, technology development and transfer, and results based demonstration activities

❖ Phase III

- Results-based actions that should be fully measured, reported, and verified

Implementation Opportunities: India's Conservation Oriented Policy Framework

Governance issues

- Indian Forest Acts (1865, 1878, and 1927)
  - Forest department created in 1864
  - Provide legal framework for forestry administration and regulation in the country
- Forest (Conservation) Act 1980
  - 1951-1980 forestland diverted – 4,328 million ha
  - 1988 ban on clearfelling
  - Reduced the rate of deforestation of forestland from 0.15 million ha per year to about 1,600 ha per year

Implementation Opportunities Contd...

Safeguards to promote conservation of biological diversity and natural forests

- Wildlife (Protection) Act 1972
  - Provides for the protection of wild animals and plants
  - Creation of a network of protected areas such as national parks, wildlife sanctuaries, conseration reserves
  - Approx. 4.75% of the total geographical area under in situ conservation through a 'Protected Area' network
- Biological Diversity Act 2002
  - States long term conservation and protection of biological resources of the country
- National Environment Policy 2006
  - Environmental, livelihood, and financial benefits
  - Calls for enhancing the density of natural forests

Implementation Opportunities Contd...

Safeguards to promote conservation of biological diversity and natural forests

- National Biodiversity Action Plan (NBAP) 2008
  - Central to achieving the objectives of the CBD
  - Considers the global threat of climate change,
  - Promotes holistic approach to conservation, enhancement, and sustainable utilization of biodiversity
  - Aims at developing and integrating biodiversity information from diverse sources into a national database,
  - Inventorization of country's floristic, faunal, and microbial resources with special attention to endangered and endemic species
  - Would be helpful in developing systems under REDD+ for providing information on safeguards related to biodiversity and natural forests conditions

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Implementation Opportunities Contd...

Meeting the requirements of land tenure and forest governance issues, gender considerations, effective participation of relevant stakeholders, and safeguards to enhance social and environmental benefits

- **National Forest Policy 1988**
  - Aims to combine the objectives of environmental stability and bio-diversity conservation with those of social justice
  - Prohibits clearfelling of natural forests and introduction of exotics
  - Discourages diversion of forests for non-forestry purposes
  - Recognizes the rights of the rural communities
  - Envisages creation of a massive people's movement with the involvement of women

Implementation Opportunities Contd...

Meeting the requirements of land tenure and forest governance issues, gender considerations, effective participation of relevant stakeholders, and safeguards to enhance social and environmental benefits

- **June 1990 and 2000 Guidelines for Joint Forest Management**
  - Provides operational frameworks for participatory forest management
  - Legal backup for JFM committees
  - Enhanced participation of women in the process
- **Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006**
  - Provisions of settling tenure and other rights to forest dwelling communities and individuals

Green India Mission, 2010

- One of the eight Missions under the NAPCC
- Recognizes climate change impacts
- Objectives

  - Increase forest/tree cover on 5 m ha of lands and improve quality of forest cover on another 5 m ha of lands
  - Improved ecosystem services including biodiversity, hydrological services and carbon sequestration
  - Increased forest-based livelihood income of about 3 million households living in and around the forests
- Key role for local communities and decentralized governance
- Revamping and capacity building of village institutions (JFMCs) and Forest Departments

Issues and Challenges of Implementation for India

National Coordination Mechanism

- MoEF deals with the environment and forests administration – responsible for REDD+ process and implementation
- 'Coordinating Committee' in forestry wing in January 2011
- REDD+ Cell in the MoEF – suggested tasks
  - Developing a national REDD+ strategy and action plan
  - Identifying and analyzing the scope of REDD+ activities for national implementation
  - Aligning the strategy with other development strategies of the country like NAPCC and GIM
  - Initiate dialogue with relevant stakeholder groups

National Coordination Contd...

- Rights and responsibilities of different levels of governments
- Developing equitable benefit sharing mechanism from national to local level
- Sources of finance for REDD+
- Identifying and establishing the network of technical institutions for MRV systems
- Coordination, monitoring, and reviewing the implementation at national level
- Interaction and reporting to relevant international bodies

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Institutionalization of MRV Systems

- Establishment of robust and transparent national MRV systems
- Forest C Inventories - Estimation of removals/changes in C Stocks
- National accounting system
- Baseline and forest reference levels
- Identification of institutions (FSI, ICFRE, IIRS, WII, IISc., SFDs)
- Capacity building

Financing REDD+ in India

- Initial investments – domestic funds, expects UNFCCC funds in future
- GIM, National Afforestation Programme, agriculture and rural development sector programmes - annually add or improve 2 million ha of forest and tree cover (annual incremental addition of 2 million tonnes of carbon)
- Require an investment of USD 2 billion every year for 10 years
- Specific fund allocation for REDD+?

Dynamics and Challenges of Resource Use

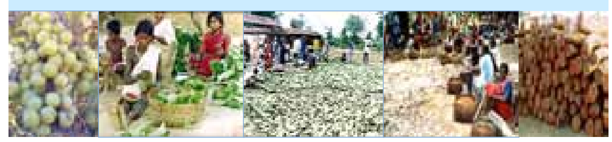
- India, having 2.5% of world's geographic area and 1.8% of world's forests, sustains 16% of planet's human population and 18% of livestock population
- In 2005 and 2007, moderately dense forest net loss – 936 km2, open forest net increase - 1,626 km2
- Productivity

  India - 0.7 m3/ha/yr, World - 2.1 m3/ha/yr
- Per capita forests

  India - 0.07 ha, World - 0.62 ha
- 70 million tribal and 200 million non-tribal rural people defined as forest-dependent

Dynamics Contd...

- Forest products contribute 20-40% of total income of households in forest areas
- NTFPs provide 55% of total employment in the forest sector
- Fuelwood consumption to go up from 250/300 million m3 in 2000 to 400 million m3 in 2020
- Industrial demand of wood to go up from 58 million m3 in the year 2000 to 153 million m3 in the year 2020



Dynamics Contd...

- Grazing pressures:
  - -78% forest area affected
  - - 270 million cattle graze inside forest
  - - 175 to 200 m tonnes of green fodder collected through lopping and harvesting of grasses
- Forest fires affecting about 1.45 to 3.73 mha area annually

Community Participation

- Integrate local communities concerns and participation, information, capacity building
- An additional co-benefit, more monetary carbon benefits
- Institution of JFM to be linked
- Settings are diverse, generalisations about implementation are not easy
- Different classes will require different degree of assurance (vulnerable groups - women, poor)
- Careful consideration beyond JFM, especially equitable benefit distribution from REDD+ to forest communities

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REDD+ Research and Demonstration Activities in India

- Dedicated funds to support REDD+ research
- Capacity building of research institutions
- Demonstration projects with internal/external funding

✓ Forest Carbon Partnership Facility for REDD+

✓ UN REDD Programme

✓ Bilateral/Multilateral support

Pilot projects in a number of countries

Still to be Explored by UNFCCC

- AWG-LCA to explore financing options for full implementation
- Methodological guidance on the estimation and contribution of emissions and removals from LULUCF activities in developing countries to the mitigation of climate change (SBSTA)
- Methodological guidance for reference levels (SBSTA)
- Modalities for MRV of REDD+ actions (SBSTA)
- Guidance for developing a system for information on safeguards (SBSTA)

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Indian Forest Carbon Cycle Assessment

V.K. Dadhwal, M.S.R. Murthy*,S.P.S.Kushwaha,
Sarnam Singh, Ravindra Naik

National Remote Sensing Centre

Indian Forest Congress ,Delhi, 23rd Nov,2011

National Assessments – Approaches
(Based on 14 National Assessments)

- National level Forest areas and BEF
- RS based National level areas, Strata level BEF at National level
- State wise RS based areas & State wise, Strata wise BEF
- District wise areas, State wise, Strata wise BEF

Kishwan et al., and Subodh et al., 2011 – Net Sink

Factors Driving

- **Spatial and Temporal Explicitness**
  - Forest cover and standing biomass
- **Precise Forest allometric databases**
  - Scale and Parameters
- **Uncertainty assessment and Controlling**
  - Data collection, Design, Estimation

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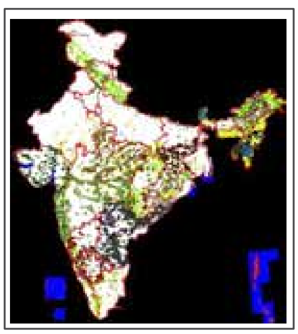
National Carbon Project

- **GOALS**
  - *Assessment of Carbon Pools, Fluxes and Net Carbon balance for terrestrial biosphere in India*
  - *To establish a observational network and remote sensing-based spatial databases for modeling and periodic assessment of carbon balance*
  - *To provide support to national activity with respect to carbon balance under National Communication to UNFCCC*
- **Sub Projects**
  - **Vegetation Carbon Pools**
  - **Soil Carbon Pools**
  - **Soil Vegetation Atmospheric Fluxes**

Vegetation Carbon Pools and Dynamics

VCPD

Spatial Biomass Assessment – Field Data Collection



6500 field plot data from forests and trees outside forests

1250 permanent sample plots (one at each cluster)

54 institutions and 74 PIs

16 test-sites in different ecological regions spectral modeling using optical and microwave data in forest ecosystem.

Seasonal crop biomass/NPP estimation using remote sensing and modeling

Crop NPP (above and below ground) from historical agricultural statistics data

Spatial Biomass - Modeling and Assessment

Current Method – Assessment

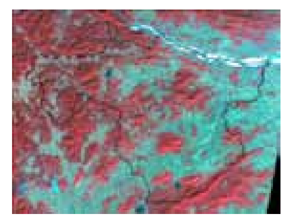
- RS derived strata and field inventory.
- Field intensive - less suitable for regional, national periodic monitoring.

New Techniques – Data mining techniques

- Non-parametric self learning method
- Multi-variate analysis
- Resistant to outliers and noisy data
- Estimation of error structure.

Objective

- To produce spatial estimates of Biomass using Data mining Techniques.

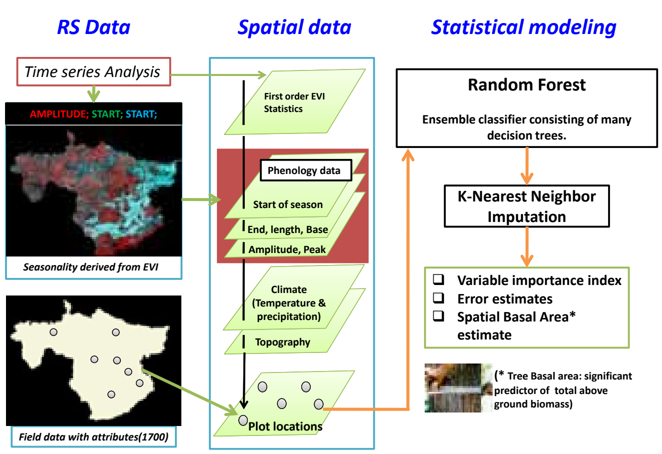


Nayagarh, Odisha

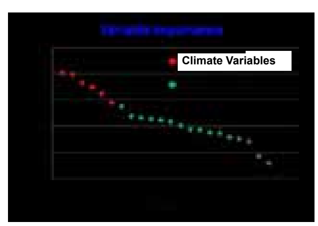
Input Data

- 16-Day composited 250m Modis EVI data (2006-2008)
- 1700 field inventory plots (2007).
- Climate, Topography

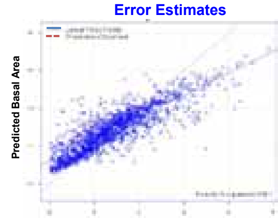
Methodology



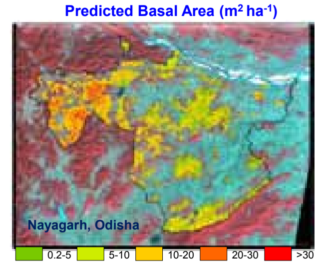
Results



Error Estimates



Predicted Basal Area ($m^2 ha^{-1}$)



Way Forward

- **Operational Methodology- regional Biomass estimates using Awifs.**
- **Inclusion of RS derived stand height to improve accuracy and optimization of field inputs.**

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National level Assessment of Trees Outside Forests using multi-resolution IRS data

Rationale :

Agroforestry gives livelihood support, Mitigation and Adaptation measure

Trees Outside Forests increasing due to public and private initiatives

IRS (Cartosat PAN/LISS IV) sensors are pivotal to provide parameterization on TOF

Current Assessment :

National level sampling by Forest Survey of India across 16 geo-blocks to provide state-wise statistics

Proposed Assessment :

Geospatial sampling design integrating multi-resolution satellite data to provide district level statistics of TOF.

National zonation using physiography, basin bounds,

↓

TOF retrieval using Carto, LISS IV (automatic/semi-auto app.)

↓

Grid wise extent of determinant infrastructure (Road, Canal, Pond)

↓

Strata of infrastructure – Sample grid TOF count

↓

Zone wise estimation of TOF quantity

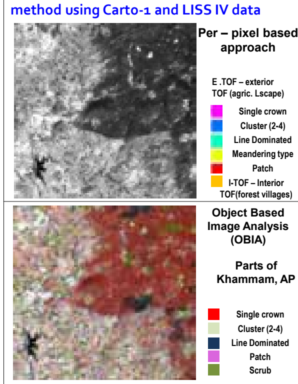
↓

National Estimate

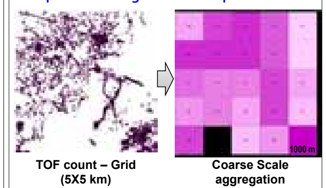
Overall approach for National TOF Assessment

Retrieval of TOF and Regional level factors

Image based retrieval : Semi-automatic method using Carto-1 and LISS IV data



TOF presence : Regional level aspects



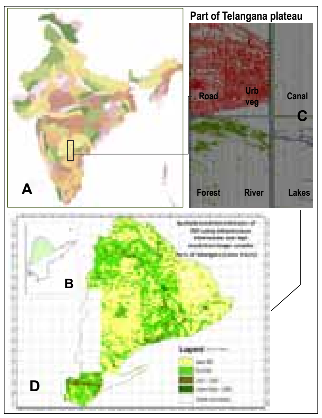
TOF Occurrence		
Patch	Indiv	Line
Plantn	Farms	Road
Lakes	Common	Rail
Settlmt	Settlmt	Canal
		Stream

Gridwise determinant > Factor

Sample > Estimate

National Geospatial Framework

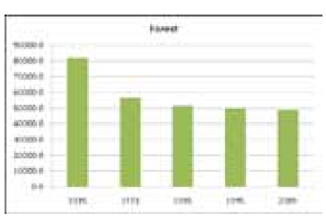
- National zonation available based on Basin limits , physiography (~200 zones) (A)
- 5X5 km grids in each zone
- Telangana plateau considered for the pilot (B)
- Gridwise estimate of ' Determinants' (C)
- Counting trees in Sample grids. Sample grids by stratified random method.
- Regionalised Estimates using factor (of gridwise determinant quantity) (D)

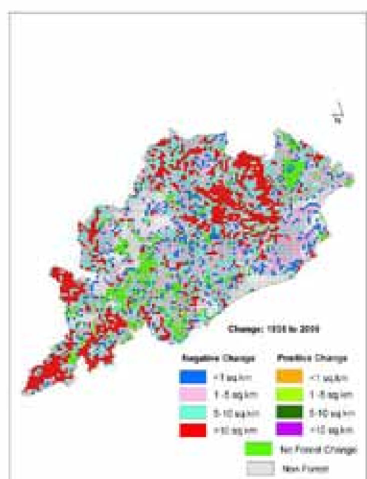


MONITORING OF LONG TERM FOREST COVER CHANGES IN ORISSA (1935-1975-1985-1995-2009)

Distribution of forest cover: Orissa

Year	Area (km^2)	% of TGA
1935	81785.6	52.5
1973	56661.1	36.4
1985	51642.3	33.2
1995	49773.0	32.0
2009	48669.4	31.3





616 forest grids have no change in forest cover

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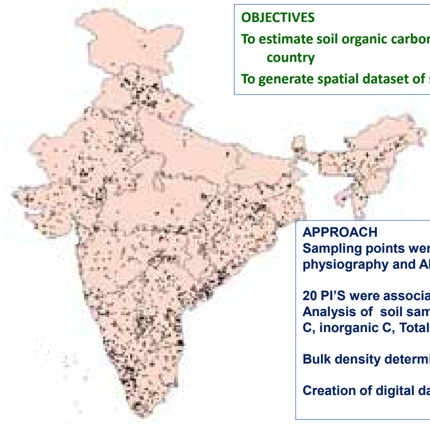
Soil Carbon Pools and Dynamics

SCPD

NATIONAL CARBON PROJECT-SPATIAL ASSESSMENT OF SOIL CARBON POOL OF INDIA



OBJECTIVES

To estimate soil organic carbon and inorganic carbon stocks of the country

To generate spatial dataset of soil carbon stocks

Sampling points	- 2850
Completed	- 2210
In progress	- 640

APPROACH

Sampling points were identified based on land use, physiography and AESR

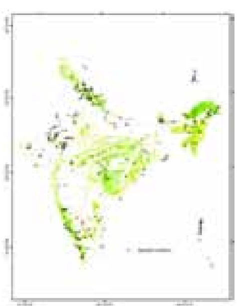
20 PI'S were associated in the collection of soil samples
Analysis of soil samples with CHN Analyser for organic C, inorganic C, Total C

Bulk density determination using core or clod method

Creation of digital database

STATUS: No. of soil samples collected = 6200 + Analysis Completed = 4400 + Remaining in progress
Spatial data modeling of Soil carbon is in progress.

Forest Soil OC Pool for SNC – ICFRE & IIRS



550 New Forest Soil Samples

S. No	Forest Types	No of Samples	Mean	SE
1	Himalayan dry temperate	24	36.19	5.56
2	Himalayan moist temperate	48	71.58	7.16
3	Littoral and Swamp	70	71.06	12.20
4	Montane wet temperate	16	115.46	14.61
5	Sub alpine and alpine	12	75.45	12.23
6	Sub tropical broad leaved hill	20	86.61	14.97
7	Sub tropical dry evergreen	3	65.28	10.37
8	Sub tropical pine	12	50.27	8.08
9	Tropical dry deciduous	143	34.19	4.16
10	Tropical dry evergreen	10	52.39	11.64
11	Tropical moist deciduous	57	55.01	6.73
12	Tropical Semi evergreen	40	54.63	5.71
13	Tropical thorn	61	20.28	5.74
14	Tropical wet evergreen	40	100.57	10.02
	Non Forest	101	44.05	8.6
	Total	657		

Pools estimated from above densities
1995 – 3.551 PgC
2005 - 3.754 PgC

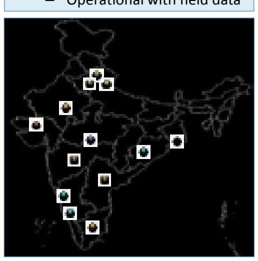
VK DADHWAL , Terrestrial C Cycle India - Understanding with RS, Shimla, 2009 November

Soil Vegetation – Atmosphere Fluxes

SVAF

Soil Vegetation Atmoshere Fluxes
Establishment of Towers and Data Assimilation

Implementation Steps
- Site Selection
- MOU / Forest Dept
- AAI/DGCA Approval
- Site Infrastructure
- Tower
- Instrument installation
- Operational with field data



Status of Flux-Tower Operation

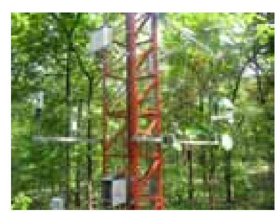
Sl no.	Site	Category
1 Opeartional	Haldwani	Forest
2	Meerut	Agriculture
3	Barkot	Forest
Commissioned		
4	Betul	Forest
Site Prepn. In Progress		
5	Sundarbans	Forest
Sites Selected		
6	Khurda	Forest
	Dandeli/Tithimathi	Forest
Proposed		
8	Gujarat/Rajasthan	Grassland
9	Tamilnadu(Annamalai)	Forest
10	Maharashtra	Agriculture
11	Andhra Pradesh	Agriculture

Operational

Under Installation

Planned

Progress in Construction for Sunderban site



Betul Tower ,Sonic anemometer , IRGA CO2/H2o analyser ,(Fast sensors) ; Hygrometer and anemometer ,(Slow sensors) at the lowest height

Betul Tower, Sensors shown on different levels

Progress at Sunderban and Betul Towers

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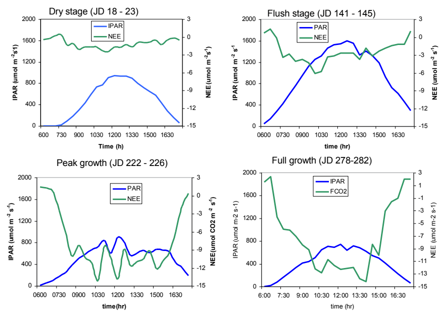
Flux Tower : Net Carbon Exchange, Haldwani

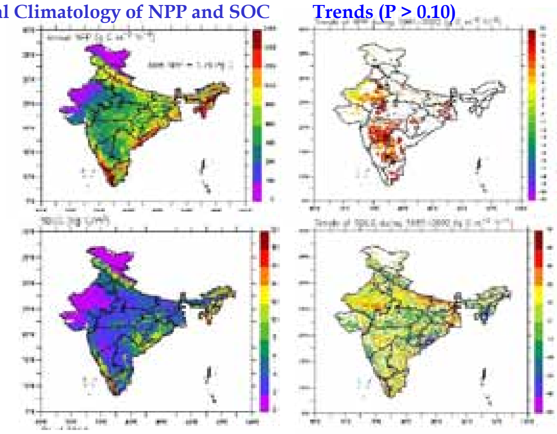


Diurnal variation in net ecosystem CO_2 exchange at key pheno-phases over mixed forest plantation

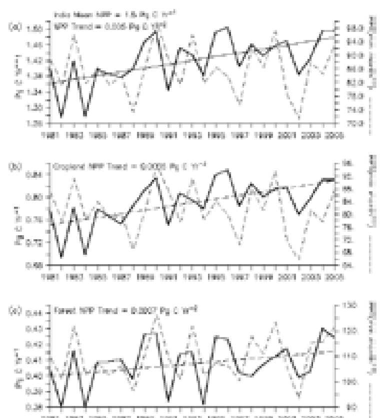
Mean and trends in NPP and SOC

(CASA, NOAA-AVHRR 1981-2003)

Annual Climatology of NPP and SOC   Trends (P > 0.10)



Long Term NPP Trends using CASA based simulations: 1981-2005



- Average annual NPP 1.5 Pg C Yr-1
- Increasing at the rate of 0.005 Pg C Yr-2
- Trend is equivalent to 8.5%

On an average India is the region of net sink of atmospheric CO2 with total annual uptake of 9.5 Tg C yr-1.

