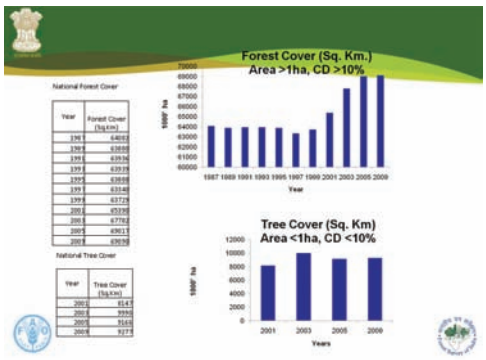
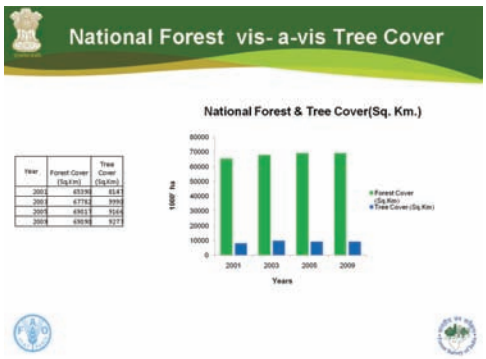
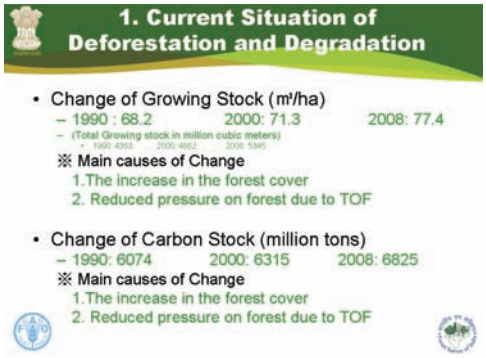
(Appendix 5.9.14)

Carbon estimations in India

Mr. Shiv Raj Singh







2. Strategy to reduce Deforestation and Degradation

The National Action Plan on Climate change released by Hon'ble Prime Minister focuses attention on 8 priorities National Missions

- 1. Solar Energy
- 2. Enhanced Energy Efficiency
- 3. Sustainable Habitat
- 4. Conserving Water
- 5. Sustaining the Himalayan Ecosystem
- 6. A "Green India"
- 7. Sustainable agriculture
- 8. Strategic Knowledge Platform for Climate Change

3. Brief on National Forest Inventory

- Brief history of Forest Inventory
  - PISFR started as FAO, UNDP project from1965 to 1968. Continued till 1981.
  - In 1981 PISFR into FSI. But inventory on local and project basis only.
  - 1st Inventory
    - By Forest Survey of India on national level during the year 2002-03 to 2003-04
  - 2nd Inventory
    - Inventory Year: 2004-05 to 2005-06
  - 3rd Inventory
    - Inventory Year: 2006-07 to 2007-08

  4th Inventory – Only TOFI is taken up during 2008-09 to - 2009-10

  5th Inventory to be taken up during 2010-11 to 2011-12. (25% districts will be revisited of 1st FI.)

3. Brief on National Forest Inventory

- Latest Design
  - Remote Sensing
    - Introduced year: 2002
    - Type of satellite data: P6, LISS IV Mx, 5.8 m
    - RS is used only for TOF (Rural) inventory
  - Field Inventory
    - Sample intensity: 3 X 3km approx. 1point represents 9 sq. Km
    - Interval of inventory: Two year cycle
    - Sample size: square (31.62 x 31.62 m)
    - Number of sample: Approx.7000 sample plots for FI & 8000 sample plots for TOFI are taken in 60 districts in per cycle

3. Brief on National Forest Inventory

- Implementation System of NFTRI in government
  - Administration
    - Organization: Forest Survey of India, Forest inventory division
    - Staffs: 14 Supervisory and 165 Technical & field staff in Hq and 4 regional offices. (Support staff is extra)
    - Budget (2010): Approx. 70 M INR, 1.5 M $
  - Research
    - Creation of separate research wing for Inventory is under consideration
  - Collaboration with policy-making system
    - Inside Forestry agency: Information is shared
      - Conservation strategies
      - Planning for farm/agro forestry strategies
      - Input for policy making for forest/wood based industrie

3. Brief on National Forest Inventory

- Relating to national development plan:
  - GDP – Contribution of forestry 1.70% - 888.23 billion INR. Out of which about 40% comes from TOF
  - Input for impact assessment of various infrastructure projects like Hydroelectric, road and rail network, power projects etc.