Challenges - Future Plans

Optimization of field sampling
Satellite derived height and inversion
Localised field data on BEF and extractions
Spatial disaggregated models – Regional biomass assessments methods

Chronosequenced Soil Sampling

Soil-Vegetation –Atmosphere flux databases

Biospheric modelling

National Frame work – Multi model estimations and uncertainty reduction

Thank You !

Soil Vegetation Atmosphere Fluxes (SVF)

12th FYP Proposal

- Continuity of the SVF tower sites from 11th five year plan
- Establishing new towers at forest and agriculture sites
- RS based up scaling and assessment of NPP over forest and agriculture sites,
- Coupling with bio-spheric and atmospheric models for carbon cycle modeling and simulation
- Development of carbon flux database system

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Carbon Fluxes Simulation and Modeling – Studies Carried out

Simulation of CO_2 fluxes in the form of NPP, NEP, SOC and C-stocks 1981-2006

- Different pools of the terrestrial system at monthly scale using CASA model
- Study on variability of NPP and NEP and other parameters were carried out
- Refinement of several biophysical parameters

Simulation of CO_2 fluxes at ocean atmosphere interface over the Indian Ocean (1981-2006)

- Key parameters of CO_2 exchange process - del pCO2, wind speed, SST, SSS

Mid tropo-spheric CO_2 data measured by Atmospheric Infra-Red Sounder (AIRS) (2002-08)

- Study variability of atmospheric CO_2 and its control through surface fluxes over India and surrounding oceans.

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Carbon Sequestration: Organic Carbon Store in the Soils under Chir (*Pinus roxburghii*) Forests at Different Altitudes in Uttarakhand State of India

M.K. Gupta and S.D. Sharma
Forest Research Institute, Dehra Dun

- GHGs re-emit some of heat to the earth's surface. If they did not perform this useful function, most of the heat energy would escape, leaving the earth cold (about - 18 ºC) and unfit to support life.
- Carbon dioxide is one of the major greenhouse gases and it has increased significantly in recent decades
- CH_4, Nitrous oxide, Chlorofluorocarbon Hydro-fluorocarbons and Per-fluorocarbons are the other GHGs

Soil and Carbon Sequestration

- Concentration of atmospheric CO_2 can be lowered either by reducing emissions or by taking CO_2 out from the atmosphere and stored in the terrestrial ecosystem
- Soil plays an important role in carbon sequestration by increasing soil organic carbon pool. Carbon pool in the soil is higher than the vegetation carbon pool
- Soil Organic Carbon (SOC) has been ignored since long but due to climate change awareness, its importance has recognized

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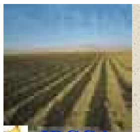


- IPCC has recognized soil organic carbon pool as one of the five major carbon pools for LULUCF sector
- It is mandatory to all nations to provide soil organic carbon pool and changes in the forest soils in LULUCF sector under National Communications to the UNFCCC
- Soil organic carbon is sensitive to impact of anthropogenic activities. The conversion of natural vegetation to various land uses results in decline in soil organic matter
- The researcher has estimated soil organic carbon simply as one of the soil attributes. To calculate Soil organic carbon pool from this data, several assumptions have to be made, which lead to high uncertainties in SOC store data

Soil Organic Carbon Pool Estimation

- Very few studies have been undertaken to estimate the soil organic carbon in forests, by following standard uniform methodology for field and laboratory work
- Estimation of Bulk density and Coarse fragments of soil is very important to reduce the uncertainty about the weight of soil of the study area
- No scientific benchmark information are available to ascertain the changes in SOC pool over the period of time

- a very prominent forests cover in Uttarakhand. Out of total *i.e.* 24,414.80 km^2 area under forests, Chir occupied 3,943.83 km^2 in the state which is 16.15 % of total forest area of the state
- This study was carried out under Chir pine forests at different altitudes in Uttarakhand
- The data for SOC calculated by using the following equation as suggested by IPCC Good Practice Guidance for LULUCF (2003):

Horizon = n Horizon = n
SOC pool = SOC horizon = ([SOC] * Bulk density * depth * (1 – C frag.) * 10) horizon
Horizon = 1 Horizon = 1

Details of the sites under different land uses

Sl. No.	Altitude range (m)	Districts Covered	Area Covered (Forest Ranges)	No. of samples
1	< 1000	Pauri Garhwal, Rudrapryag, Chamoli, Dehra Dun, Champawat, Pithoragarh, Bageshwer	Srinagar, Rudrapryag, Dhanpur, Atagad, Nandapryag, Chamoli, Narian Garh, Madhya Pindari, River, Kali Kumaun, Melatha, Batelghat, Bageshwer,	120
2	1001 – 1500	Tehri Garhwal, Nainital, Uttarkashi, Chamoli, Champawat, Almora, Pauri Garhwal, Bageshwer, Pithoragarh,	Jaunpur, Saklana,Tehri, Nainital, Mungersanti, Rawai, Civil Soyam Kuthnor, Yamunotri, Chamoli, Papil koti, Pashmi Pindari, Madhya Pindari, Kali Kumaun, Someshwer, Jogeshwer, Dwarhat, Ranikhet, Almora, Lansdown, Duggadda, Pathani, Pauri, Baijnath, Kapkot, Bageshwer, Askot, Dharchula,	329
3	1501 - 2000	Tehri Garhwal, Nainital, Uttarkashi, Dehra Dun, Champawat, Almora, Pauri Garhwal, Chamoli, Bageshwer, Pithoragarh	Jaunpur, Naina, Bhowali, Rawai, Tehri Dam, River, Champawat, Kalagarh Tiger Reserve, Almora, Jogeshwer, Kosi, Binser, Someshwer, Dwarhat, Ranikhet, Kosi, Pauri, Joshimath, Pipal koti, Madhya Pindari, Baijnath, Kapkot, Bageshwer, Askot, Didihat, Pithoragarh	364
4	> 2000	Uttarkashi, Tehri Garhwal	Rawai, Tehri, Tehri Dam,	21
			Total	834

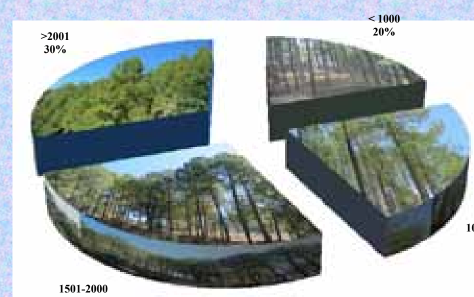
Soil organic carbon pool under Chirpine at different Altitudes

(up to 30 cm)

Sl. No.	Altitude	SOC Pool (t ha^{-1})	SD	Mitigation Potential	SE	Confidence Interval (t ha^{-1}) (α = 0.05)	
						Lower bound	Upper bound
1	< 1000 m	49.27^a	± 25.0437	1.00	2.31	44.70	53.83
2	1001 – 1500 m	56.41^a	± 22.0803	1.14	1.38	53.68	59.13
3	1501 – 2000 m	67.43^b	± 26.4059	1.37	1.65	64.21	70.65
4	> 2001 m	75.81^b	± 18.5663	1.54	4.79	65.53	86.09
	Uttarakhand State	61.10	25.4641		1.00	--	--

Same alphabets represent statistically at par group
± Standard Deviation; SE - Standard Error

Share of total SOC pool occupied at different altitudes



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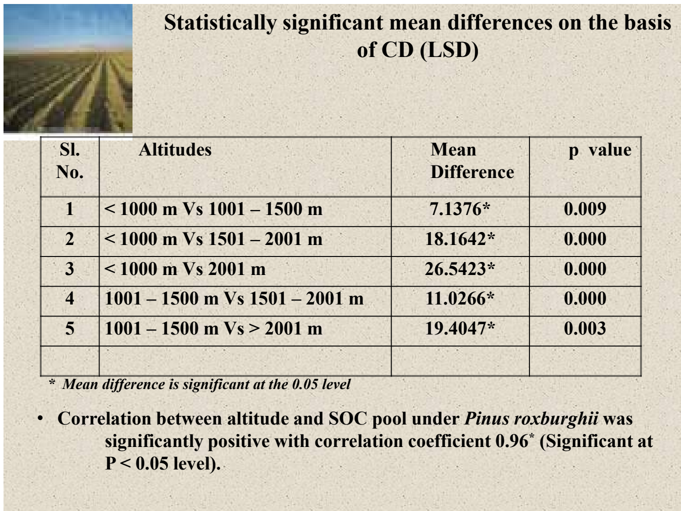
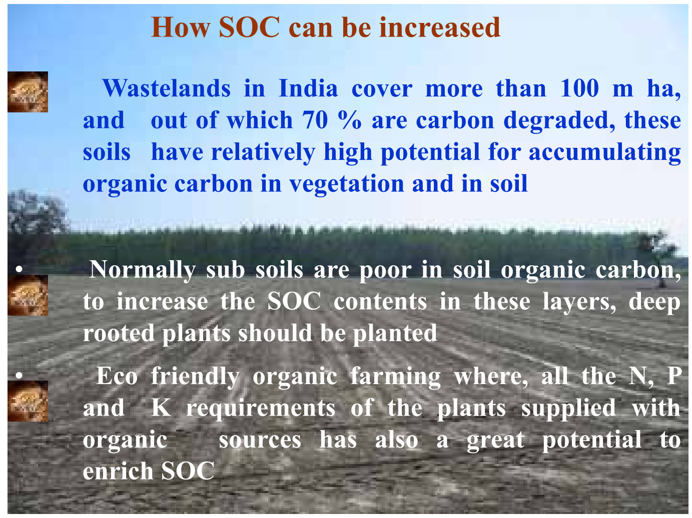


Statistically significant mean differences on the basis of CD (LSD)

Sl. No.	Altitudes	Mean Difference	p value
1	< 1000 m Vs 1001 – 1500 m	7.1376*	0.009
2	< 1000 m Vs 1501 – 2001 m	18.1642*	0.000
3	< 1000 m Vs 2001 m	26.5423*	0.000
4	1001 – 1500 m Vs 1501 – 2001 m	11.0266*	0.000
5	1001 – 1500 m Vs > 2001 m	19.4047*	0.003

* *Mean difference is significant at the 0.05 level*

- Correlation between altitude and SOC pool under *Pinus roxburghii* was significantly positive with correlation coefficient 0.96* (Significant at $P < 0.05$ level).



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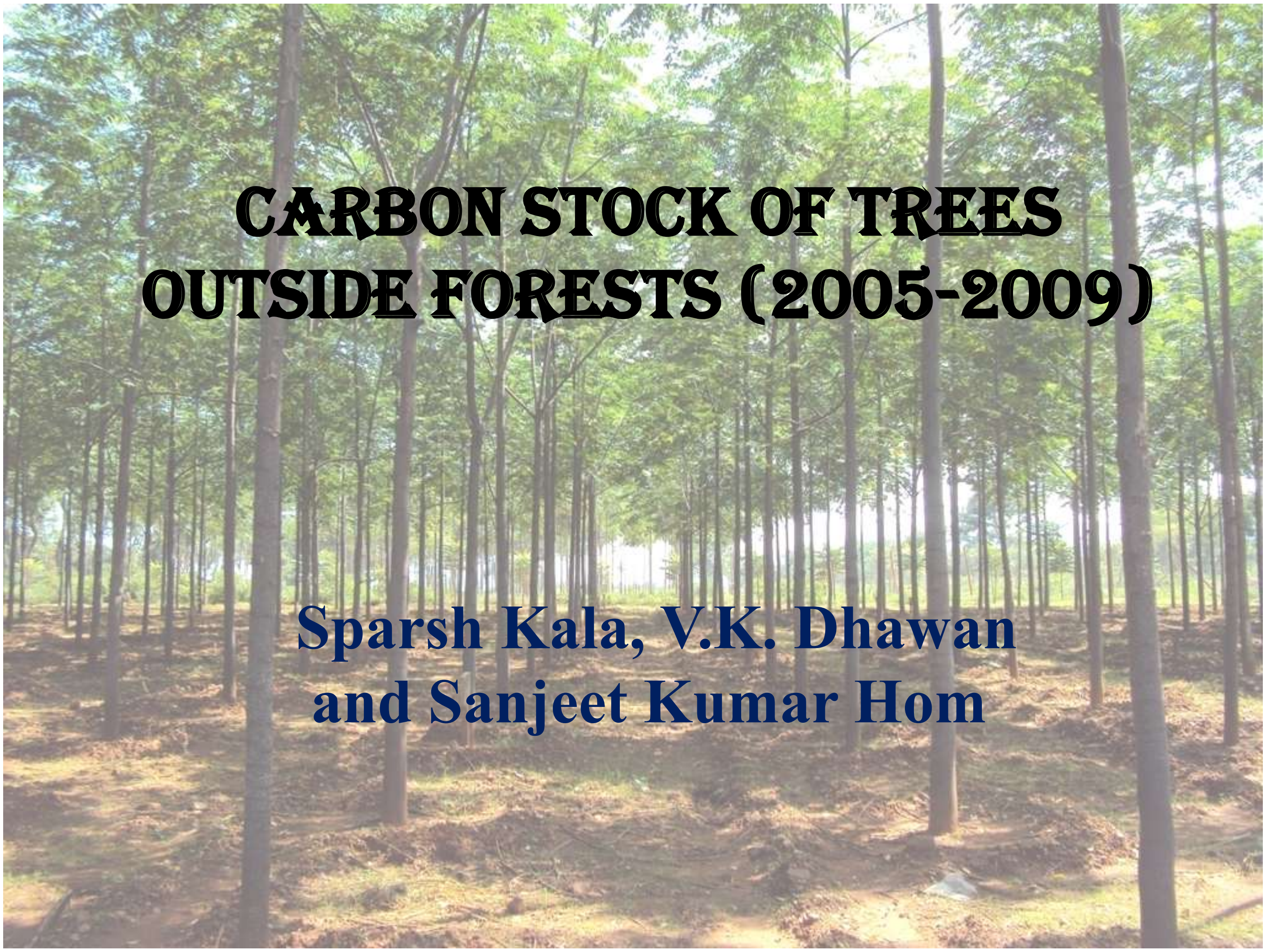

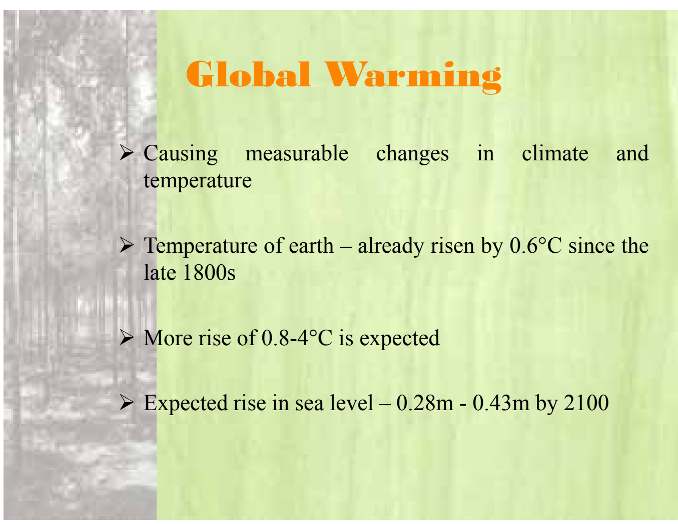

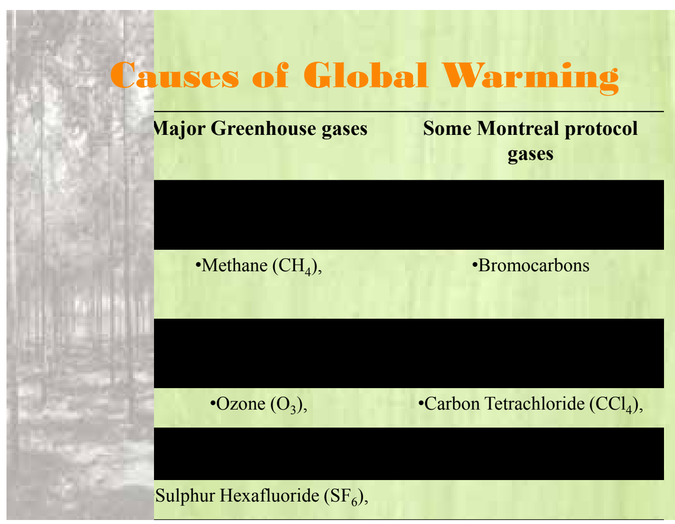

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Carbon Dioxide (CO_2)

- Major contributor to Global Warming
- Causes of Carbon dioxide emission
  - Burning of fossil fuels
  - Deforestation
  - Forest degradation
  - Fragmentation
  - Diversion of forest land for non-forest purposes

continue

- Global CO_2 concentration has increased from pre-industrial value of 280 ppm to 370 ppm in 2005
- The annual CO_2 growth rate
  - 1999 - 2005 -19 ppm per year
- Combined radiative forcing due to increase in CO_2, CH_4, and N_2O is + 2.30Wm^{-2}
- CO_2 emission growth can be checked by

PLANTING MORE TREES

Forests as Carbon Sink

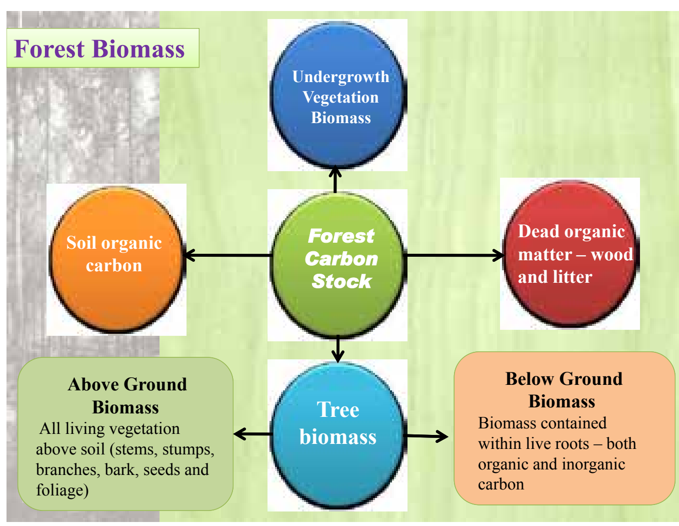
- Remove carbon dioxide from atmosphere through Carbon Sequestration.
- Total forest area of world - 31% of world's total land area
- Plantation area- 5%, Natural Forests- 95%
- Forest and tree cover in India- 78.37 million ha (23.84% of total geographic area of country)

Carbon Sequestration

- Removal of atmospheric carbon dioxide into green plants where it can be stored indefinitely
- Carbon is stored in plant (above ground biomass), roots (below ground biomass) and in soil
- Productivity of carbon sequestration can be increased by creating-
  - Afforestation/Reforestation
  - Agroforestry
  - Increasing productivity of degraded forests

continue

- The rate of carbon sequestration depends on
  - the growth characteristics of the tree species,
  - the conditions for growth where the tree is planted, and
  - the density of the tree's wood
- It is greatest in the younger stages of tree growth, between 20 to 50 years
- About half the dry weight of tree is carbon and 1 ton of carbon represents 3.67 tons of CO_2



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Mathematical assessment of carbon stocks

$$C_{carbon} = C_{biomass} + C_{soil}$$

C_{carbon} = Total available carbon (vegetation + soil)

$C_{biomass}$ = AGB + BGB

C_{soil} = Soil Organic Carbon (SOC) upto 30 cm depth

Objective

Estimation of carbon storage potential of Trees Outside forests (TOF) from 2005 – 2009

Why plant trees?

- To achieve national goal of 33% forest and tree cover
- Plantations provide higher productivity
- Promotion of agro-forestry
- Introduction of exotics

Concept of trees outside forests

- Reduce pressure on forests
- Provide raw materials to wood based and paper industries
- Restoration of degraded ecological balance
- Recreational and aesthetic opportunities
- Meet demands of fruit, fodder and fuelwood
- Creating employment opportunities

Methodology

Collection of data : State Forest Report of FSI

↓

Assessment of data of number of stems and volume according to different diameter classes

↓

Calculation of carbon stock using suitable conversion factors

↓

Comparison between carbon stock of 2005 and 2009

Calculations

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Above Ground Biomass (AGB) = Volume of Tree X 1.58
(Biomass Expansion Factor (BEF) in Indian Context, Kaul *et al*)

Below Ground Biomass (BGB) = AGB X 0.27
(Mean ratio of BGB to AGB in Indian Context, Kaul *et al*)

Total Biomass = AGB + BGB

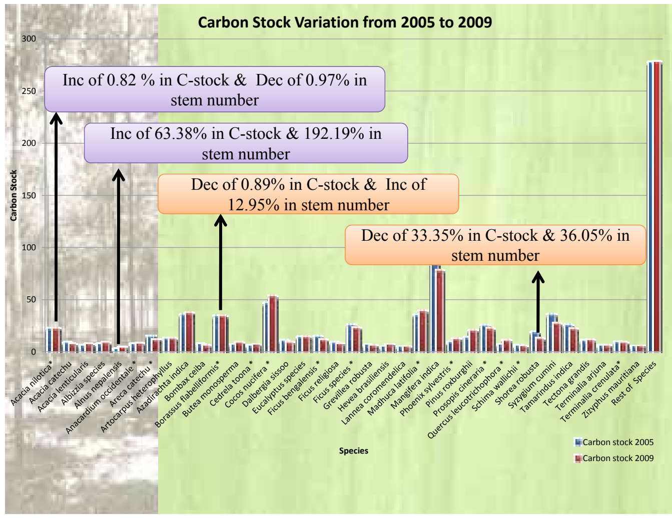
Total weight = Total Biomass X Mean Wood Density (MWD)

Dry weight = 80% of total weight

Total carbon = 50% of dry weight

Results & Discussions

Diameter class (cm)	Year	No. of Stems (nos. in '000)	Volume (million m^3)	Above Ground Biomass (million m^3)	Below Ground Biomass (million m^3)	Total Biomass (million m^3)	Weight (Mt)	Dry wt. (Mt)	Carbon Stock (Mt)
10- 30	2005	43,15,102	549.418	868.08	234.382	1102.46	793.77	635.01	317.50
	2009	46,52,830	567.455	897.369	242.29	1139.65	820.55	656.44	328.22
Increment %		**7.83**	3.28	3.37	3.37	3.37	3.37	3.37	**3.37**
30-50	2005	6,81,000	488.476	771.792	208.384	980.176	705.72	564.58	282.29
	2009	7,01,950	486.824	769.182	207.679	976.861	703.34	562.67	281.33
Increment %		**3.08**	-0.34	-0.34	-0.34	-0.34	-0.34	-0.34	**-0.34**
50+	2005	163,645	578.35	913.793	246.724	1160.51	835.57	668.45	334.22
	2009	153,676	544.791	860.77	232.408	1093.17	787.08	629.67	314.83
Increment %		**-6.09**	-5.80	-5.80	-5.80	-5.80	-5.80	-5.80	**-5.80**



Conclusion

- The study estimates that there was a net decrease of 1.21% in the total carbon sequestered by trees outside forests in year 2005 to 2009
- The decrease in carbon stock may be due to decrease in number of stems in more than 50 cm diameter class, which stores more carbon as compared to lower diameter classes
- Even though there is rise in number of stems falling under diameter classes 10-30 cm and 30-50 cm, it might not compensate the decrease in net carbon stock

Limitations

- BEF and ratio of below ground to above ground biomass assumed are the average for the entire country. However these factors vary for different sites and localities
- Mean wood density assumed for different species is the average for the entire country
- A common MWD has been considered for the tree species for which data were unavailable
- For the calculation of dry weight and carbon content, the conversion factor assumed is also a constant

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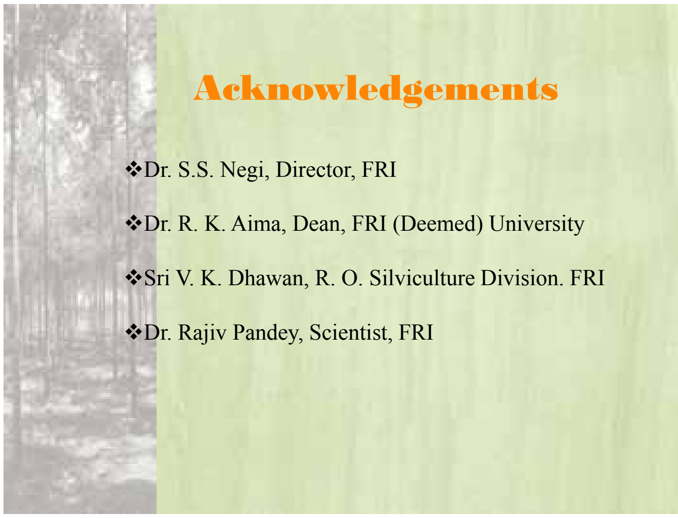
Acknowledgements
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TREE GROWTH, C SEQUESTRATION AND N ALLOCATION IN *GMELINA ARBOREA* ROXB. STANDS GROWN IN MONOCULTURES AND AGRISILVICULTURE

Speakers

Dr. S. L. Swamy & Alka Mishra

Department of Forestry,

Indira Gandhi Agricultural University,

Raipur (C.G.) 492 006 India

Introduction

Gmelina arborea Roxb., is one among the moderately fast growing indigenous tree, which is greatly encouraged under different social and agroforestry plantations in humid and sub-humid tropics of India for the purpose of timber, fuel and paper pulp production was selected for quantifying the biomass carbon and nitrogen storage. Only limited studies were made to understand the growth and biomass production of *G. arborea* in monocultures and no detailed information is available on agroforestry practices.

OBJECTIVES

1) To examine the growth and biomass productivity of *G. arborea* stands in monoculture and agroforestry practices in different sites
2) To evaluate the productivity of different crops in agrisilviculture system
3) To quantify the carbon and nitrogen allocation patterns in different stands
4) To assess the changes in carbon and nitrogen pools in soils
5) To explore the use of crop residues to manage organic carbon in soil under agrisilviculture system. The results of five year studies on above aspects in *G. arborea* stands are presented.

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Study sites

The study was conducted in two sites at Chhattisgarh, Central India.

Site 1:- Forestry Research Farm of Indira Gandhi Agricultural University, Raipur (latitude 21^0 12^1 N and longitude 81^0 36^1 E)

Site 2:- Kusumi village of Durg district (latitude 21^0 76^1 N longitude and 81^0 40^1 E).

Mean elevation of the sites ranged from 290-320 m above mean sea level.

The climate of study area is sub-humid tropical with an annual precipitation of 1200-1400 mm.

Plantation of *Gmelina arborea* (5 yr-old)

Growth of *Gmelina arborea* stands

Stand type	Age (years)					
	1	2	3	4	5	Mean
			Dbh (cm)			
MS-AAL	1.99 h	2.81 g	4.76 e	7.25 c	11.88 a	5.73 a
AS-AAL	1.96 h	2.29 gh	4.50 e	5.44 d	8.63 b	4.52 b
MS-RLW	1.33 i	2.16 h	3.65 f	4.86 e	6.94 c	3.79 c
Mean	1.69 e	2.42 d	4.31 c	5.85 b	9.15 a	
			Height (m)			
MS-AAL	2.27 i	2.92 g	3.71 f	4.82 e	7.07 a	4.16 a
AS-AAL	2.24 i	2.52 h	3.63 f	4.47 e	6.62 b	3.83 b
MS-RLW	1.28 j	2.13 hi	3.37 f	5.34 d	6.13 c	3.65 b
Mean	1.81 e	2.53 d	3.57 c	4.87 b	6.61 a	

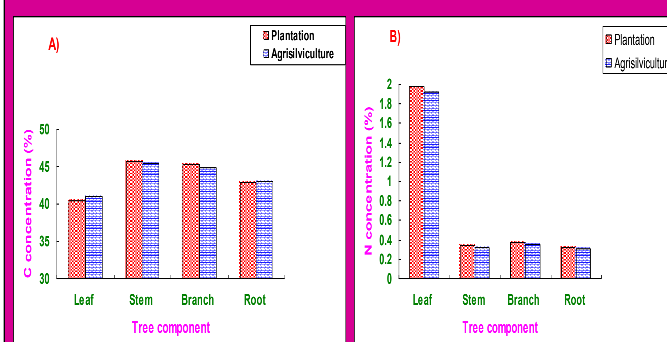
Regression models for biomass estimation of different components of *G. arborea* stands

Biomass Component	Form of the Model
Leaf	$Y_1 = a+bD+cD^2+gDH+\varepsilon$
Stem	$Y_2=a+bD+cD^2+dD^3+gDH+\varepsilon$
Branch	$Y_3=a+bD+cD^2+\varepsilon$
Root	$Y_4=a+bD+cD^2+eH+\varepsilon$
Total	$Y_5=a+bD+cD^2+eH+fH^2+\varepsilon$

Biomass of *Gmelina arborea* stands

Stand type	Age (years)					
	1	2	3	4	5	Mean
			Total biomass			
MS-AAL	0.53 h	2.07 g	5.87 e	11.10 c	21.73 a	8.26 a
AS-AAL	0.41 h	1.10 gh	5.45 e	7.35 d	14.09 b	5.68 b
MS-RLW	0.13 h	0.84 h	3.72 f	6.09 e	10.38 c	4.23 c
Mean	0.36 e	1.33 d	5.01 c	8.18 b	15.40 a	-

Carbon (A) and nitrogen (B) concentrations in different components of *Gmelina arborea* 5-yr-old stands



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Carbon storage in *Gmelina arborea* stand

	Total carbon kg ha^{-1}					
MS-AAL	241.304 h	932.505 g	2640.640 e	4987.705 e	9754.05 a	3711.241 a
AS-AAL	185.751 h	493.363 gh	2437.875 e	3289.424 d	6297.659 b	2541.21 b
MS-RLW	136.646 h	366.926 h	1631.483 f	2669.528 e	4554.640 c	1871.844 c
Mean	187.840 e	597.598 d	2236.66 c	3648.985 b	6868.783 a	

Nitrogen allocation in *Gmelina arborea* stand

	Total nitrogen kg ha^{-1}					
MS-AAL	2.389 i	8.052 h	22.34 f	43.774 c	89.585 a	33.286 a
AS-AAL	1.865 i	4.247 hi	19.937 f	27.094 e	53.624 b	21.389 b
MS-RLW	1.264 i	3.136 i	12.810 g	21.062 f	36.650 d	14.910 c
Mean	1.716 e	5.145 d	18.460 c	30.643 b	59.953 a	

Productivity of crops in sole cropping and under *Gmelina arborea* stands during rainy season

Crops	I. Grain yield (q ha^{-1})								
	3 years			4 years			5 years		
	SC	IC	YR (%)	SC	IC	YR (%)	SC	IC	YR (%)
Mung	2.45 ± 0.23	1.28 ± 0.15	47.75	2.50 ± 0.18	1.18 ± 0.25	52.8	2.29 ± 0.25	0.935 ± 0.1	59.25
Cowpea	3.40 ± 0.42	2.80 ± 0.35	17.64	3.46 ± 0.35	2.52 ± 0.49	27.16	3.30 ± 0.45	2.185 ± 0.3	34.38
Urd	3.86 ± 0.56	1.98 ± 0.25	48.70	4.00 ± 0.85	1.84 ± 0.21	54.0	3.80 ± 0.19	1.342 ± 0.2	64.68
Soybean	10.5 ± 1.11	8.80 ± 1.25	16.19	10.8 ± 1.26	8.54 ± 0.95	20.9	10.32 ± 1.4	7.71 ± 1.25	25.29

Productivity of crops in sole cropping and under *Gmelina arborea* stands during winter season

Crops	I. Grain yield (q ha^{-1})								
	3 years			4 years			5 years		
	SC	IC	YR (%)	SC	IC	YR (%)	SC	IC	YR (%)
Wheat	38.5 ± 2.15	37.5 ± 2.05	2.59	41.2 ± 3.25	37.2 ± 3.15	3.95	39.25 ± 2.1	36.46 ± 2.4	7.11
Linseed	13.20 ± 1.1	11.90 ± 0.9	9.85	13.80 ± 1.1	11.4 ± 0.69	17.39	12.10 ± 0.6	10.17 ± 0.9	15.95
Mustard	12.10 ± 1.2	11.50 ± 0.8	4.96	12.50 ± 1.0	11.3 ± 1.15	9.60	11.11 ± 0.9	9.57 ± 0.76	13.8
Chickpea	12.20 ± 1.1	9.80 ± 0.6	19.67	12.80 ± 1.1	8.90 ± 1.25	30.46	11.90 ± 1.1	8.90 ± 1.12	35.70

Intercropping of Mustard under *Gmelina arborea* based agrisilviculture system

- Intercropping of Linseed under *Gmelina arborea* based agrisilviculture system

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Carbon content (kg ha-^{1}) in crops grown in *Gmelina arborea* stand

Crops	Rainy season crops (kg ha^{-1})								
	3 years			4 years			5 years		
	C in grain	C in straw	Total C	C in grain	C in straw	Total C	C in grain	C in straw	Total C
Mung	51.21	323.54	374.76	47.21	278.75	325.96	37.41	229.38	266.79
Urd	78.21	279.62	357.83	72.68	291.10	363.78	53.01	237.80	290.81
Cowpea	106.40	405.06	511.46	95.76	348.30	444.06	83.03	323.79	406.82
Soybean	352.00	620.40	972.40	341.60	583.00	924.60	308.40	502.48	810.88
Crops	**Winter season crops (kg ha^{-1})**								
Wheat	1315.13	2345.85	3660.98	1304.6	2245.6	3550.20	1278.65	2229.56	3508.21
Linseed	526.58	899.91	1426.49	504.45	913.545	1418.00	450.02	852.64	1302.6
Mustard	507.15	2302.76	2809.91	498.33	2249.4	2747.73	422.04	2055.66	2478.7
Chickpea	372.4	632.00	1004.40	338.2	624.00	962.20	338.2	554	892.20

Nitrogen uptake (kg ha^{-1}) in crops grown in *Gmelina arborea* stand

Crops	Rainy season crops (kg ha^{-1})								
	3 years			4 years			5 years		
	N content in grain	N content in straw	Total N content	N content in grain	N content in straw	Total N content	N content in grain	N content in straw	Total N content
Mung	4.86	7.02	11.88	4.46	5.64	10.11	3.65	4.53	8.18
Urd	7.76	6.55	14.31	7.01	6.67	13.68	5.30	5.28	10.58
Cowpea	9.69	7.91	17.60	8.19	6.56	14.75	7.10	6.48	13.58
Soybean	55.44	17.06	72.50	52.09	16.43	68.52	49.34	14.96	64.30
Crops	**Winter season crops (kg ha^{-1})**								
Wheat	41.69	31.59	72.84	40.92	30.24	71.16	40.10	30.02	70.13
Linseed	13.68	10.29	23.98	14.14	10.45	24.59	12.50	9.75	22.26
Mustard	15.06	26.03	41.10	15.03	26.40	41.44	12.92	25.04	37.96
Chickpea	30.97	11.38	42.34	27.23	10.60	37.84	29.19	9.97	39.16

Carbon and nitrogen changes in soils

Stand type	Soil depth (cm)						Mean	
	0-20 cm (d_1)		21-40 cm (d_2)		41-60 cm (d_3)			
	Bpl	Apl	Bpl	Apl	Bpl	Apl	Bpl	Apl
Total organic carbon g kg^{-1}								
MS-AAL	3.08 h	4.65 a	3.05 h	4.61 b	3.01 i	4.60 b	3.05 a	4.62 a
AS-AAL	3.08 h	3.55 f	3.04 h	3.51 g	3.02 i	3.46 g	3.05 a	3.51 c
MS-RLW	2.12 j	3.62 c	2.09 jk	3.54 d	2.06 k	3.50 e	2.29 b	3.55 b
Mean	2.76 d	3.98 a	2.73 e	3.93 b	2.70 f	3.90 c		
Available nitrogen g kg^{-1}								
MS-AAL	0.31 cd	0.42 a	0.29 e	0.40 ab	0.26 ef	0.37 b	0.29 a	0.40 a
AS-AAL	0.31 cd	0.34 c	0.29 e	0.31 cd	0.26 ef	0.29 d	0.29 a	0.31 b
MS-RLW	0.24 g	0.36 bc	0.21 gh	0.33 d	0.16 i	0.31 d	0.20 b	0.33 b
Mean	0.29 d	0.37 a	0.26 e	0.35 b	0.23 f	0.33 c		

Net stand carbon and nitrogen storage (Kg ha^{-1}) in soil (up to 60 cm) and vegetation in *G. arborea* stands after 5 years of planting

Location	Phyto C BFP	Phyto C AFP	Δ Phyto C	Soil C BFP	Soil C AFP	Δ Soil C	Total C BFP	Total C AFP	Net Δ C
MS-AAL	1050 a	9754.1 a	8704 a	25254	36036	10782	26304	45790.1	19486.1
AS-AAL	1050 a	6297.7 b	5247.7 b	25254	27378	2124	26304	33675.7	7371.7
MS-RLW	410 b	4554.6 c	4144.6 c	18961	27690	8729	19371	32244.6	12873.6
Mean	836.6	6868.8	6032.2	23156.3	30368	7211.7	23993	30429.8	13243.8

Conclusions

Our studies indicate that *G. arborea* is a suitable tree to be planted in degraded lateritic soils. Although, the growth and biomass production of species was low during initial period, but a significant increase was observed after three years of planting. Growth of *G. arborea* in red lateritic soil was comparatively better than many other indigenous species. The species was also found to be useful for soil amelioration through nitrogen and potassium enrichment in the soil and it even increased the soil pH to a significant level. Phosphorus additions are recommended for lateritic soils to ensure better growth and biomass production.

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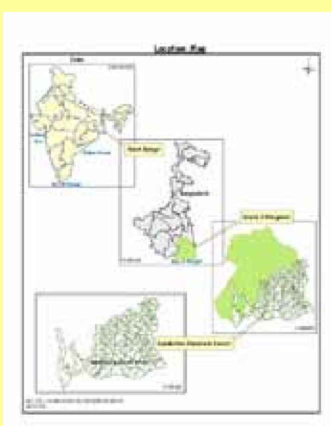
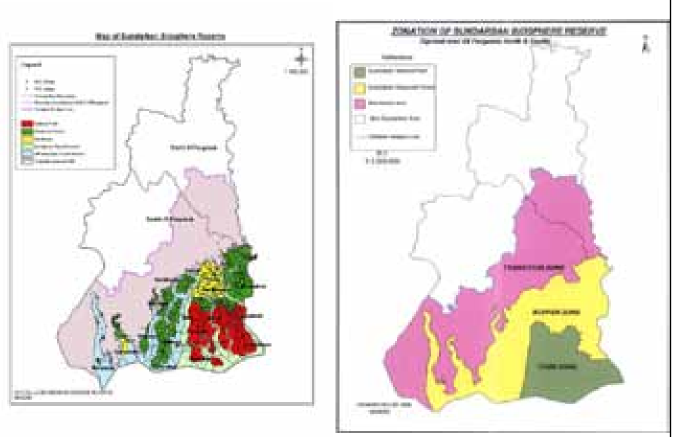
Sundarban and Global Warming – where lies the threat

Dr Atanu Kumar Raha, IFS
Principal Chief Conservator of Forests, W.B
Head of Forest Forces

Location of Sunderban Biosphere Reserve



Zonation of Sunderban Biosphere Reserve



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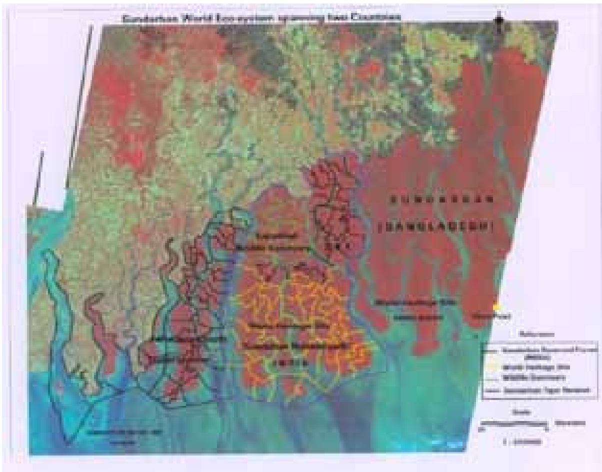
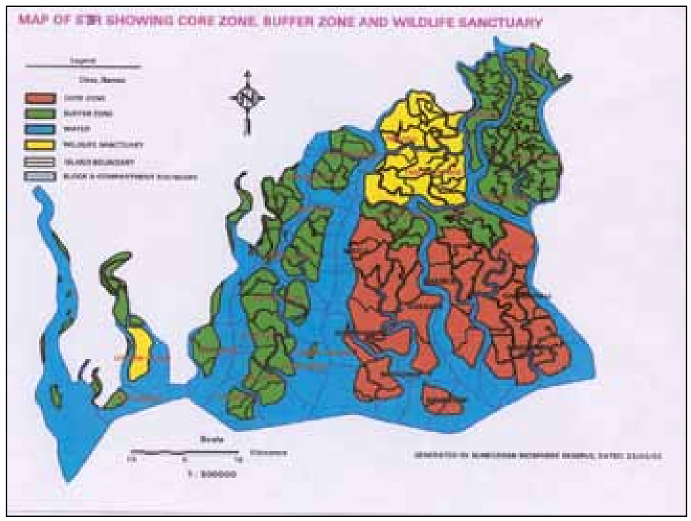


Sunderbans: a transboundary ecosystem

- Sunderbans, a unique mangrove delta, is spread over two countries, i.e., India and Bangladesh
- It is situated along the coast of Bay of Bengal
- The rich floral and faunal diversity and the unique ecosystem has been under threat due to natural and biotic factors
- Though it is a single ecosystem, yet the management perceptions and interventions differ

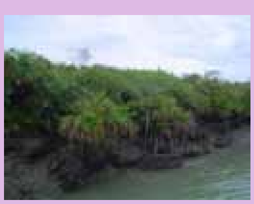
Sundarban ecosystem

- Mangrove vegetation develops in the estuaries where sweet river water meets the saline water of the sea
- There are 102 islands comprising Indian sundarban, out of which 54 are habitated and balance 48 islands contain mangrove reserved Forest
- Sundarban Reserved forest comprises 4200 sq km, out of which 45% is water



International status of Sunderban

- **Sunderban National Park** in India is a **World Heritage Site** (Well protected by Reserved Forest as Buffer all around) declared by UNESCO in 1987
- Sunderban region in India is a **Global Biosphere Reserve**, recognised by **UNESCO in2001**
- **Indian Sunderban** has been selected for inclusion as **Ramsar Site**
- **Sunderban Tiger Reserve(1973)** is part of **Project Tiger of GOI**



The Importance of Sundarban Forest are noted below:-

- 1) **The only mangrove forest of the world having largest floral and faunal diversity**
- **2) The only mangrove forest having a Tiger population**
- **3) Selected as World Heritage Sites, a Ramsar Site (Bangladesh) and a Biosphere Reserve in the Global Network(India)**
- **4) It supports the single largest tiger population in both the countries**
- **5) Home of several endangered, threatened and endemic floral and faunal species**
- **6) A few million people depend on the mangrove forest for livelihood**
- **7) Sundarban mangrove acts as a fish nursery and supports coastal fisheries along Bay of Bengal and Indian Ocean**
- **8) Sundarban forest acts as a sink for the mega-metropolitan pollutants**
- **9) The mangrove forest provides protection to inland habitations against the fury of cyclones**

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Sundarban and climate change

- "Sea-level rise is the greatest threat and challenge for sustainable adaptation within South and Southeast Asia. A 45 cm rise in global sea levels would lead to the destruction of 75 percent of the Sundarbans mangroves," a UNESCO report warned.
- Along with global sea level rise, there is a continuous natural subsidence in the Sundarbans, causing a rise of about 2.2 mm per year. The resulting net rise rate is 3.1 mm per year at Sagar, the biggest delta of Sundarbans, the report added.
- Underlining that climate change will constitute one of the major challenges of the 21st century; Unesco Director General Koïchiro Matsuura in the report has called for "an integrated approach to issues of environmental preservation and sustainable development".