4. Suggestions for promoting and strengthening NFI System

- Human Resources
  - Administration – Capacity building desirable
  - Research – A separate wing needs to be developed
- Financial Resources etc.
  - National – need more for further strengthening
  - International –required for technical collaboration and capacity building.

Assessment of Biomass Carbon Stock of India's Forests- various components

- Forest cover maps,
- Forest types maps,
- National Forest and Tree Resource Inventory,
- Estimation of other components of forest biomass, and
- Integrating the above four components to estimate the forest carbon and change

Forest Cover Assessment

INPUTS

- Satellite data of the entire country from National Remote Sensing Centre (NRSC) IRS ID/IRS-P6 (23.5m spatial resolution)
- SOI Topographic sheets - 1: 50,000

METHODOLOGY

- Digital / visual Interpretation
- Ground Verification
- Minimum map able area is I ha

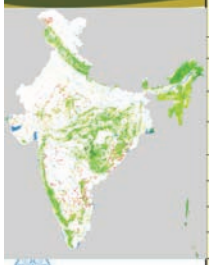
OUTPUTS

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

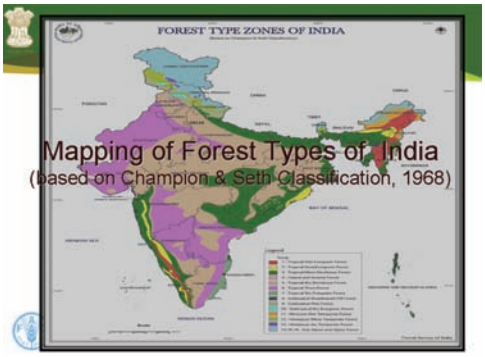
CATEGORY	CANOPY DENSITY
Very Dense Forest	More than 70% canopy
Moderately Dense Forest	40-70%
Open Forest	10-40%
Scrub	Less than 10% in forest lands

It takes almost two years to complete the assessment process

Forest Cover of the Country - 2007



Class	Area (km²)	% of Geo. Area
Forest Cover		
a) Very Dense Forest (more than 70% density)	83,510	2.54
b) Moderately Dense Forest (40% to 70% density)	319,012	9.71
c) Open Forest (10% to 40 % density)	288,377	8.77
Total Forest Cover	690,899	21.02
Non-forest Area		
Scrub	41,525	1.26
Non-forest	2,554,839	77.72
Total Geographic Area	3,287,263	100.00



Forest Types of India*

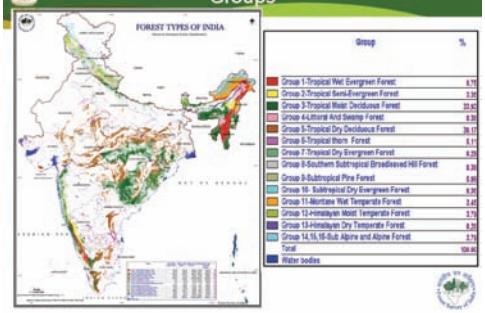
MAJOR GROUPS	TYPE GROUPS
Moist Tropical Forests	Group 1-Tropical Wet Evergreen Forests
	Group 2-Tropical Semi-Evergreen Forests
	Group 3-Tropical Moist Deciduous Forests
	Group 4-Littoral And Swamp Forests
Dry Tropical Forests	Group 5-Tropical Dry Deciduous Forests
	Group 6-Tropical thorn Forests
	Group 7-Tropical Dry Evergreen Forests
	Group 8-Southern Subtropical Broadleaved Hill Forests
Montane Temperate Forests	Group 9-Subtropical Pine Forests
Montane Subtropical Forests	Group 10- Subtropical Dry Evergreen Forests
	Group 11-Montane Wet Temperate Forests
	Group 12-Himalayan Moist Temperate Forests
Sub Alpine Forests	Group 13-Himalayan Dry Temperate Forests
	Group 14-Sub Alpine Forests
Alpine Scrub	Group 15-Moist Alpine Scrub
	Group 16- Dry Alpine Scrub