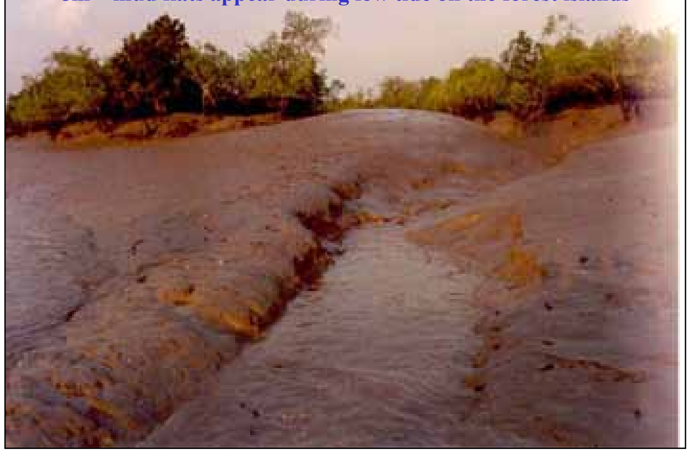
Climate change reconsidered – 2009 Report of NG Int. Panel on Climate Change

- Part of the northern hemisphere that holds lion's share of hemisphere's ice, has been cooling for past half century, at a very significant rate, making it unlikely that its frozen water will be released to the world's oceans
- The studies revealed that the Arctic is still not as warm as it was many centuries ago, when there was much less carbon dioxide and methane in air than there is today
- There is no way …. To suggest that a significant increase in atmospheric carbon dioxide would necessarily lead to any global warming, much less than…. predicted by IPCC

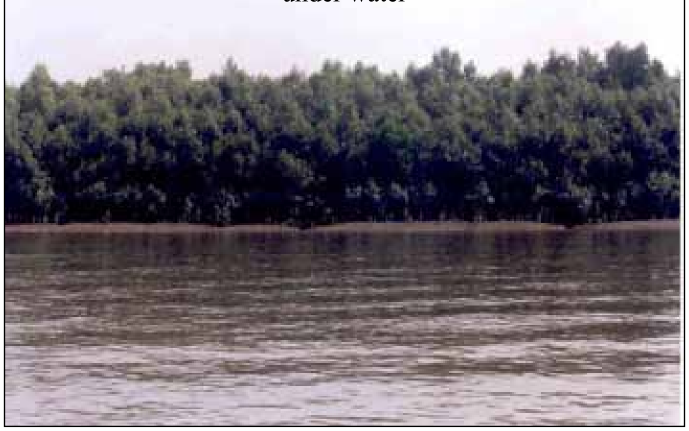
When we talk of Sundarban, we must

- Segregate 48 islands, under complete mangrove forest, from 54 islands, totally devoid of forest and thickly populated
- Realize that forested islands are left to nature, whereas populated islands have permanent embankments, 3500 km long, all around them
- Remember that present settlements were established in sundarban, around 250 years back, after cutting down the forests
- Accept that islands in Sundarban are still-growing within a dynamic estuary

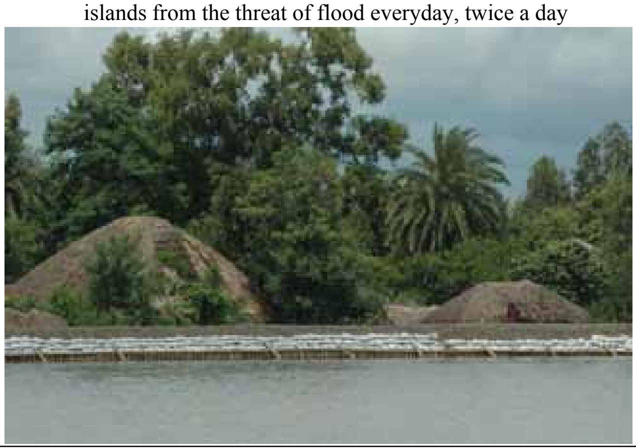
Difference of High Tide and Low tide level can be as much as 8m – mud flats appear during low tide on the forest islands



During high tide, much of the forest island goes under water



There are 54 populated islands in Sundarban facing High Tide twice a day – nearly 3500 km long embankment protect 54 islands from the threat of flood everyday, twice a day



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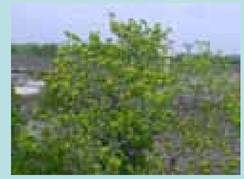
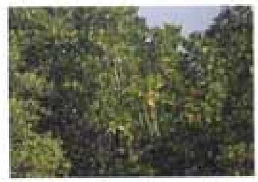
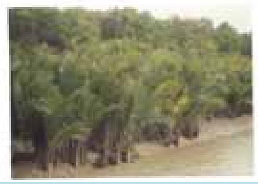
The key issues to ponder

- What can be the effect of climate change on floral and faunal diversity
- What can be the effect on the people living in sundarban villages
- Whether sea level rise has perceptibly threatened the home of tiger

Floral Diversity- highest amongst the mangroves of the world





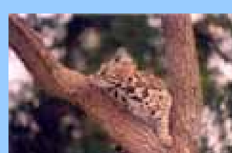


True Mangrove species = 26
Mangrove associates = 29
Back mangrove species= 29
Family = 40 Genera = 60

<u>Total Species = 84</u>

The Fauna

Total No of Species = 1586
Vertebrate Spp = 481
Hemichordate Spp = 1
Invertebrate Spp = 1104
Protozoan species = 106



Species included in Sch. I &II of WLP Act
Mammals = 7
Birds = 8
Reptiles = 17

Total species included in Sch. I of WLP Act = 24
Total spp included in Appendix I of CITES Regulation = 14

Nypa spp – a sweet water loving plant gradually vanishing due to increasing salinity in Indian Sunderban – but why this increasing salinity ?

Pneumatophores – the breathing roots adapting to increased salinity in soil

Rhizophora species – stilt roots to support the water pressure during submergence

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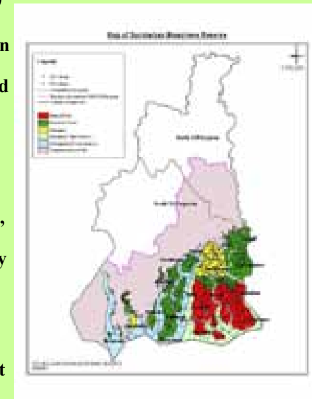
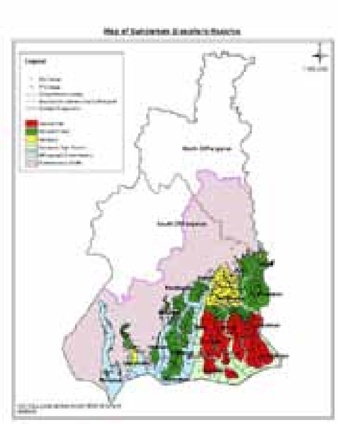
Viviparous germination to facilitate seedling establishment

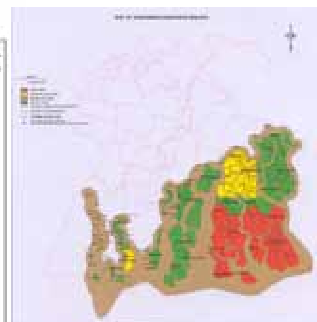
Socio-economic status of fringe population

- **There is no human habitation in 4260 sq km of R.F.in Indian part**
- **Along the northern and north-western fringes of Indian Sunderban, around 4.1 m people live. The figure is around 3.5 m for Bangladesh. A large no of fringe people depend on Sunderban for subsistence**
- **Large percentage of population is Below Poverty Line**
- **Due to non-availibility of sweet water, except in monsoon, agriculture is mono-cropping, which is also primary occupation of 90% of population**
- **Second most important occupation is fishing, either in R.F.water or in the sea**
- **Due to lack of industries, employment opportunities are poor**



Nearly 4.1 million people live in the non-forest zone of SBR-around 0.22 million living in 66 mouzas within 2 km buffer zone





Fishing is the second largest occupation of the fringe villagers
Fishing is controlled and not allowed within Protected Areas

Tiger prawn seed collection damages aquatic biodiversity as well as embankments

Saline blanks appear in mangrove islands

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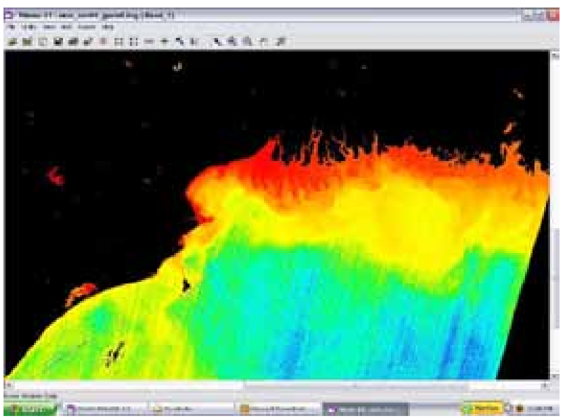
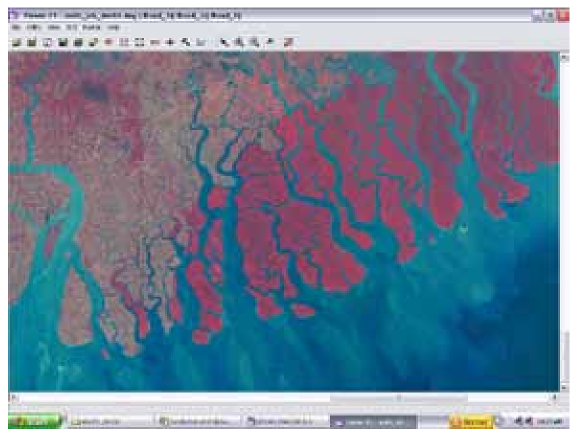
Using GPS for Ground Truth Verification of Satellite Data

Saline Blanks in areas not inundated by High tides

Chlorophyll monitoring in Sundarban estuary



Erosion and accretion are natural processes in a developing estuary like Sundarban



Time series change study of Mayadwip island

Jambu Island in Sunderban as in 1989

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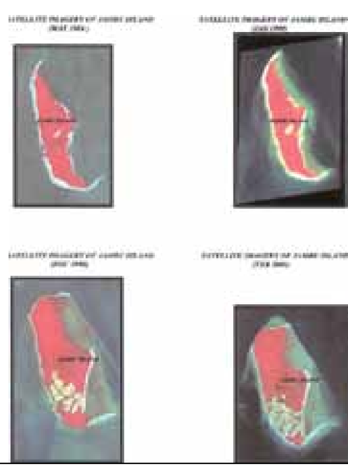
Encroachment at centre of forested island

Encroachment grows and island erodes

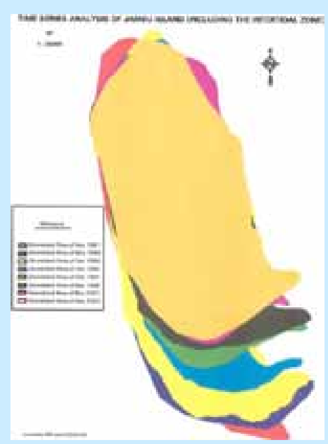
More than 200 ha cleared by Mar 2001

In July 02, encroachers removed and blanks planted

Time series analysis of Jambudwip



GIS analysis of island dynamics



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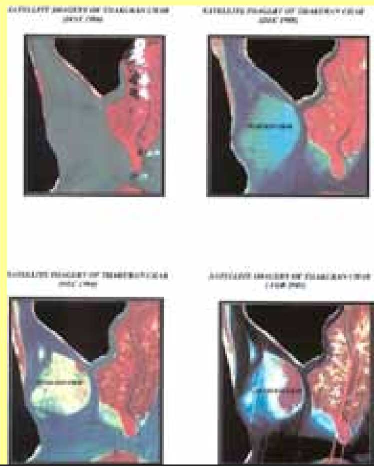
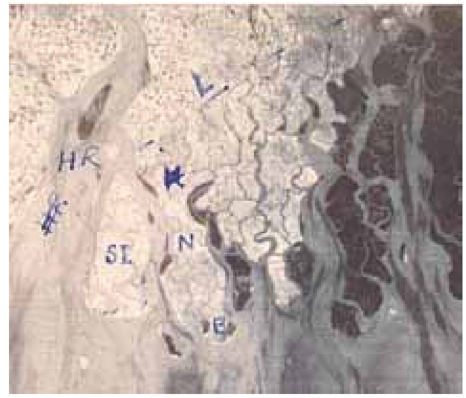
Monitoring accretion and afforestation in remote areas

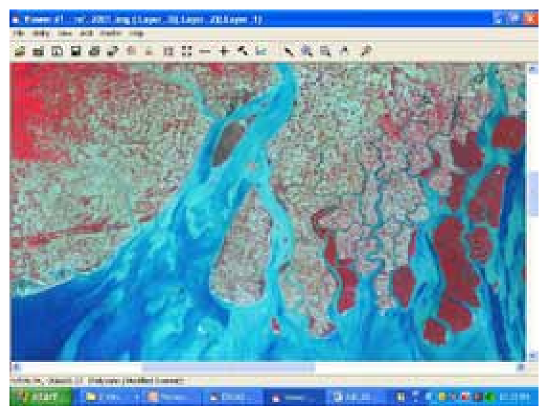


Satellite imagery of 1973

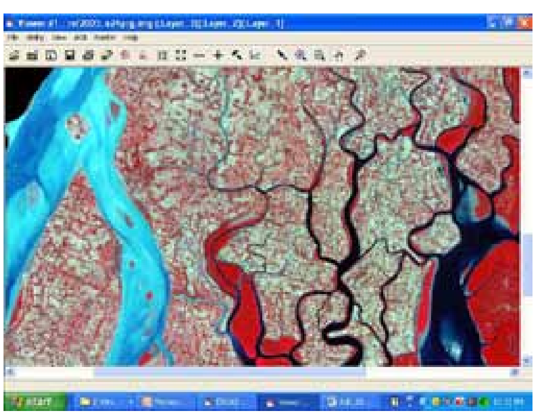


Satellite Imagery of 1981

IRS 1C satellite data showing status of Ghoramara in 2001



Satellite image of 2005



Satellite image of 2009

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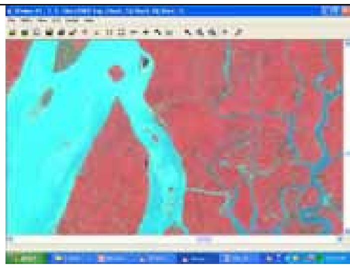
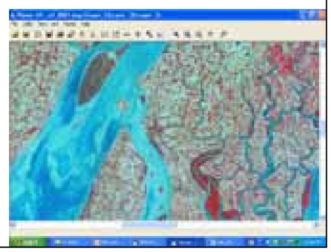


Satellite imagery 2009

Satellite imagery 2001



Eco-Development and JFM activities

Sunflower cultivation in winter with stored rain water

Producing dry chilli powder- income for EDC members

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Members of EDC attending micro-planning meeting

Training of women SHG in zari work

Sundarban – the real threats conveniently forgotten

- the present trend of reduced fresh water flow in Indian Sundarban due to construction of dams/ barrages upstream
- Arresting the process of formation of populated islands by constructing embankments
- Tremendous biotic pressure on forest biodiversity from the forest fringe population
- Present Sundarban, hardly six thousand years old, is a geologically sinking delta
- A tectonic tilt in this part of Bengal, hundreds of years ago, had shifted the sweet water flow more towards Bangladesh Sundarban

Sundarban – an example of natural adaptation

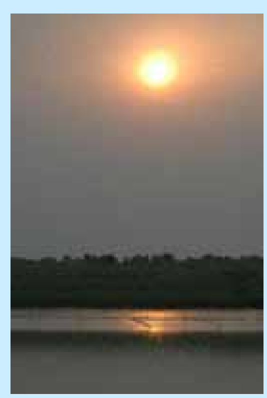
- Due to increased salinity in Indian sundarban water, more salt-tolerant species predominate Indian Sundarban
- The saline blanks are gradually getting vegetated with highly salt-tolerant species like *Ceriops decandra*
- Tigers, deer drink saline water only in Sundarban
- Wild animals have adapted to the daily rise of water level by 10 to 15 ft everyday, twice a day

What is feasible to counter the threats

- To control further increase in population within and around the estuary
- To harvest rain water for providing multiple cropping in villages
- Discourage drawal of ground water which threatens sinking of the inhabited islands
- Provide alternate sustainable livelihood in villages to reduce biotic pressure on Sundarban forests
- Generate awareness and involve local people to prevent poaching of deer/ tiger in the forest and conserve floral and faunal diversity

Sundarban - A thought for all

- Global warming is a reality and global phenomena
- An act of mis-deed elsewhere in the world will un-do all the good works done in Sundarban
- If Sundarban goes under water, Kolkata, Mumbai, Holland, NuYork and similar others will also go under water



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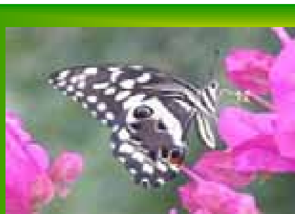
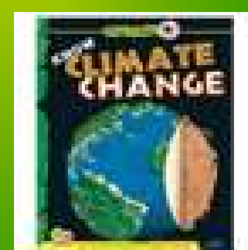
[761]

Your intelligence has threatened our home –show your wisdom to save us

Your home is protected by Embankments and unsafe, but our home is safe if you don't interfere



CLIMATE CHANGE AND ITS IMPACT ON THE FOREST INSECT PESTS



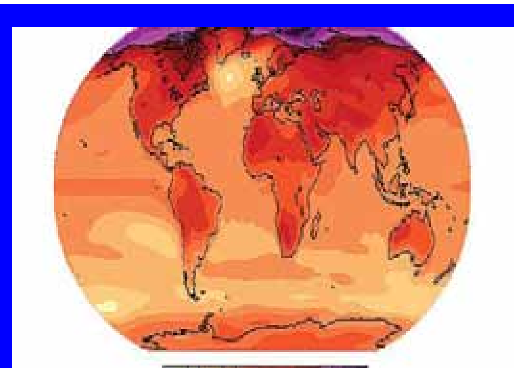
For millions of years trees kept Earth from overheating by absorbing carbon dioxide. Fossil fuels have overwhelmed this natural carbon

cycle.

CO2 capture systems that look like trees? Aren't real trees doing their job?
They do their job. But their job is not to clean up after our CO2 emissions and they are not really designed to do that for two reasons: One is that a tree spends most of its effort converting that CO2 into biomass; the other is that it is biomass which you still have to store.

If you wanted to collect all the CO2 we produce by using biomass growth, which could be trees or corn, you would roughly be talking about using all the agricultural land available

globally



•**Global Warming is defined as the increase of the average temperature on Earth. As the Earth gets hotter, disasters like hurricanes, droughts and floods become more frequent.**

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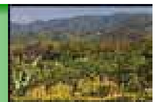


What do forests do?

Forests ---- use solar energy to perform photosynthesis transforming carbon dioxide and water into sugar, which stores the solar energy.

Not just that, they also act as filters of carbon dioxide and reduce the amount of energy or heat the planet radiates into space.

This helps lock the heat on earth. But, when trees are felled or burned, the carbon dioxide they store, escapes back into the air.

As the concentrations of these gases increases, the earth's temperature also goes up, making the planet's surface warmer.

last 100 years,

(the average air temperature near the Earth's surface ha risen by a little less than 1 degree Celsius, or 1.3 degrees Fahrenheit)

↓

Doesn't seem that much, does it?

↓

say scientists –

Yet this warming is responsible for the conspicuous

increase in storms, floods and raging forest fires

we have seen in recent years

↓

Their data show that an increase of one degree Celsius makes the Earth warmer now than it has been

for at least a thousand years.

The top 11 warmest years on record were all in the previous 13 years, said NASA in 2007, and the first half of 2010 has already gone down in history as the hottest ever recorded.

Projections from the

UN climate change body the Intergovernmental Panel on Climate Change (IPCC) say that global surface temperature will probably rise a further

1.1 to 6.4 degrees Celsius (2.0 to 11.5 degrees Fahrenheit) during the 21st century.

Concerns - **Possibility of drought and climate change**

[making the trees more susceptible to an insect that is not native to that habitat, have been expressed by the scientific community].

↓

Under pressure from human encroachment, the planet's forest cover has had to cope with insect invasions too

↓

thanks to the favourable temperature conditions being supported by global climate changes.

↓

Global warming, it appears, has not only increased tree pests' resistance levels, but also led them to thrive and wipe out entire forests in a span of a few months.

vast research [last two decades]

↓

Understand

how these human-induced changes in climate have affected individual species and communities

and

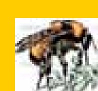
will do in the near future

↓

Consequently, we have started to gain significant evidence of the ecological impacts of current warming on a broad range of organisms with diverse life-history traits and geographical distributions

(reviewed in Hughes 2000, McCarty 2001, Peñuelas & Filella 2001, Walter et al. 2002, Parmesan & Yohe 2003, Root et al. 2003, Badeck et al. 2004, Lovejoy & Hannah 2005, Parmesan 2006).

Insects comprise **54 %** of all known species and occupy every **terrestrial habitat** (Schowalter 2000), so exploring the responses of insects to climate change will provide us with a good understanding of how climate change is affecting biological systems.



Spring comes early for bees

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Why should we expect an effect of climate change on insects?

Insects (groups of organisms)
most likely to be affected by climate change
because climate has a strong direct influence
on their development, reproduction, and survival

↓

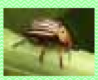
moreover,
have short generation times and high reproductive rates
respond quicker to climate change than long-lived organisms,
such as plants and vertebrates

Warming

[potentially affects several aspects of insect life-cycle and ecology, especially those directly controlled by energy availability variables such as degree day (ac-cumulative temperature needed for development)]

↓

Consequently, potential responses include changes in phenological patterns, changes in habitat selection, and expansion and contraction of geographic and altitudinal ranges



The fossil record provides good evidence
Insects have responded to past changes in climate

[**Beetle** remains clearly illustrate that species shifted their geographic ranges during the Quaternary in response to the glacial/interglacial climatic oscillations (Coope 1995).

Several **carabid species** living today only in the boreal regions of Europe, were present in the British Isles when the ice sheets covered most of northern and central Europe.

Conversely, many dung beetle species restricted today to the south of Europe were living in the British Isles during the thermal maximum of the Last Interglacial, when the climate of Britain was considerably warmer than it is today (Coope 1995).

Species responses are expected to be idiosyncratic depending on the flexibility of different life-history characteristics

Bale et al. (2002) proposed

Different growth rate and diapause requirements may influence **distributional responses to climate change**

Fast growing-
[non-diapausing species or those which are not dependent on low temperature to induce diapause]
will respond to warming by **expanding their distributions**
In contrast

slow growing species
which need low temperatures to induce diapause
(such as boreal and mountain species in the northern hemisphere)
will suffer range contractions

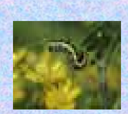
Thus, climate change will affect species ranges, with expansion in some species and contractions in others, which in turn will lead to changes in regional and local diversity

Best documented responses to recent climate change

↓

Phenological changes are probably the best documented responses to recent climate change and have been detected for a wide range of organisms from plants to vertebrates (Root et al. 2003, Root & Hughes 2005)

↓



With **rise in temperature**
will pass through their larval stages faster and will become adults earlier

↓

Thus, observed responses include **both an advance in the timing of adult emergence** and **an increase in the length of the flight period**

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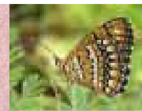
In this regard :



Lepidoptera are by far the best documented group

Changes in butterfly phenology have been reported in the UK (Roy & Sparks 2000), with species advancing their flight periods by around 2–10 days for every 1 °C increase in temperature. This has resulted in an extended flight period, especially for multivoltine species

In Spain butterflies have advanced their first appearance between one and seven weeks in a period of 15 year (Stefanescu et al. 2003)
and

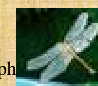
by around eight days per decade in California (Forister & Shapiro 2003)

[In both cases phenological changes were correlated with the amount of warming experienced during the same time period].

Several species of

Microlepidoptera In The Netherlands (Ellis et al. 1997)
and

Odonata in the UK (Hassall et al. 2007)



have also experienced considerable temporal shifts in their ph earlier in the year.

Aphids are another group for which **long term datasets** are available(due no doubt to their agricultural importance as pests)
Early adult emergence and an early arrival of migratory species have been reported in the UK for this group (Zhou et al. 1995, Harrington 2007).

Although evidence for other groups of insects is rare, this is probably due to a lack of data more than to a lack of response

↓

Gordo & Sanz (2005) observed a common phenological response in four unrelated species of insects (a butterfly, a bee, a fly and a beetle)

↓

During the last 50 years all four species showed significant temporal changes in their first appearance date. In all cases their appearance earlier in the year was correlated with the increase in spring temperature observed in the area during the same time period.

Thus phenological responses are likely to be widespread within all groups of insects

↓

especially at higher latitudes and elevations where temperature has increased and is predicted to increase more than in other parts of the world (Houghton et al. 2001)

↓

There are not enough data yet to prove these predic-tions because information on phenological changes from different latitudes (especially southern and tropical areas) and from different altitudes is not available

↓

However, Parmesan (2007) reported a significant increase in the strength of advancement of spring events in the northern hemisphere with increasing latitude, although latitude explained only 4% of overall variation of phenological changes.

Distributional shifts

Climate is an important determinant of geographic range for many species (Andrewartha & Birch 1954)

↓

Consequently warming is expected to force species to shift their distributions by expanding into the new climatic areas and by disappearing from areas that have become climatically unsuitable (Hughes 2000)

↓

Shifts in distributions will occur, in part, by range expansion at the cool, upper altitudinal and latitudinal limits

and

by contractions at the warm, lower altitudinal and latitudinal limits of species' ranges. Numerous cases of recent distributional shifts have been recorded for a variety of taxa from around the world (Pounds et al. 2005, Wilson et al. 2005,

Climate Change

[Increase in mean temperature- Changes in precipitation- Frequency of extreme weather events]

1. **Changes in Phenology-** Early spring occurrence- Extended flight period- Multi-voltinism

2. **Changes in distributions-** Expansions northward and uphill- Southward and downhill contractions

3. **Evolutionary processChanges in Species interactions-** Insect-host plant- Host-parasitoid - Competition- Decoupling of mutualism

4. **Further shifts in distributions**

5. **Extinction of some species**

6. **Changes in Biodiversity and Community composition-** Loss of local and regional diversity-

7. **Progressive dominance of generalist species**

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Climate change can also affect insects in indirect ways, where the insect responds to climate-induced changes mediated by other factors. These other factors may include interaction with other species (competition, predation and parasitism) or for her-bivorous insects, host plant

Finally, warming may affect the structure of existing communities because individual responses will inevi-tably alter species interactions, leading to changes in the composition of natural communities

Climate change
indirectly affect the forest ecosystems through the activity of phytophagous insects

FOR INSECTS
1. increased CO_2 levels in the atmosphere may cause the C/N balance in the plant tissues to shoot up, which results in a lower food quality for many defoliating insects.

2. Some insects respond by increasing the level of leaf consumption and consequently the damage to the tree, whereas others show higher mortality and lower performance.

Temperature rise can also alter the **mechanism** by which the **insects adjust their cycles to the local climate** (diapause), resulting in faster development and higher feeding rate. This has been exhibited by the spruce web-spinning sawfly outbreaks in the Southern Alps

Pest outbreaks can contribute either directly or indirectly to economic and environmental losses and have adverse effects on tree growth.

Insect outbreaks

are **expected to increase in frequency and intensity**

with **projected changes in global climate**

through **direct effects of climate change**

on **insect populations and through disruption of community interactions**

Understanding the effects of rapid climate change on ecosystems and species is an important goal of modern ecological research.

Increased unpredictability and variability in regional climates, particularly with regard to precipitation, should be exceptionally disruptive:

a)models of climate change have predicted greater frequency and duration of droughts in some areas

b)increased periods of high precipitation in others and

c) a widespread increase in the frequency of extreme weather events.

Recent studies of forest insects have linked population outbreaks to phenological changes in insect life histories brought about by global climate change
[Such analyses have predicted increased frequencies of outbreaks and longer durations of outbreaks]

The pests that affect trees in India

Defoliator - *Calopepla leayana* (Chrysomelidae) Gmelina arobrea
Bud shoot feeder - *Dioryctria sp.* (Pyralidae) Pinus sp.
Defoliator - *Hybleaea puera* (Hyblaeidae) Teak
Defoliator - *Eutectona machaeralis* (Pyralidae) Teak
Wood borer - *Hoplocerambyx spinicornis* (Cerambycidae) Shorea robusta
Bud shoot feeder - *Hypsipyla robusta* (Pyralidae) Mahogony
Sap feeder - *Tingis beesoni* (Tingidae) Gmelina arborea
Wood borer - *Xyleutes ceramica* (Cossidae) Teak, Gmelina
Wood borer - *Xystocera festiva* (Cerambycidae) Paraserianthes falcataria
Gall inducer - *Leptocybe invasa* (Eulophidae) Eucalyptus

Subterranienan - *Termites (*Termattidae) Eucalyptus

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In India,

an increase in the destruction of forests has made forest managers analyse and compare the percentages of national forest cover lost to pest and disease problems over a period of time.

GALL INSECT [*Leptocybe invasa*]

Says Dr Manimekalan, an assistant professor at the department of entomology, Bharatiar University, "Various teams have been conducting surveys in Tamil Nadu, Kerala and Andhra Pradesh to assess the damage in nurseries and plantations. Experts have also made field visits to study the damage of eucalyptus plantations in Andhra Pradesh and the gravity of the pest problem."

Galls
first observed in 2004 at Marakkanam, Tamil Nadu.
[The invasive wasp effect has been more severe in eucalyptus plantation and nurseries in Tamil Nadu, Karnataka, Kerala and Andhra Pradesh]

Earlier it was an insect of South India
ICFRE INSTITUTES - The Institute of Forest Genetics and Tree Breeding and Tropical Forest Research Institute has been doing extensive research in this area and has reported the presence of gall-making insects in eucalyptus and alerted various state forest departments, forest corporations, wood-based industries and farmers.

But Recently
this insect has migrated to North India also
and work has been taken on warfooting in Forest Research Institute also.

Scientists are of the opinion

Natural forests usually have their own control mechanisms to fight such infestations. "In natural forest, the pest effect is not much because nature takes care of the insects. It is the plantation areas that bear the brunt," says Dr Manimekalan.

But some feel

Greenhouse gas emissions, especially from smokestacks, vehicles and burning forests, contribute to global warming in a big way. So, blaming insects for deforestation is rather unfair. Vouching for this theory is Dr Mohammed Shafi.

"Scientists believe that
insects and pests are not the real culprits, they cannot be blamed needlessly. Compared to the enormous destruction mankind causes to the ecosystem, their contribution is negligible. These poor insects are blamed unnecessarily, when it is the global emissions that have caused warmer planets."

Death of trees
severely disrupts the forest ecosystem
and causes catastrophic losses as well.

Insects and Diseases are integral components of forests

outbreaks can have adverse effects on the growth of trees and their survival and also affect global temperatures in the long run, in addition to hitting the food chain.

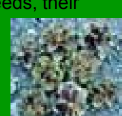
kinds of problems by insects and diseases, often interlinked, have changed rapidly in recent years.

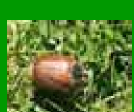
The main concern across the globe is the larvae from insects, which though native to one country, have now invaded forests across the globe following the change in temperatures, which helps them multiply.

The trees bleed sap and eventually die.

Most dangerous insects are defoliators
(needle-gnawing and leaves-gnawing) category.

Coniferous forests are most sensitive to attacks from needle-gnawing insects. Pests of cones, fruits and seeds are also a threat to forest seed plantations, since they decrease the yield, quality of seeds, their germinating capacity and energy.

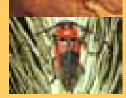




Of the pests in young forests and nurseries, the most dangerous are two species of cockchafers (Family Scarabaediae) – east (Melolontha hipocastani) and west (M melolontha).

The cockchafers have been disastrous for forests

Insect pell-mell



1. The tiny bark beetle- that has decimated millions of acres of pine forest from British Columbia down to New Mexico is considered to be the largest insect infestation in North American history.

2. **The cerambycid beetles** - also transmit nematodes, fungi and other pathogens can kill the host trees. They are also likely to transmit pitch canker and other fungal diseases. The tunnels made by cerambycid larvae destroy the vascular tissues of the tree, killing the entire tree.

3. In the US, **the beetles** target the maples, horsechestnuts, black locusts, elms, birches, willows and poplars. They have infested thousands of trees in New York and Chicago. To eliminate the beetle, cutting of infested trees and destroying them are the only effective means.

According to FAO figures, 13 million hectares of forests worldwide are lost every year, almost entirely in the tropics. Deforestation remains high in Africa, Latin America and Southeast Asia.

In Asia, the Siberian eggar (Dendrolimus sibiricus superans) envelopes large areas and

causes high level of mortality of dark coniferous species

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Challenges of Joint Forest Management and Green India Mission

Dr Dharmendra Verma, IFS

Green India Mission (GIM)

- One of the Eight Missions under National Action Plan on Climate Change (NAPCC)
- GIM Aims to achieve:-
  - 43 million tonnes of CO_2 sequestration annually
  - Eco restoration of 10 m ha of forests in 10 years (5 m ha within forest estate and 5 m ha outside the forest estate)
  - enhance forest based livelihoods of 3 million households dependent on forests
  - Forest Department- Local communities
    - Co-management (JFM)
  - Outlay Rs 46,000 Crore for 10 years

Forest Management in India

- **Strong institutional support mechanism**
  - Strong policy framework
    - NFP, 1988
  - Strong legislative mechanism
    - IFA, 1927, Wildlife Act, 1972, FCA, 1980
  - Strong planning base
    - Five Year Plans, State Planning, NFAP
  - Strong organisational structure
    - MoEF, SFDs, FDCs
  - Specialised Institutional base
    - Research Orgainsations
      - ICFRE, SFRI
    - Training Organisations
      - IGNFA, DFE

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Challenges of Forest Management in India

- Increase of forest cover to 33% of GA
  - Not achieved though gain are being made
    - Best case scenario predicts forest cover from 23% in 1997 to 26.6% by 2020
    - Business as usual predicts it at 23.9% by 2020
    - Perhaps a need to revisit the same in view of land availability in the productive zone
  - World forest cover average 30%

Per capita forest, India =0.07 ha, World= 0.64 ha

- Increase of forest stocking
  - Stocking remain low (78/58 m^3 per ha) as compared with world average (131 m^3 per ha)
  - Productivity remain low (0.7 m^3 per ha per year) as compared with world average (2.1 m^3 per ha per year)

Challenges of Forest Management in India

- Forest Product Supply: Bridging the Gap
  - Timber availability (Base yr 2004)
    - demand rising, currently about 74 m m^3
    - supply stagnant at 40 m m^3 — Gap about 34 m m^3
    - Gap met through imports, — Causing unrecorded removals
  - Fuelwood availability (Base yr 2006)
    - 40% of energy needs met from forests
    - Demand rising, currently about 270 m tonnes
    - Supply stagnant, about 102 m tonnes — Gap about 170 m tonnes
    - Gap met through unauthorized removal. — Causing forest degradation
  - Fodder availability (Base yr 2002)
    - 30% of fodder needs met from forest
    - 270 million cattle grazing in forests

Demand	1337 m tonne
supply	972 m tonne
Gap	365 m tonne

Causing forest degradation

Challenges of Forest Management in India

- Forest Product Supply: Meeting the Gap
  - Non Timber Forest Product
    - Providing employment to millions
    - contributes up to 30% of income of forest dependent communities
    - 75% of foreign forest export revenue
    - Total contribution = 27 billion US $ equivalent
    - Supply deteriorating
      - No authentic data available
      - forest management still not tuned to increase NTFP supply
      - decrease in supply is reflection of natural forest degradation

Challenges of Forest Management in India

- Protection of Wildlife
  - Protected area increased to about 5% of GA
  - Yet, key carnivores threatened [Tigers only 1300!]
  - Herbivores multiplying beyond carrying capacity [damaging agricultural crops]
- Protection of ecosystems
  - Ecosystems remain under stress
    - fragile and sensitive areas under management improving (mangroves, Doon valley)
    - Development interventions mainly to blame
      - Mining, submergence due to river valley projects
      - However, diversion of forestland reduced

Opportunities of Forest Management in India

- Afforestation: Raising man made forests
  - 32.6 million hectares planted by 2000
    - 45% of the area planted by fast growing species
    - 8% teak, 10% pines and conifers, rest misc
    - 8 million hectares in private, communal and non forestland
  - 50% of plantations since 1980 are in agro-forestry environment
  - Annual planting rate 1.51 m ha during 1990-2000
  - Private planting exceeding public planting
    - 0.56 m ha rubber plantations

Opportunities of Co-Management in India

- Substantial forest area under co-management
  - 106,000 JFMCs working in the country
  - Covering about 22 million ha of forestland
    - (about one-third of total forest cover)
  - democratization of government functions
  - Rural infrastructure and employment increased
  - Large scale assets created under FDA-JFMC mechanism
  - About Rs 2000 crore invested through FDA mechanism since 2002
- JFM has contributed towards Empowerment of local communities
  - Although linkage of JFM with PRI needs clarity

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Challenges of integrating JFM and GIM

- Enhance forest productivity
  - Meeting timber, fuelwood, NTFP requirements
- Increase stocking of forests
  - Increase carbon sink
- Biodiversity conservation in natural forests
  - To act as reservoir of gene pool and meet diverse local needs
- Ecological functions of forests
  - Management of water and soil regime, nutrient recycling
- Meeting local needs
  - Forest products, employment and poverty alleviation initiatives
- Decentralised forest management
  - Next generational issues of JFM need to be addressed. E.g., benefit sharing, capacity building, leadership, institutional sustainability, linkage with development schemes like MNREGA
- Forest leadership to address challenges of the sector

Conclusion: Way Forward

- Priortisation of forest management objectives by suitable mix of:-
  - Production Forestry
  - Conservation Forestry
  - Rural Development Forestry
- Management process from command and control to participatory
- Forest planning to be strategic and landscape based
- Modernise and innovate in management procedure, silviculture, technologies, and research
- Skill upgradation of forestry personnel and JFMC
- Introduce pluralism in forestry personnel with functional specialisation
- Forestry extension on a large scale
  - Area, people, technology

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Silvicultural Challenges and Opportunities for Green India Mission

Dinesh Kumar and Anita Tomar[1]

Forest Research Institute, Dehradun

[1]Centre for Social Forestry and Eco-Rehabilitation, Allahabad

Green India Mission

Some key points

- Quality improvement of 5 million ha forest area and creation of additional 5 million ha tree/forest cover
- Departure from traditional afforestation programmes of the past
- Achieving 50-60 million tonne annual carbon sequestration requires use of fast-growing species

Challenges

- Difficult choice of species for underplanting/ gap filling
  - Light intensity available in stand
    - Species
    - Age or tree size
    - Density
  - Tolerance to shade
  - Allelopathy
  - Growth rate
  - Utility

Inadequate experience of researchers and managers in mixed planting

Underplanting and planting in mixture would require very careful selection of species.

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- It is often seen that involvement of locals in plantation planning is limited only upto deciding ***what species*** should be planted, the bigger issue of ***how many plants of each species*** should be planted, is largely decided by officials of implementing agencies alone depending upon their convenience.

- Inadequate availability of planting material
  - Availability of seed and cuttings, especially superior material (tree, shrubs, herbs)
  - Techniques for nursery, planting and aftercare of several species
- Inadequate trained manpower

What Should Be Done?

- Difficult choice of species for underplanting/ gap filling ?
  Can be worked out with field surveys
- Inadequate availability of planting material?
  Ask researchers for species-specific information/solution
- Planting operation
  - Demarcation of smallest unit of land (area with one labourer) on ground with GPS reading for better monitoring and incentives to better performers
    - Use of rectangular/square plots as far as possible
  - Payment on basis of numbers planted (rather than manday)
    - Pre-planting inventorisation of seedlings
    - Post-planting inventorisation

- Training of workers at ground level as well as supervisors
  - Prefer local youth; provide basic training and some exposure
- Transparency in execution of all activities to face any audit or RTI query.
  - Unique ID, PAN Number, voter ID, etc.
  - Data must be fully computerised.
  - Modern means of communication: Website, email, SMS; all potential workers must easily get information about jobs in forestry activities regularly *irrespective of their nearness to forest officials*.