SUB-GROUPS: *Sub-group- 22 Nos.*

TYPES: *Types - 200 Nos.*

*As per Champion and Seth classification(1968)

Forest Cover of India in Different Forest Type Groups



National Forest and Tree Resources Inventory- methodology

- Two year cycle
- Multistage and multiphase design is followed.
- The country is stratified into 14 physiographic zones
- Ten percent (60) districts are randomly selected in every cycle from each physiographic zone (proportion to size of zone).
- In each following 3 surveys are carried out:
  - Forests,
  - TOF (rural), and
  - TOF (urban)

Schematic diagram of the National Forest Inventory (NFI) in India

Step 1. Stratify the Country into 14 homogeneous physiographic zones.

Step 2. Randomly select 60 districts (10% of the total) from these zones in proportion to their sizes.

Step 3. Divide the area of selected districts into grids of 2½′ × 2½′.

Step 4. Divide each grid of 2½′ × 2½′ into four sub-grids of 1¼′ × 1¼′.

Step 5. Randomly select two sub-grids out of four grids starting at one end. Systematic sampling is then adopted to select two sub-grids in other grids of the district.

Step 6. Lay out a square sample plot of size 0.1 ha at the centre of each selected forest sub-grid.

Step 7. Measure dbh of all tree over 10 cm, collect litter and soil sample, record regeneration status, bamboo, land use, legal status, crop composition, etc.

Step 8. Conduct manual check of sample data on random basis and then enter into data entry module.

Step 9. Conduct inconsistency check of sample data through software and then process.

Step 10. Analysis and estimation of various parameters

National Forest Inventory-Methodology

Physiographic Zone Map of India

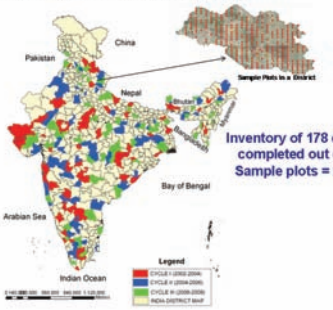
National Forest Inventory- Methodology --contd

Physiographic Zones on Forest Cover

National Forest Inventory – Methodology --contd

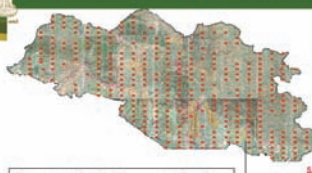
Randomly Selected 60 districts

Districts Completed Under National Forest Inventory



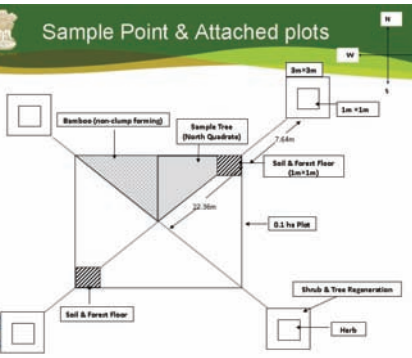
Inventory of 178 districts completed out of 593
Sample plots = 22,000

Distribution of sample plots in a selected District



Two sample plots are randomly selected. Thereafter, every alternate 1¼'X 1¼' GRID is systematically selected to form two systematic samples. At center of selected 1¼'X 1¼' SUB GRID, sample plots of 0.1 ha is laid out.

Sample Point & Attached plots



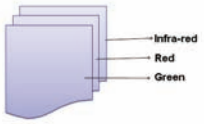
Methodology of NFI -- contd

- Use of the suitable volume equation for accurately estimating the volume (biomass) of the tress.
- To estimating growing stock about 250 volume equations have been developed for tree species growing in different physiographic zones.
- These volume equations are based on measurement of trees above 10 cm dbh and excludes volume of main stem below 10 cm and branch wood below 5 cm diameter.