- Avoiding contractors or middlemen
- People's estimate - Demystification of the technical detailed estimate. Apart from technical part, there must be simple estimate for layman to ensure transparency and accountability.
- Work identified and approved by village institutions.
- All works sanctioned with physical/technical/financial details in public domain (notice boards/web).
- Preventing bogus records and payment of wages below prescribed levels
- Social audit as well as independent verification and monitoring by external agencies at various steps of implementation of activities
- Lessons from similar programmes e.g. MNREGA, JFM etc must be put to use

- Research support must be provided to the Mission's execution on priority
  – Immediate research solutions
  – Long-term studies

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Going Green Computing - An ecological perspective to reduce carbon footprint in forestry organizations

R.VIVEKANANDAN
IFGTB, COIMBATORE

Green IT

- Green IT refers to environmentally sound IT, and is the study and practice of designing, manufacturing, using, and disposing of computers, efficiently and effectively with minimal or no impact on the environment (Murugesan2008).

Information Technology Ecosystem

- Similar to Biological ecosystems, Information technology (IT) has evolved its own "ecosystem," in which the output of one component serves as the input of another component.
- IT Ecosystem (ITE): Computers System Hardware, Telecommunications/Networks, Embedded Systems, and the Software which makes them all work.

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Information Technology Ecosystem

- Computers System Hardware: Desktops, Laptops, Net books, Tablet PC, Ipad, Servers, Data centre, Cloud environment, storage resources, printers, scanners, photocopiers, phone handsets, other electronic office equipment and Gadgets.
- Telecommunications/ Networks (Routers, Switches, hubs, cables, antennae, satellites etc.)
- Embedded Systems (vehicle components, electronic pace-makers, DVD players, digital televisions, smart phones, robots)
- The Software (Operating system, Microsoft office, Adobe Acrobat, Database Management Systems etc, and even all "apps" for smart phones)

- According to the International Energy Agency (IEA), Information Communications Technology (ICT) equipment accounted for 4 per cent of total global electricity consumption in 2008, a figure expected to rise to 40 per cent by 2030.
- McKinsey reports that ITE's —including laptops and PCs, data centers and computing networks, mobile phones and telecommunications networks—could be among the biggest greenhouse gas emitters by 2020.

(Agatha Gilmore)

- Gartner(2009) "Global IT spending in 2010 will be about $3 trillion and its effect on the Earth's environment can be potentially very significant because IT is the enhancer of many human activities, which can be detrimental to the environment."
- A recent report by UNEP states that e-waste increases by about 40 million tons every year, and also states that consumption of natural resources such as gold, silver, and palladium are also increasing rapidly due to ever increasing production of mobile phones and computers.

(Santosh S. Venkatraman)

- The number of computers in use globally is set to hit four billion by 2020.
- IT accounts for approximately two per cent of global carbon dioxide emissions and this is set to rise to three per cent by 2020, according to the Global e-Sustainability Initiative (GeSi), a group representing the UN Environment Programme, the International Telecommunications Union and several leading global companies.
- IT-related CO_2 emissions doubled between 2002 and 2007 and are expected to triple by 2020.

Green strategies

- Reducing carbon emissions from large data centres by Optimization of energy consumption.
- Server and storage virtualization
- Using alternative energy resources
- Procurement of environmentally friendly ITE Components (PCs and servers, networking,embeded systems etc.)
- PC power management
- Leveraging on technologies like telecommuting and telepresence

Green strategies

- Increasing video conferencing to reduce travelling
- Responsible management of e-waste, businesses to reduce carbon footprint.
- Global position systems, radio frequency identification, Web services, unified communications, next-generation broadband, wireless, smart urban infrastructures, and other new integration technologies make it possible for organizations to become eco-friendly. (V.C Gopalratnam)

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Eco-friendly green computing strategies

- Turning off computers and machines when not in use
- Use of Thin clients to reduce power usage and lower emissions (Thin-client terminals consume from 6W to 50W — much less than the 150W to 350W used by PCs).
- Use of 100 percent post-consumer waste paper (PCW)
- Reduce printing costs viz. Print double sides as standard procedure, get rid of color printers
- Reducing wastage of consumables
- Minimize non-recyclable waste and eliminate toxic waste, enabling active power management

Data centres

- Data centers consumed 330 Billion kWh in 2007, are projected to consume 1,012 Billion kWh by 2020, expected to increase three times in 13 years. (GreenPeace 2010)
- Average capacity utilization is 12%-15% in working hours
- 33%-40% power used is wasted
- Cooling costs are very high

Virtualization

- Virtualization or server consolidation is perhaps the most popular way of significantly reducing the number of underutilized servers in a data centre.
- Energy conservation, improved performance and reduced cooling costs are benefits virtualization and consolidation

(DENNIS McCAFFERTY, The growing appetite for virtualization, BASELINE , JAN/FEB 2009)

- Server virtualization allows a single physical server to be "logically" split using software into "several independent computers," each capable of running its own operating system, and application server software.
- (Santosh S. Venkatraman)

Virtualization

- Servers once consolidated and virtualized efficiently, can run at utilization rates that approach 85% or greater (Wendt 2010).
- Intel (intel.com) and AMD (amd.com) have built-in virtualization capabilities in their chip sets that enhance virtualization software.
- Virtualization/consolidation tools available from companies such as VMware, HP and Dell

Cloud computing

- Cloud computing is an Internet-based technology initiated by Amazon, Google and others that allow clients to develop and run software as a suite of technology and pay based on their usage of software without investing heavily on data centre, big servers, storage systems etc
- Wipro's Cloudwise "Enables organizations to formulate the right cloud strategy and implement it within six to eight weeks.

- The total CO_2 emissions from the global cloud were estimated to be about 820 million tons in 2007, and are projected to rise sharply to 1430 million tons by 2020

(Green Peace 2010).

- Nevertheless, it is likely better for the environment if several clients use an efficient cloud data centre instead of inefficient independent data centres.

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Conclusion

- Information technology is clearly very advantageous for humans, and helps us accomplish many activities more effectively and efficiently.
- IT, if used without consideration of the environment, however, can result in devastating consequences to the very natural systems that support life on this wonderful planet.
- Solutions such as virtualization, cloud computing, better and more efficient cooling practices in data centres, policy changes in organization, environment friendly government regulations will contribute to minimizing the environmental damage due to the fast growing global demand for IT.

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Carbon Sequestration Potential of Biomass under different agroforestry land use systems in Poanta area of Himachal Pradesh

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Indian Forestry Congress 2011
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INTRODUCTION

❖Global climate change, caused by increased emission of greenhouse gases (GHGs) is likely to affect the agro ecosystems.

❖ In agroforestry systems carbon sequestration is a dynamic process and can be divided into phases. At establishment, many systems are likely to be source of GHGs.

❖These follow a quick accumulation phase and a maturation period when tonnes of carbon are stored in boles, stems, and roots of trees and in soils.

❖ At the end of rotation period, when the trees are harvested and land returned to cropping (sequential systems), part of carbon will be released back to atmosphere (Dixon, 1995).

❖ In case of simultaneous systems like hedgerow inter-cropping, silvi-pasture systems and agri-silviculture systems fate of carbon will be different.

❖ Therefore, effective sequestration can only be considered if there is a positive net carbon balance from an initial stock after a few decades (Feller et al., 2001).

Study Area

The present investigation was conducted during January-June 2007. Poanta valley is located at an elevation of 350 m asml. It is on the western extreme of the Doon Valley distance of about 55 km from Dehradun.

Locality factors of the study area

Latitude	30^0 26' N
Longitude	77^0 37' E
Altitude	1276 (feet), 388 (m)
MAT	21.3^0C
MAP	1250 mm
Soil type	Brown hills & alluvial group
Texture	coarse

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Material and Methods

Six agroforestry systems were selected viz.

Agroforestry system type	Code	Tree crop combination	Net cropped area m²	Area under trees m²	Area under grasses m²	No. of trees/ hectare	Age of the land use system
Hortipastoral	HP	Mango+ Litchi + natural grasses	-	1000	9000	100	12
Silvi-pastoral	SP	Dalbergia+ natural grasses	-	1300	8700	400	12
Agri-silviculture	AS	Sal + wheat	9000	1000	-	60	12
Horti-silvi-pastoral	HSP	Mango+ Litchi+poplar+Natural grasses	-	1400	8600	144	12
Pure forest	PF	Sal	-	10000	-	200	40
Natural grassland	NG	-	-	-	10000	-	-

Stem biomass

To estimate stem biomass of all the trees falling in the plot (10 x 10 m) were enumerated. The diameter at breast height was measured with caliper and height with Ravi's multimeter. Form factor was calculated with Spiegel Relaskope to find out the tree volume using the formula given by (Pressler, 1865; Bitlerlich, 1984). Volume was calculated by Pressler formula(1865) $v = f \times h \times g$

$(f = 2h_1 / 3h)$

Where; f - Form factor

h_1 – height at which diameter is half of dbh

h- Total height

Specific gravity

The stem cores were taken to find out specific gravity which was used further to determine the biomass of the stem using maximum moisture method (Smith, 1954)

$$G_f = \frac{1}{\frac{M_n - M_o}{M_o} + \frac{1}{G_{so}}}$$

Where,

G_f specific gravity based on gross volume

M_n weight of saturated volume sample

M_o weight of oven dried sample

G_{so} average density of wood substances equal to 1.53

Branch Biomass

Total numbers of branches irrespective of size were counted on each of the sample tree, then these branches were categorized on the basis of basal diameter into three groups viz < 6 cm, 6-10 cm, and > 10 cm. Fresh weight of two sampled branches from each group was recorded separately. The following formula (Chidumaya, 1990) was used to determine the dry weight of branches:

$$B_{dwi} = B_{fwi}/1 + M_{cbdi}$$

Where B_{dwi} - oven dry weight of branch, B_{fwi}- fresh/green weight of branches, M_{cbdi}- moisture content of branch on dry weight basis

Total branch biomass (fresh/dry) per sample tree was determined as given by:

$$B_{bt} = n_1 bw_1 + n_2 bw_2 + n_3 bw_3 = \sum_{i=1}^{n} n_i bwi$$

Where B_{bt} – branch biomass (fresh/dry) per tree, N_i- number of branches in the i th branch group, Bwi-average weight of branch of i th group, i = 1, 2, 3, average refers to branch group

Leaf biomass

Leaves from the branches were removed, weighed and oven dried separately to a constant weigh at 80 ± 5⁰C (Chidumaya, 1990).

Tree biomass

The total tree biomass was the sum of stem biomass, branch biomass and leaf biomass. The tree biomass was converted into carbon by a factor of 0.45 (Woomer, 1999).

Crop, Grass and Underground Biomass

•Crop biomass was estimated using 1 m x 1m quadrates. All the crop plants occurring within the borders of the quadrant were cut at ground level and collected samples were weighted, sub sampled and oven dried at 65 ± 5⁰C to a constant weight.

•The crop biomass was converted into carbon by multiplying with a factor of 0.45 (Woomer, 1999). Grass biomass was estimated using 1m x 1m quadrates. The total grass biomass occurring within the borders of the quadrat were cut at ground level and collected samples were weighed, sub sampled and oven dried at 65 ± 5⁰C to a constant weight.

•Underground biomass of roots was calculated by multiplying the above ground biomass by a factor of 0.26.(Cairns et al, 1997)

•The data obtained were subjected to statistical analysis using RBD of experimentation as per the procedure suggested by (Gomez and Gomez 1984). Wherever, the effects exhibited significance at 5 per cent level of probability, the critical difference (CD) was calculated. .

Results

Biomass production levels of different land use systems (tonnes/ha).

Systems \ Biomass	Above ground biomass (Tonnes ha⁻¹)	Below ground biomass (Tonnes ha⁻¹)	Total biomass (Tonnes ha⁻¹)	Rate of biomass production (Tonnes ha⁻¹yr⁻¹)
Hortipastoral system (HP)	15.26	5.37	20.63	2.06
Silvipastoral system (SP)	32.72	11.50	44.22	3.68
Agrisiliviculture system AS)	34.05	11.97	46.02	3.83
Hortisilvipastoral system HSP)	18.20	6.40	24.60	2.46
Pure forest (F)	134.18	47.16	181.34	4.53
Natural grassland (NG)	3.44	1.03	4.47	4.43
SE ±	5.97	2.0	5.95	
$CD_{0.05}$	13.31	4.45	13.26	

The data presented in table evinced that the maximum above ground biomass (134.18 tonnes ha⁻¹) was produced by pure forest (Sal) which was found to be significantly higher than the all other land use systems.

Carbon stock under different land use systems (Tonnes ha⁻¹)

Land use systems	Above ground carbon (Tonnes ha⁻¹)	Below ground carbon (Tonnes ha⁻¹)	Total carbon (Tonnes ha⁻¹)
Hortipastoral system (HP)	6.86	2.41	9.28
Silvipastoral system (SP)	14.72	5.17	19.89
Agrisilviculture system (AS)	15.32	5.38	20.70
Hortisilvipastoral system (HSP)	8.19	2.88	11.07
Pure forest (F)	60.38	21.22	81.60
Natural grassland (NG)	1.54	0.46	2.01
SE ±	0.02	2.69	2.67
CD0.05	0.03	5.99	5.96

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CO_2 mitigation levels of different land use systems (Tonnes ha^{-1})

Land use systems	CO_2 mitigation levels		Total
	Above ground	Below ground)	
Hortipastoral system (HP)	25.03	8.79	33.87
Silvipastoral system (SP)	53.7	18.87	72.59
Agrisiliviculture system (AS)	55.91	19.63	75.55
Hortisilvipastoral system (HSP)	29.89	10.51	40.40
Pure forest (F)	220.38	77.44	297.84
Natural grassland (NG)	5.621	1.67	7.34
SE ±	5.45	3.10	5.30
$CD_{0.05}$	12.13	6.90	12.0

Biomass carbon stocks and carbon mitigation potential

•The biomass carbon stock in a particular land use system depends upon it age, structure, functional components and the management. As revealed in table, the carbon stored under Pure forest was found to be highest, which is due to the more age of this land use system. Among the four agroforestry system under the present study the Agrisilviculture system stored highest quantity of carbon followed by silvipastoral, Hortisilvipastoral and Hortipastoral system.

•The carbon storage capacity of natural grassland was least. This is because in natural grassland the biomass in removed from the system every year leaving only the biomass in the underground parts (roots), which has got limited storage capacity. The carbon mitigation potential of different land uses as shown in table followed the same trend as that of carbon stocks.

•It is deduced from the above discussion that variability in the carbon stocks of different land use system types depends primarily on its complexity. (Albrecht & Kandji, 2003) have also reported that carbon variability in plant biomass can be high within complex agroforestry systems and productivity depends on several factors including the age, the structure and the way system in managed.

Conclusions

•The results obtained revealed the biomass production level both below and above ground was highest (181.34 tonnes ha^{-1}) in Pure forest system whereas minimum (4.47 tonnes ha^{-1}) in natural grassland.

•Agrisilviculture system produced the second highest biomass level among the different systems despite having less number of trees (60 tonnes ha^{-1}) over silvi-pastoral system which contained 400 numbers of trees per hectare.

•The CO2 mitigation was highest in pure forest system (297.84 tonnes ha^{-1}) followed by Agri-silviculture system, Silvipastoral system, Horti-silvipastoral, Hortipastoral, Natural grassland. The minimum value was in natural grassland system.

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A STUDY ON GROWTH PERFORMANCE OF SELECTED TREE SPECIES IN VERMICOMPOSTED COAL MINE SOILS IN JHARKHAND, INDIA

Dr. M.V. Durai

Institute of Forest Productivity

Ranchi (Jharkhand)

Email: duraimv@gmail.com

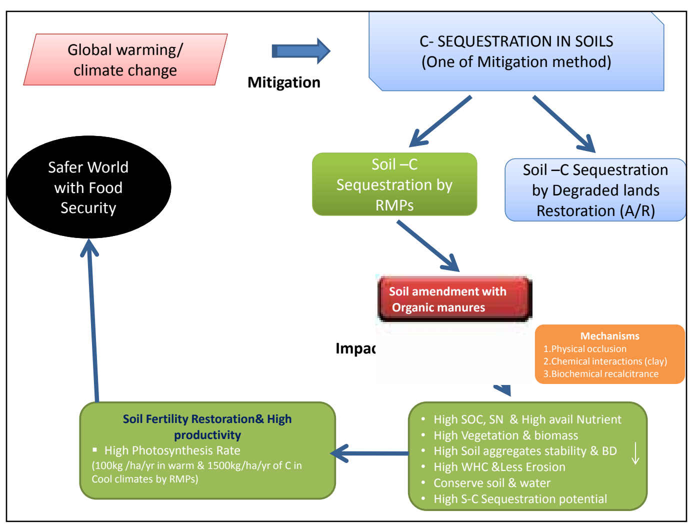
4ha destroyed for 1tonne coal (Ghosh 1990)

Coal industry accounts 1400ha unproductive land/yr in 2000 in India

Overburden means:

- **Un-weathered bed rock – mostly boulders**
- **Physico- chemical & biological properties not support vegetation**
- **Acidic (pH <5.2), Nutrient far below from optimum level, No microbes, high bulk density, for low OC & N**
- **Extensive area – unmanageable land.**

= "biologically dead soil"



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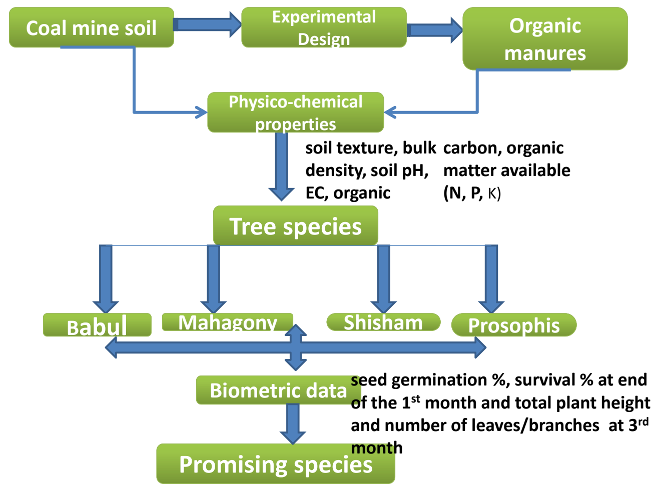


METHODOLOGY

(1). Control	(Tc)
(2) Mined soil 150kg + Sand (7.5kg) + VC 7.5kg	(T1)
(3). Mined soil 150kg + Sand (15kg) + VC 15kg,	(T2)
(4). Mined soil 150kg + Sand (22.5kg) + VC 22.5kg	(T3)
(5) Mined soil 150kg + Sand (30kg) + VC 30kg	(T4)
(6) Mined soil 150kg + Sand (7.5kg) + VL 15 litre	(T5)
(7) Mined soil 150kg + Sand (15) + VL 22.5 litre	(T6)
(8) Mined soil 150kg + Sand (22.5kg) + VL 30 litre.	(T7)

At the end of 1st month

At the end of 3rd month

PLATE SHOWING THE GROWTH RESPONSES OF SELECTED SPECIES IN DIFFEERENT TREATMENT

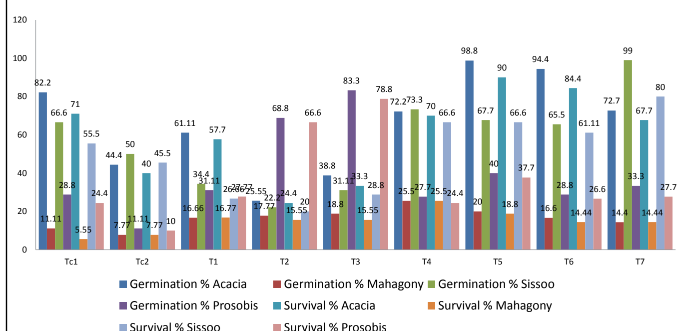
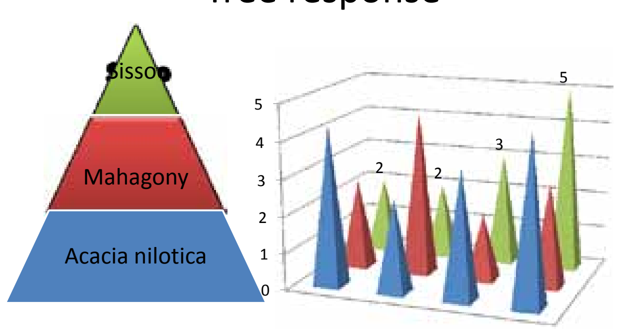


Fig –3 Species response on coal mine –organic manure treated soils

Tree response



Changes in bulk density after 3-months

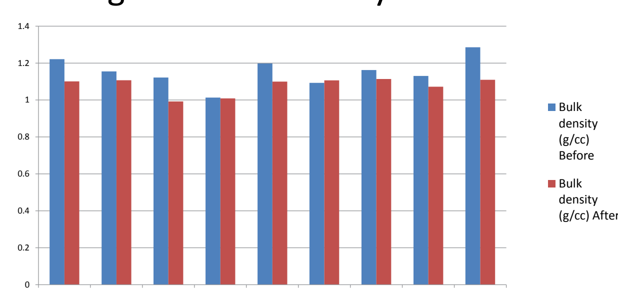


Fig - 1 Bulk density of coal mine – organic manure treated soils
Before: Freshly vermicomposted soil;
After: 3-month old vermicomposted soil

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Changes in pH, OC & OM after 3-months

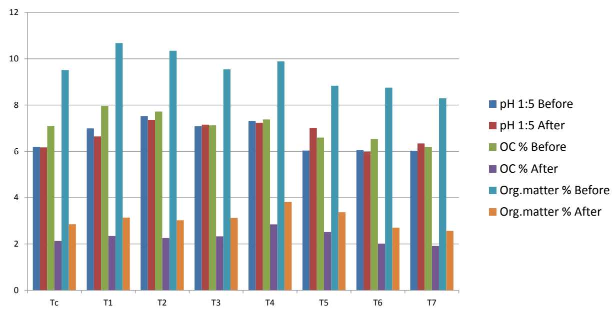

Fig – 2. Chemical properties of coal mine – organic manure treated soils
Before: Freshly vermicompost soil,
After: 3-month old vermicompost soil.

Conclusion

- ❖ **Babul is most promising tree species for mine lands**
- ❖ **Incorporation of sand in mine soil reduce bulk density, increase porosity & WHC**
- ❖ **But unexpected changes in chemical properties with vemicompost – need through deep research to confirm its behaviour.**

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A Cost effective strategy for forestry based climate change mitigation in India: CDM program of Activities with TOF.

PP Bhojvaid, IFS and Promode Kant

Forests are both source and sink

- Source
  - Deforestation
  - Fire and degradation
  - Around 15% warming is attributed to these
- Sink
  - Photosynthesis
  - Biomass assimilation

India's forests and CC

- Different GC models have been used in IPCC report
- Significant effect on forests
- Both structure and function
- By 2085 70% forest grids are likely to shift
- May affect NPP of Forests
- Forest planning and policies should take account of this

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India's forests and CC:ICFRE report 2009

- 135.15 million tons of CO^2e yr^{-1}
- This can neutralize 9.31 of countries emission at 2000 level
- Even if sequestration remains stagnant at this level
- Forests will offset 6.53% and 4.87 % of projected increased emissions

Paradigm Shift: Focused Management

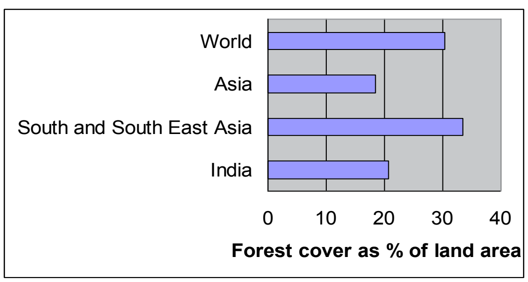
•Payment of environmental Services: Geographic Dimension of Growth and Development

- •Variation in Development: VP
- •Smart Payments : JS

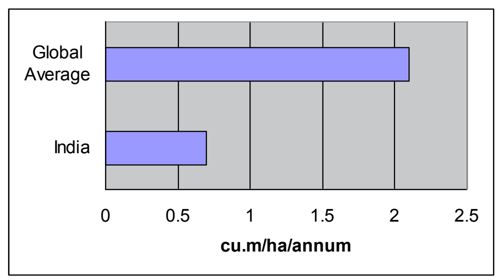
•Climate change and Forests: Opportunities and challenges

- •Adaptation and mitigation: drought and productivity
- •Low volume High Value tropical Crops (MP)
- •Smart subsidies for agro/farm forests..sequestration
- •Afforestation and reforestation

Comparative Figures for Forest cover



Forest Productivity



Haryana

	Classified	TOF	Total
Area (Km²)	1517 (1558)*	1415	2932
% of TGA	3. 43	3. 20	6. 63
Growing Stock million M³	2. 37	15. 36	17. 33
Per ha Growing Stock M³	15. 3	108. 5	62. 5

Trees per ha CNFA = 12.3 Total Tree= 50 million

Area TOF > 1 ha block = 834 KM²

Based on SFR 2003,

Haryana Analysis

- Classified Forests
  - Main species, Eucalyptus, Acacias, Dulbergia and Misc.
  - Rotation 15-50 years
  - Average 30 yrs
  - MAI 0.5 M^3 Yr^{-1}
  - Most planting by seedlings of seed origin
  - Large scope for improvement

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Haryana TOF

- Most plantations under AF
- QGS poplars and Eucalyptus
- Good fertile soils, Better protection
- Ensured irrigation and fertilization?
  - Rotation 5-10 years
  - Average 7 yrs
  - MAI 15-18 M^3 Yr^{-1}
- Still major planting stock from seeds

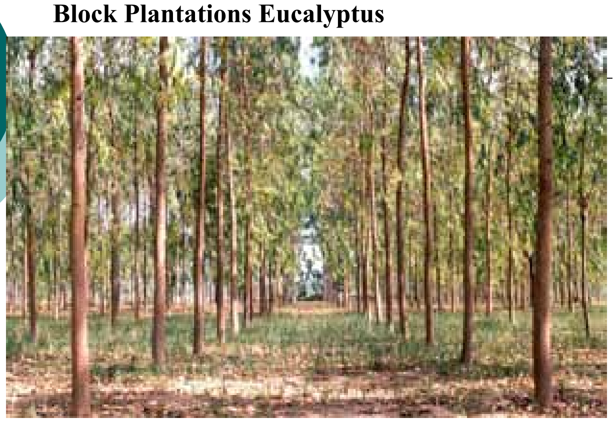
Haryana TOF

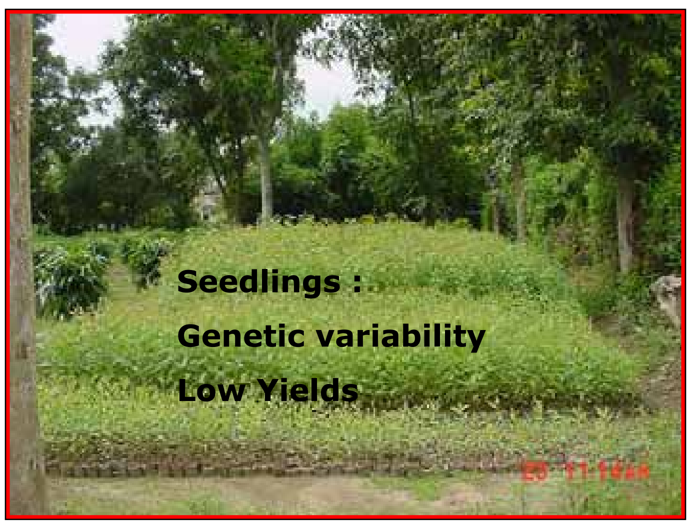
- Most plantations under AF
- QGS poplars and Eucalyptus
- Good fertile soils, Better protection
- Ensured irrigation and fertilization?
  - Rotation 5-10 years
  - Average 7 yrs
  - MAI 15-18 M^3 Yr^{-1}
- Still major planting stock from seeds

PUNJAB	Classified Forests	TOF	Total
Tree cover (Km^2)	1580	1608	3188
% of Total Geographical Area	3.14	3.19	6.33
Growing Stock million M^3	11.08	17.90	28.98
Per ha Growing Stock M^3	35.20	110.70	-
Rotation age of tree species (years)	35	7	-
Mean annual increment M^3 ha^{-1} $Year^{-1}$	1.1	15.81	-

UP	Classified Forests	TOF	Total
Tree cover (Km^2)	14118	7715	21833
% of Total Geographical Area	5.86	3.20	9.06
Growing Stock million M^3	164	88	252
Per ha Growing Stock M^3	99	114	-
Rotation age of tree species (years)	80	27	-
Mean annual increment M^3 ha^{-1} $Year^{-1}$	1.2	4-5	-

Block Plantations Eucalyptus





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Five-year-old *Eucalyptus* forest productivity 40 m^3 / ha / year

Enhacement of Eucalyptus Productivity

The MAI realized under Agroforestry for species such as Poplar and Eucalyptus

- Poplar 10 -25 m^3 ha^{-1} year^{-1} (Haryana and UP)
- Eucalyptus 8-14 m^3 ha^{-1} year^{-1} (Haryana)
- ITC Clonal Eucalyptus 35 m^3 ha^{-1} year^{-1} (AP)
- ITC Clonal Eucalyptus 22 m^3 ha^{-1} year^{-1} (Haryana, under trial)

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Contemporary Agroforestry in Haryana

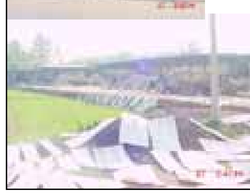
- 20 million seedling year^{-1}
- 20,000 ha year^{-1}
- Eucalyptus and Poplar
- Quality planting stock
- Private Nurseries

Wood Based Industries

- Research and development
- Establishment of industries
- In state value addition

Agroforests & Industries

•1.6 million m^3
•Enabling environment
•Adequate Infrastructure



•600 plywood units
•Purchase 1 million US$ day^{-1}
•Value added 3 million US$ day-1
•60000 man days day-1
•2.5 million $US as tax month^{-1}

Other Environmental Benefits

- CO_2 sequestration
- Increase in tree cover (8%)
- Alleviation of pressure from Natural Forests: hence a case for REDD+
- Biodiversity conservation

Poplar with *Asparagus recemosa*

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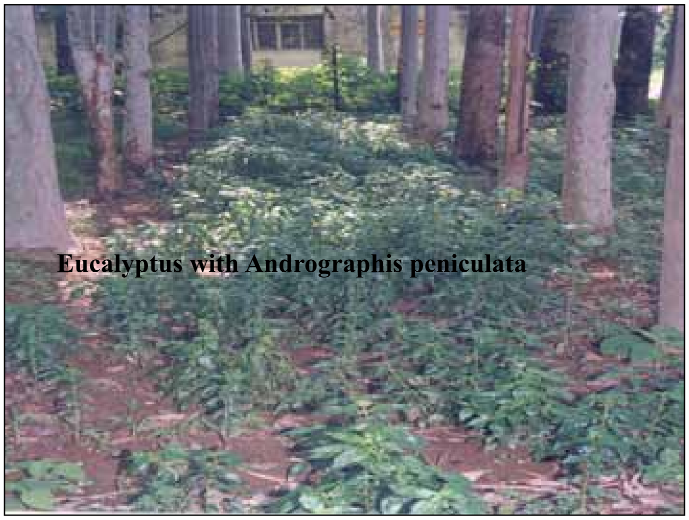

Lessons learnt from Haryana

- Changes in rainfall pattern
- Late arrival of Monsoon
- Number of rainy days
- Results into too much and too less
- Mortality of new saplings
- Loss of time and money
- Wasted efforts

Base line scenario: the usual landscape

Lessons continued

Change in patterns

1. Earth work
2. Planting time

Out of Box thinking

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Improvisation in interventions

Optimization of landuse

Plantations created in April put on incremental growth

Higher success

Five year old plantation

Adaptation of model by farmers

Other crop same model

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Common landscape: TOF

Low volume high value crops

Innovative models

Way Ahead

- Forest policy: 33% tree cover &Increased productivity
- State Forests : difficult degraded
  - Cost per tree 80-100 INR
  - MAI 2-4 m^3
- Agroforestry: good fertile lands
  - Cost per tree: 10-20 INR
  - MAI 12-40 m^3

Factors contributing to the success story

- Role of FD
- Infrastructure
- Innovations
- Technology
- Legal policy regime
- People
- Private sector

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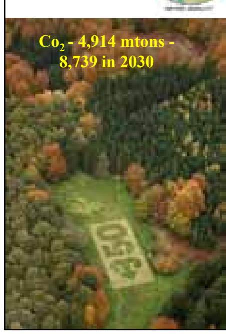
Impact of insect disturbance on forest carbon sequestration

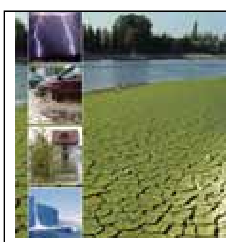
Dr. N. Senthilkumar
Division of Bioprospecting
Institute of Forest Genetics and Tree Breeding
(*Indian Council of Forestry Research & Education*)
Coimbatore, Tamilnadu

Panel on
005 was 3

Past climatic and biotic changes

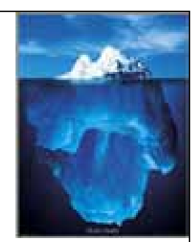
air temperature near the Earth's surface rose 0.74 ±
ast 100 years
past decades have already caused detectable effects on
and ecosystem processes.





CLIMATE CHANGE

Predictions



- The projected concentration of CO_2 in the year 2100 ranges from 540 to 970 ppm, compared to about 280 ppm in the pre-industrial era and about 368 ppm in the year 2000
- Increase in globally averaged surface temperature of 1.4 to 5.8°C over the period 1990 to 2100
- Increases of both atmospheric CO_2 and temperature are expected to affect ecosystem structure and functions.

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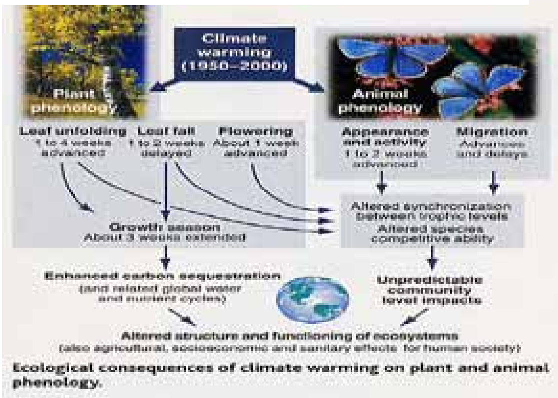
Phenological Changes



Penuelas J and Filella I 2001.

The general problem

35% of worlds existing terrestrial habitat predicted to be altered

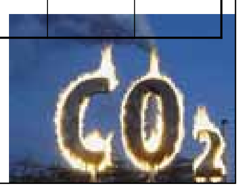
Studies found that deforestation in different areas of the globe affects rainfall patterns over a considerable region

Per capita carbon emission, by income classes (kg C/year)

	1990	2000	2002	2010	2020	2030
Top class >5 lakhs /yr	873.6	894.15	898.26	914.7	935.25	955.8
Middle class 50,000- 5 Lakhs	245.7	262.55	265.92	279.4	296.25	313.1
Bottom class <50,000	103.4	112.95	114.86	122.5	132.05	141.6
All India	127.9	200.5	215.08	273.2	345.85	418.5

Archana Warran & Ankur patwardhan, 2003

(Increase per capita per year: Top =2.055 kg C /year, Middle = 1.685 kg C /year, Bottom = 0.955 kg C /year , All India = 7 .265 kg C /year.)

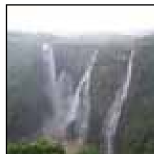


CLIMATE CHANGE

- One of the most important global environmental challenges.
- Impacts needed to be understood & assessed.
- Vulnerability needed to be addressed
- Adaptation needed to be initiated

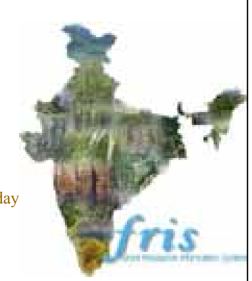
How forest sector is relevant to Climate Change?

- As a source (deforestation and forest degradation)
- Impacted by the Climate Change
- As a sink (Existing natural forests)
- Offer opportunities for C-sequestration (Afforestation, reforestation & existing plantations)



The world geographical area = 14894 m ha
India's geographical area = 328.7 m ha
World forest area = 3952 m ha
India's forest area = 67.7m ha
(Between 1990 and 2005, India gained 3,762,000 hectares (5.9%) of its forest cover.)

World forest loss (1990-2000) = 10.16 m ha
World forest loss (2000-2005) = 10.4 m ha (32,300 ha / day
India's total forest loss since 1990= 3,762,000 ha
1990-2000 = @ 361500 ha
2000-2005 = @ 29400 ha



FSI, 2009

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1993-1994

The biomass density/ha in Indian forests is = 92 t/ha.
Carbon stock of in Indian forests = 2933.8 million tonnes.

The forest area - carbon stock = 63.86 Mha wood (stem) biomass - 4327.99 Mt growing stock (GS) - 2398.19 Mt carbon stock - 1085.06 Mt of Indian forests for 1984 and 1993.

Of which, the Conifers stocked maximum carbon in their woods,
Conifer forest, 28.88 to 65.21 t C ha−1
Mangrove forests, 28.24 t C ha−1
Dipterocarp forests, 28.00 t C ha−1
Shorea robusta forests, 24.07 t C ha−1
Boswellia serrata, 3.91 t C ha−1
(with 0.22 Mha forest area)

Carbon stock in forests

	Biomass (t/ha)		Carbon stock (t/ha)		Net change Carbon stock (%)	Annual carbon loss/gain	Area (ha)
Year	1984	1994	1984	1994			
Managed Forest	170.54	163.79	85.27	83.79	-1.48	-0.15	244800
Reserve Forests	233.41	252.66	116.70	127.75	11.05	1.11	1011840

Bhatt *et al*. 2002

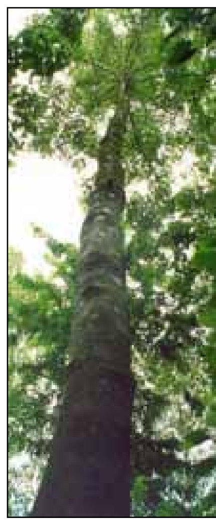
Above-ground mean tree biomass density

Reserved forest	=1158 t·ha−1
Protected forest	= 728
Fallow land	=13
Cultivated-unirrigated land	=11
Grassland	= 8
Orchard land	= 5
Cultivated-irrigated land	= 3 t·ha−1.

Sharma *et al*., 2008

Median carbon storage by agroforestry practices

9 tC/ha in semi-arid
21 tC/ha in sub-humid
50 tC/ha in humid
63 tC/ha in temperate ecozones.



Biomass and carbon stock

	Above ground biomass (t/ha)	Rate of accumulation of biomass (t/ha)	Above ground carbon stock (t/ha)	Rate of accumulation of carbon stock (t/ha)
Dalbergia sissoo	393.15	43.68	176.92	19.66
Terminalia arjuna	251.46	28.10	113.16	13.66
Shorea robusta	1980.04	66.00	891.02	29.75

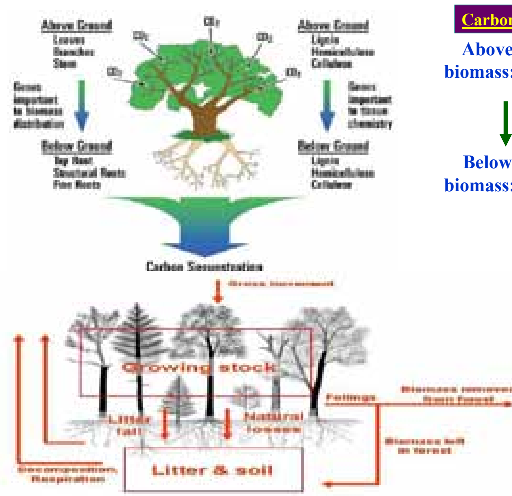
Koul and Panwar, 2008

Carbon sequestration and benefit under different plantation model 2005-2030

Plantation model	Sequestration potential (t/ha)	Annual incremental carbon (t/ha)	Benefit (Rs. /ha/yr)
Poplar	55	2.13	1251
Eucalyptus	43	1.64	963
Teak	74	2.85	1674
Mango	38	1.46	857
Lichi	38	1.46	857
Poplar bund plantation	37	1.42	834
Eucalyptus bund plantation	42	1.62	951

@ carbon price of US$4/tco$_2$

Ravindranath, 2008



Carbon storage

Above-ground biomass: 4,093 M t

Below-ground biomass: 1,085 M t

Loss of carbon sequestration

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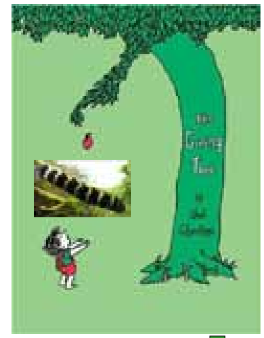
Areas under Forest loss - annually by

Diseases: 8,400,000 ha

Fire: 3,700,000 ha

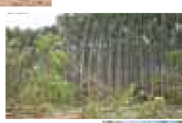
Insects: 1,000,000 ha

Forest biomass loss due to insects disturbance 1m ha/yr

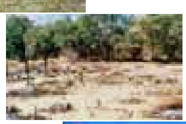


Forest Damage

Pest outbreaks as major source of natural disturbance.



The effects vary from defoliation and growth loss, to timber damage, to massive mortality.



North America- 2.9% p.a.

Insect damage – world scenario
In1998–2002,
US- 5 m ha – 1.7%
Canada – 14 m ha – 4.5%

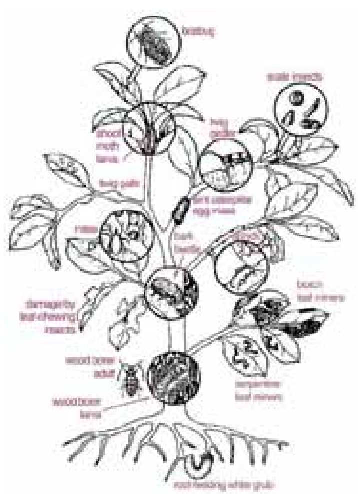
India ?