ASSESSMENT OF TREES OUTSIDE FORESTS (TOF)

Methodology Adopted

- Remote sensing technique is used for stratification.
- The IRS P6 LISS IV scenes of the study area are identified and procured from NRSA.
- IRS P6 LISS IV scenes provides information in 3 spectral bands.



As a first step, corresponding toposheet No. (1:50,000 scale) and District boundaries are identified with the help of S.O.I grid and boundary map.

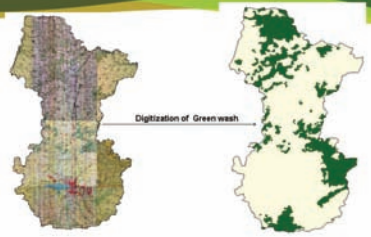
Map of India showing Administrative Boundaries

Boundary and Toposheets ID

- **The Toposheets corresponding to district boundary are scanned and geo-referenced to give them co-ordinate system.**
- **Further mosaicing of referenced toposheet and subsetting is done.**

Total No. of toposheets falling in the district

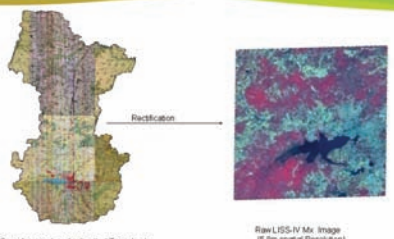
The Reserved and Restricted forest area is digitize to prepare the greenwash map



Mosaiced and subsetted Toposheets of district

Green wash map of district

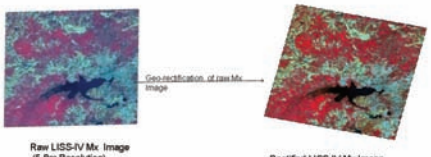
The geo-referenced and sub-setted Toposheets are then utilized for the rectification of the LISS-IV Mx Satellite Image.



Georeferenced and subsetted Toposheets

Raw LISS-IV Mx Image (5.8m spatial Resolution)

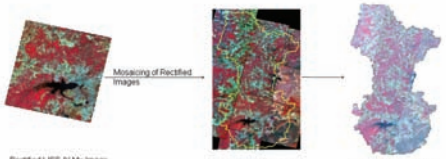
The raw IRS P6 LISS-IV Mx Satellite Data having spatial resolution of 5.8m is rectified from the georefernced toposheet of the district



Raw LISS-IV Mx Image (5.8m Resolution)

Rectified LISS-IV Mx Image

Rectified LISS IV Mx Images are mosaiced together and overlayed with the district boundary for making a subset.



Rectified LISS-IV Mx Image

Overlaying of boundary on Mosaic Images

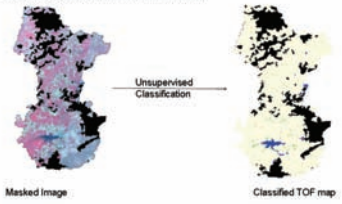
Subsetted district map

The greenwash area is masked out from the mosaic image of the district

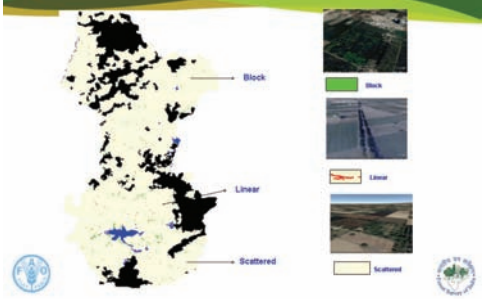
Greenwash map overlayed over mosaic image of the district

Greenwash masked out

- Then Unsupervised classification is performed over the masked image.
- The classification is done to obtain two classes: TOF area, and water bodies.
- TOF area is further divided into three classes :- Block, Linear & Scattered which are identified according to their geometric shape.



Classified Trees Outside Map of district showing three different stratums i.e. Block, linear and Scattered.