Carbon in biomass and mean annual increment (t C/ha)

Area under disturbance	Tropical	Temperate	Subtropical	Alpine	Total
Insect	14341	656	1260	519	16776
Annual loss	-1.6	-0.2	-0.2	-0.1	-2
Dead biomass	-382	-32	-32	-15	-416

Haripriya, 2001

Insect pests spectrum in a tree



Major insect pests that affect trees in India

Defoliator - *Calopepla leayana* (Chrysomelidae) *Gmelina arobrea*
Bud shoot feeder - *Dioryctria* sp. (Pyralidae) *Pinus* sp.
Defoliator - *Hybleaea puera* (Hyblaeidae) Teak
Defoliator - *Eutectona machaeralis* (Pyralidae) Teak
Wood borer - *Hoplocerambyx spinicornis* (Cerambycidae) *Shorea robusta*
Bud shoot feeder - *Hypsipyla robusta* (Pyralidae) Mahogony
Sap feeder - *Tingis beesoni* (Tingidae) *Gmelina arborea*
Wood borer - *Xyleutes ceramica* (Cossidae) Teak, Gmelina
Wood borer - *Xystocera festiva* (Cerambycidae) *Paraserianthes falcataria*
Gall inducer - *Leptocybe invasa* (Eulophidae) Eucalyptus
Subterranean - *Termites* (Termattidae) Eucalyptus
Bark eating caterpillar- *Indarbela quadrinotata* on *Casuarina equisetifolia*

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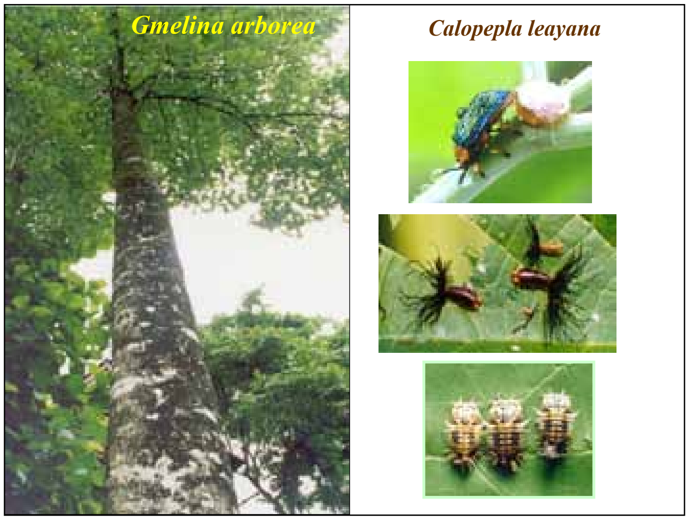

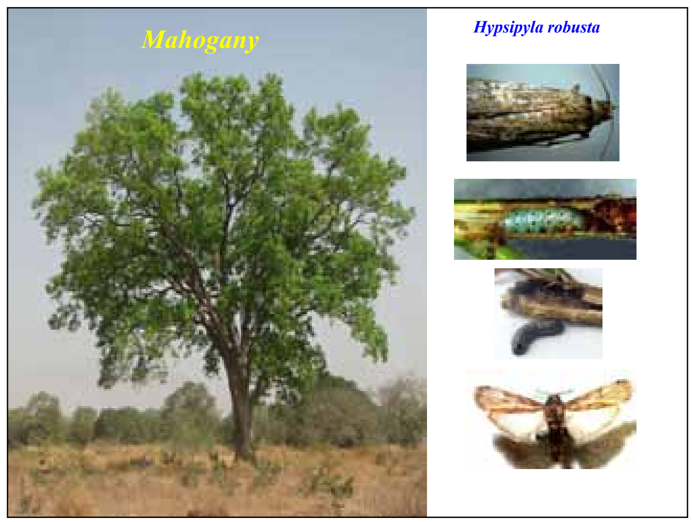

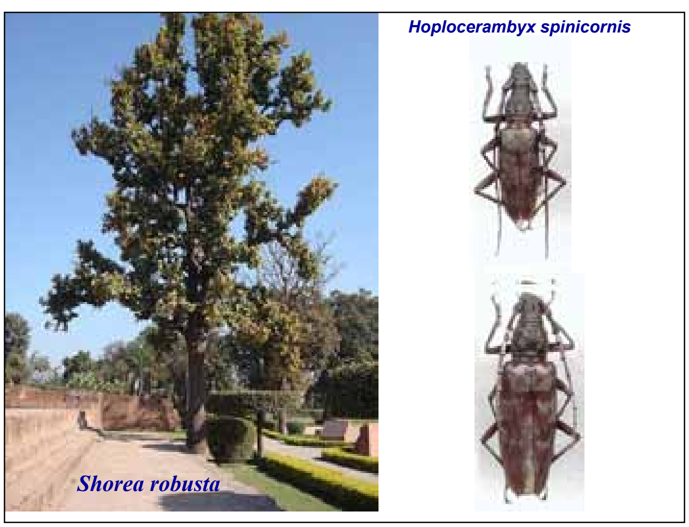

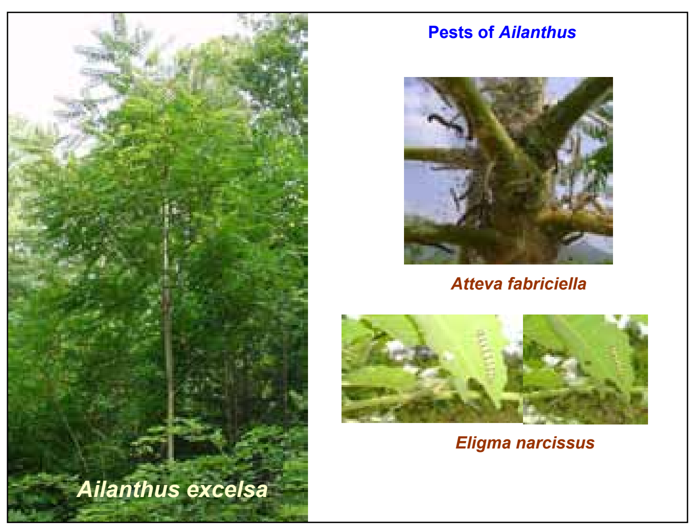

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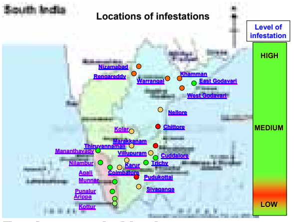
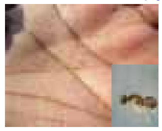
OUTBREAK OF A NEW INVASIVE GALL-INDUCING WASP IN EUCALYPTS PLANTATIONS

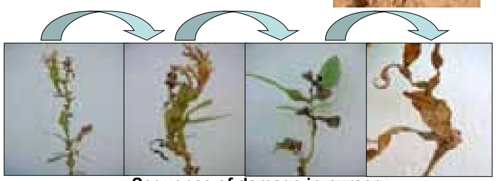
Leptocybe invasa
(Hymenoptera : Eulophidae





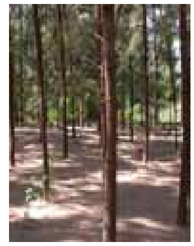
Eucalypts attacked by the pest

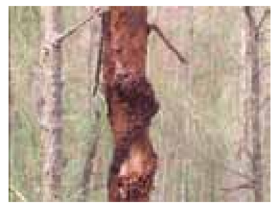
Eucalyptus camaldulensis
E. tereticornis
E. globulus
E. gunii
E. grandis
E. botryoides
E. saligna
E. robusta
E. ridgesiana
E. viminalis



Sequence of damage in nursery

Indarbela quadrinotata* on *Casuarina equisetifolia





Indarbela quadrinotata on *Casuarina equisetifolia*

Courtesy TNFD

Biomass estimation and carbon sequestration calculation

Determine the total (green) weight of the tree
The algorithm to calculate the weight of a tree is
W = Above-ground weight of the tree in pounds
D = Diameter of the trunk in inches
H = Height of the tree in feet
For trees with D < 11:
W = 0.25D2H
For trees with D >= 11:
W = 0.15D2H
The root system weighs about 20% as much as the above-ground weight of the tree. Therefore, to determine the total green weight of the tree, multiply the above-ground weight of the tree by 120%.

Determine the dry weight of the tree
The average tree is 72.5% dry matter and 27.5% moisture.
Therefore, to determine the dry weight of the tree, multiply the weight of the tree by 72.5%.

Determine the weight of carbon in the tree
The average carbon content is generally 50% of the tree's total volume. Therefore, to determine the weight of carbon in the tree, multiply the dry weight of the tree by 50%.

Determine the weight of carbon dioxide sequestered in the tree
CO2 is composed of one molecule of Carbon and 2 molecules of Oxygen.
The atomic weight of Carbon is 12.001115.
The atomic weight of Oxygen is 15.9994.
The weight of CO2 is C+2*O=43.999915.
The ratio of CO2 to C is 43.999915/12.001115=3.6663.
Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.6663

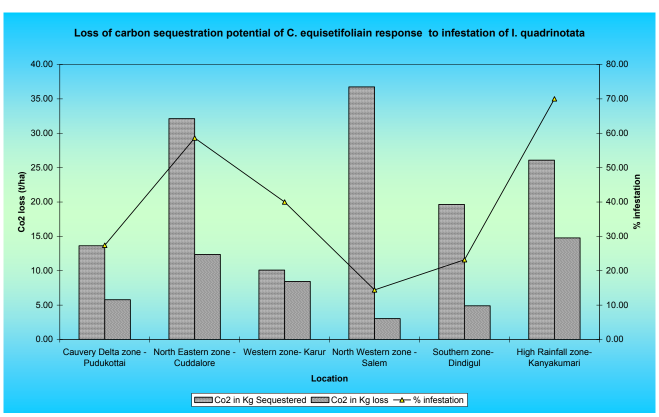
Determine the weight of CO2 sequestered in the tree per year
Divide the weight of carbon dioxide sequestered in the tree by the age of the tree.

Biomass changes before infestation of *I. quadrinotata* on *C. equisetifolia*

Location	Before infestation						
	DBH (cm)	Height (m)	Wt in lbs	Green Wt. Root included	Dry Wt. (t/ha)	Carbon (t/ha)	Co2 Sequst. (t/ha)
Cauvery Delta zone - Pudukottai	6.58	9.03	24.45	29.34	53.18	26.59	44.22
North Eastern zone -Cuddalore	10.38	13.83	93.03	111.63	202.34	101.17	168.24
Western zone- Karur	6.09	8.67	20.12	24.14	43.75	21.88	36.38
North Western zone -Salem	9.80	12.59	75.61	90.73	164.46	82.23	136.74
Southern zone- Dindigul	7.50	9.95	34.98	41.98	76.08	38.04	63.26
High Rainfall zone- Kanyakumari	8.51	10.69	48.39	58.07	105.25	52.63	87.52

Biomass changes after infestation of *I. quadrinotata* on *C. equisetifolia*

Location	After infestation							
	DBH (cm)	Ht (m)	Wt in lbs	Green. Wt. Root included	Dry wt. (lbs)	Dry Wt. (t/ha)	Carbon (t/ha)	Co2 Sequst. (t/ha)
Cauvery Delta zone - Pudukottai	8.48	9.62	43.30	51.95	37.67	94.17	47.08	78.30
North Eastern zone -Cuddalore	12.36	14.39	137.43	164.92	119.56	298.91	149.46	248.55
Western zone- Karur	7.80	8.95	34.06	40.87	29.63	74.08	37.04	61.60
North Western zone -Salem	12.46	13.03	126.40	151.67	109.96	274.91	137.45	228.59
Southern zone- Dindigul	9.76	10.44	62.13	74.56	54.05	135.13	67.57	112.36
High Rainfall zone- Kanyakumari	11.02	11.12	84.45	101.34	73.47	183.68	91.84	152.73



Biomass changes and loss of carbon sequestration potential of *C. equisetifolia* due to infestation of *I. quadrinotata*

Location	Initial	Final					
	Dry wt. (t/ha)	Dry wt. (t/ha)	Increment	Carbon (t/ha)	Co2 Sequest. (t	% infestation	Co2 loss (t/ha)
Cauvery Delta zone - Pudukottai	53.18	94.17	40.98	20.49	75.13	27.40	25.21
North Eastern zone -Cuddalore	202.34	298.91	96.58	48.29	177.04	58.60	53.91
Western zone- Karur	43.75	74.08	30.33	15.17	55.60	40.00	36.80
North Western zone -Salem	164.46	274.91	110.45	55.23	202.48	14.40	13.25
Southern zone- Dindigul	76.08	135.13	59.05	29.52	108.25	23.20	21.34
High Rainfall zone- Kanyakumari	105.25	183.68	78.42	39.21	143.76	70.00	64.40

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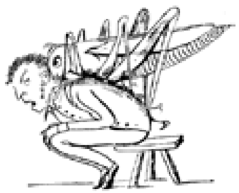
Why Pest Management?



Collapse of control systems
Environmental contamination

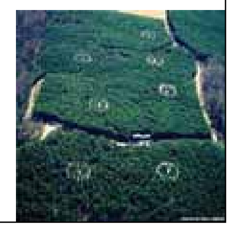
- Insects are major, but frequently overlooked ecosystem components that influence their structure and functions
- They are generally neglected in global change research

Climate change & insects

Insect herbivory of plants in high co_2 environments is dramatically increased.

Management of natural forests as co_2 sinks will need to be adjusted to compensate for this increase in defoliation.

If insects and other forest pests adapt a more aggressive consumption pattern in a future global climate, net co_2 sequestration of future forests may be less than it is in current condition.



Carbon Sequestration by US Forests

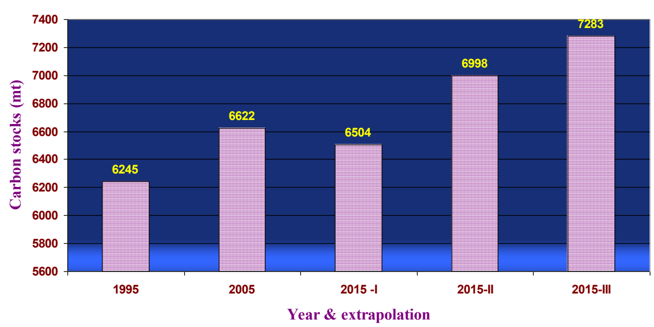
All US Forests

- **U.S. forests sequester carbon at a rate of 250 MMTC/yr -- 15% of U.S. emissions**
- **At $5/ton, annual value of sequestration is more than $1 billion**
- **It is technically feasible to increase the rate of carbon sequestration in forests by 150 MMTC/yr:**
  - **Afforestation**
  - **Improved management**
  - **Efficient wood production**
  - **Bio-products and energy**
  - **Agroforestry**

150,000 ha protected from Spruce budworm (*Choristoneura fumiferana* Clem.)

sequestered 24.95 million metric tons with the cost of $64.23

Carbon stocks in India's forest tree cover (million tonnes)



2015 – I @ world average@0.18%p.a.

2015 – II @ historical rate of the last decade@0.6%p.a.

2015 – III @ anticipated @ 285mt/yr = Rs. 6,000 crores/yr benefit=US$7/ton

Kiswan, 2009

Stand biomass of *Gmelina arborea* ranged from 3.94 (1-year-old) to 53.67 t ha−1 (6-year-old) and stand carbon in 6-year-old plantations ranged from 24.12 to 31.12 t ha−1. At 6 years, *G. arborea* stands sequestered 31.37 t ha−1 carbon

Acacia nilotica (185.2), *Gmelina arborea* (130.5), *Dalbergia sissoo* (129.6), and *Eucalyptus* hybrid (125.2)

Swamy, Puri and Singh, 2003

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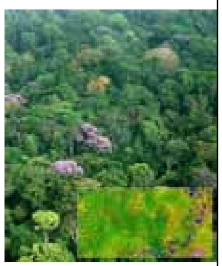
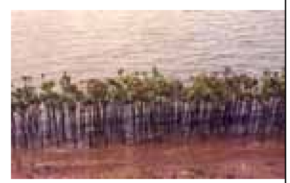
Of the total accessible biomass, only 0.31% was extracted annually by the local people for fuel, fodder and other uses. Forest biomass production was simulated for the next 30 years with a logistic growth model. The model results highlighted the <u>declining forest resources in the long run.</u>

appropriate
Government policies
Management plan
Afforestation
Tree cultivation in private lands
Agroforestry can, however, increase the rate of carbon sequestration.



Plant trees – Lets all be a little bit greener



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Elevated CO_2 effect on Photosynthetic behavior and Bio-chemical changes in *Ocimum sanctum* Linn. an Medicinal herb

S. Saravanan, Karthik, L and R.S.C. Jayaraj

Forestry Land Use and Climate Change division
Institute of Forest Genetics and Tree Breeding
Forest Campus, PB.NO: 1061, R.S. Puram, Coimbatore - 641 002

Purpose of the study

- 2nd largest producer of medicinal plants.
- Share in global trade is about 2.5% (China 13%).
- Domestic trade of 80-90 billion (Export 10 billion).
- World trade expected to reach US $ 7 trillion by 2050.
- Medicinal plants are mainly the alternate income-generating source of underprivileged communities.
- Steady increase for demand, overexploitation.
- Farmers showing interests in cultivation under farmland conditions.
- World trade mainly based on the presence of quality and quantity of active principles.

- The concentration of CO_2 and other greenhouse gases (GHGs) in the atmosphere has considerably increased over the last century and is set to rise further.
- Increasing levels of atmospheric CO_2 will stimulate photosynthesis and productivity in most ecosystems; the duration and magnitude of this stimulation is especially in medicinal plants not yet studied.
- Adjustments at the physiological, organism, and ecosystem levels have the potential to moderate the growth response to elevated CO_2.
- Under climatic change conditions their structure and function may greatly change, their integrity may be violated and their services to people may be greatly modified.
- World trade mainly based on the presence of quality and quantity of active principles.
- Exporters, traders and mainly farmers struggling to market their products in the world trade due to changes in the active ingredients.
- The present study is proposed to understand the response of the medicinal plants to the elevated CO_2 levels under simulated temperature and moisture regimes.

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Study area

Methodology

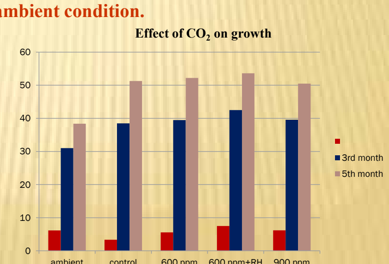
- RBD with 3 replications with control and ambient condition.
- Ambient, Control, 600 ppm, 600 ppm+Rh and 900 ppm as treatments.
- Each 25 plants per replication.
- Collection of periodical data on physiological parameters and monitoring the bio-chemical changes.

Growth performance of Ocimum

Under 600 ppm+RH, plants recorded highest height growth followed by 600 ppm, 900 ppm, control and least in ambient condition.

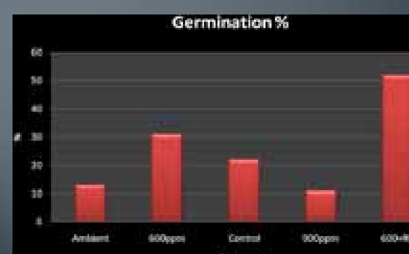
The same trend was observed in total number of leaves, chlorophyll ‘a’, ‘b’ and total.

Further, other aspects *viz.*, No. of leaves, root shoot ratio, fresh weight, dry weight, primary and secondary roots registered higher under the 600 ppm+RH and least under the ambient condition.



Higher germination percentage was recorded under 600ppm+RH (13±0.54) and the least germination percentage was recorded under 900ppm (2.75±0.54).

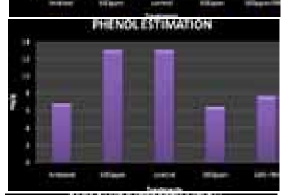
The germination percentage was almost 4 times higher in chamber with 600ppm plus the temperature regulation through humidifier .



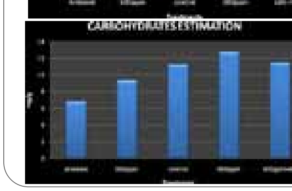
The highest photosynthesis rate recorded (2.61±0.23) in chamber with 600ppm+RH. Higher transpiration rate (3.01±0.23) as well as stomatal conductance was recorded in the same treatment. Under the ambient condition, all the parameters were recorded lowest.

Treatments	Photosynthesis (μmol co_2 m^{-2} s^{-1})	Transpiration (mmol H_2O m^{-2} s^{-1})	Conductance (mol co_2 m^{-2} s^{-1})
Ambient	1.41±0.25	0.34±0.44	0.012±0.45
600ppm	2.42±0.43	2.01±0.45	0.03±0.57
Control	2.32±0.56	2.87±0.29	0.04±0.33
900ppm	2.06±0.342	1.66±0.30	0.05±0.16
600ppm+RH	2.61±0.33	3.01±0.23	0.05±0.31

Highest protein registered under control and least in ambient.



Under 600 ppm, the total phenols content recorded higher and least in 900 ppm.



Under 900 ppm, the Carbohydrates registered higher and lowest in ambient condition.

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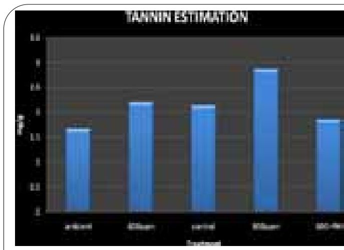

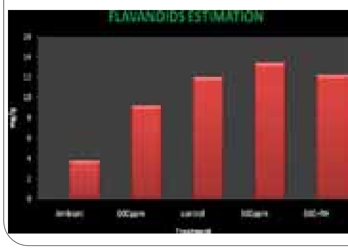

Tannin and Flavonoids registered higher under 900 ppm and lowest in ambient condition.

Conclusions

1. **Effect of elevated CO_2 on growth, physiological and bio-chemical changes was observed in Ocimum.**

2. **Best growth was observed under the 600 ppm+RH control chamber and least under ambient condition.**

3. **The same trend was observed in chlorophyll 'a', 'b' and total and other parameters like root,shoot ratio, no. of leaves, primary and secondary roots, etc.**

4. **Higher germination was registered under the 600 ppm+RH and least under 900 ppm.**

5. **Photosynthetic parameters showed higher under the 600 ppm+RH and least under ambient condition.**

6. **Bio-chemical analysis shows different results. Highest phenols under 600 ppm, Protein under control and Carbohydrates, Flavonoids and Tannin registered highest under the 900 ppm.**

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