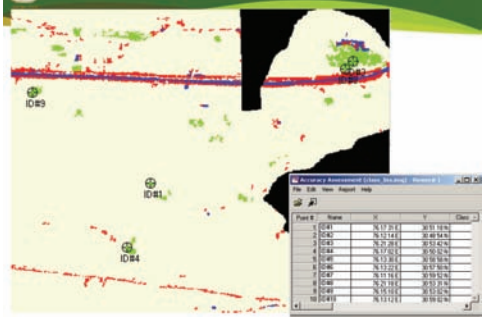
Plot & Sample Size

Field survey requires plot sizes and sample sizes

Strata	Plot size	Sample size
Block	0.1 ha	35
Linear	10x125 m	50
Scattered	3.0 ha	50
Scattered (Hill)	0.5 ha	95

These sizes will provide estimate at 85% accuracy.

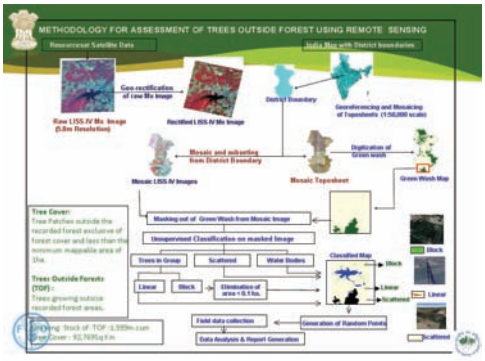
Automatic generation of random points in block, linear and scattered stratum in the TOF area.



Field Survey

- Random points for block, linear & scattered stratum along with coordinates communicated to field units for survey
- Survey carried out in the field using GPS & data recorded in prescribed formats
- Data processed to obtain estimates for all TOF parameters on Culturable Non Forest Area (CNFA)

METHODOLOGY FOR ASSESSMENT OF TREES OUTSIDE FOREST USING REMOTE SENSING



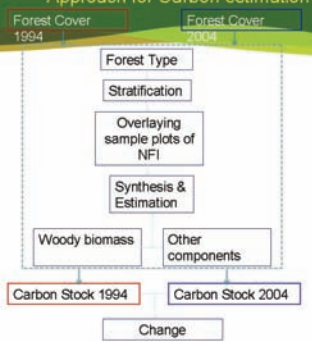
Other Components of Forest Biomass

- Volume of trees below 10 cm dbh, branches below 5 cm, foliage etc.
- Shrubs, herbs, climbers etc.
- Dead wood
- Litter (branches only)
- Soil organic carbon
- Below ground root volume
- Tree bark

New Biomass Study

- FSI launched a new biomass study in August 2008 to measure other components of forest biomass which are not measured by NFI.
- The study has followed two approaches
- (a) measure biomass of herb, shrub, climber, dead wood and litter by laying out sample plots (about 100 plots in each physiographic zone thus in all 1,400 sample plots)
- (b) select 20 to 30 number of trees for each species in different zones cut and measure their biomass to generate biomass equations for:
  - i) Dbh of NFI trees Vs. biomass of branch for trees above 10 cm dbh.
  - ii) dbh/collar dia Vs. total biomass of trees below 10 cm dbh.

Approach for Carbon estimation



Preliminary Component wise estimates of Biomass and Carbon stock in India's Forests (2004)

	Components	Biomass (m tonnes)	Carbon (m tonnes)
A.	Above Ground		
	Woody biomass of trees above 10 cm dbh	3076	1507
	biomass of small wood of trees above 10 cm dbh	872	410
	biomass of foliage of trees above 10 cm dbh	53	24
	biomass of small wood of trees below 10 cm dbh	132	61
	biomass of foliage of trees below 10 cm dbh	6	2
	Biomass of shrubs	27	12
	Biomass of climbers	14	6
	Biomass of herbs	3	1
	Total Above Ground	4182	2023
B.	Below ground	1319	638
	total live biomass	5501	2661
C.	Deadwood	56	26
D.	Litter	-	80
E.	Soil Organic Carbon	-	3972
	Total		6740

Gratitude

- FAO
- Republic of Korea
- India

Thank you!

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