NATIONAL FOREST INVENTORY IN INDIA

Workshop on "Monitoring of reduction of emissions from forest degradation"

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Some highlights of India's forests

- Forests constitute a very important natural resource for India.
- It is a major land-use and occupy about 23% land area of the country (77 mn ha) but the actual forest cover is only about 20.60% (67.7 mn ha).
- India's population being more than a 1 billion, the per capita forest is too low (600 m2) against world's average of 6000 m2.
- The pressure on forests is therefore high also because more than 70% India's population has rural based economy.
- Trees outside forest (TOF) has become the most potential source for production of wood contributing to more than 80% of the timber at present.

Two decades of Forest Cover Assessment in India

Cycle	Year of Assessment	Satellite & Sensor	Resolution	Scale
I	1987	LANDSAT MSS	80m x 80m	1:1million
II	1989	LANDSAT TM	30m x 30m	1:250,000
III	1991			
IV	1993			
V	1995	IRS-1B LISS-II	36m x 36m	
VI	1997			
VII	1999	IRS-1C LISS-III	23m x 23m	
VIII	2001	IRS-1C/1D LISS-III	23m x 23m	1:50,000
IX	2003	IRS-1D, LISS-III	23m x 23m	1:50,000
X	2005	IRS-P6, LISS-III	23m x 23m	1:50,000

Forest Cover of the Country - 2005

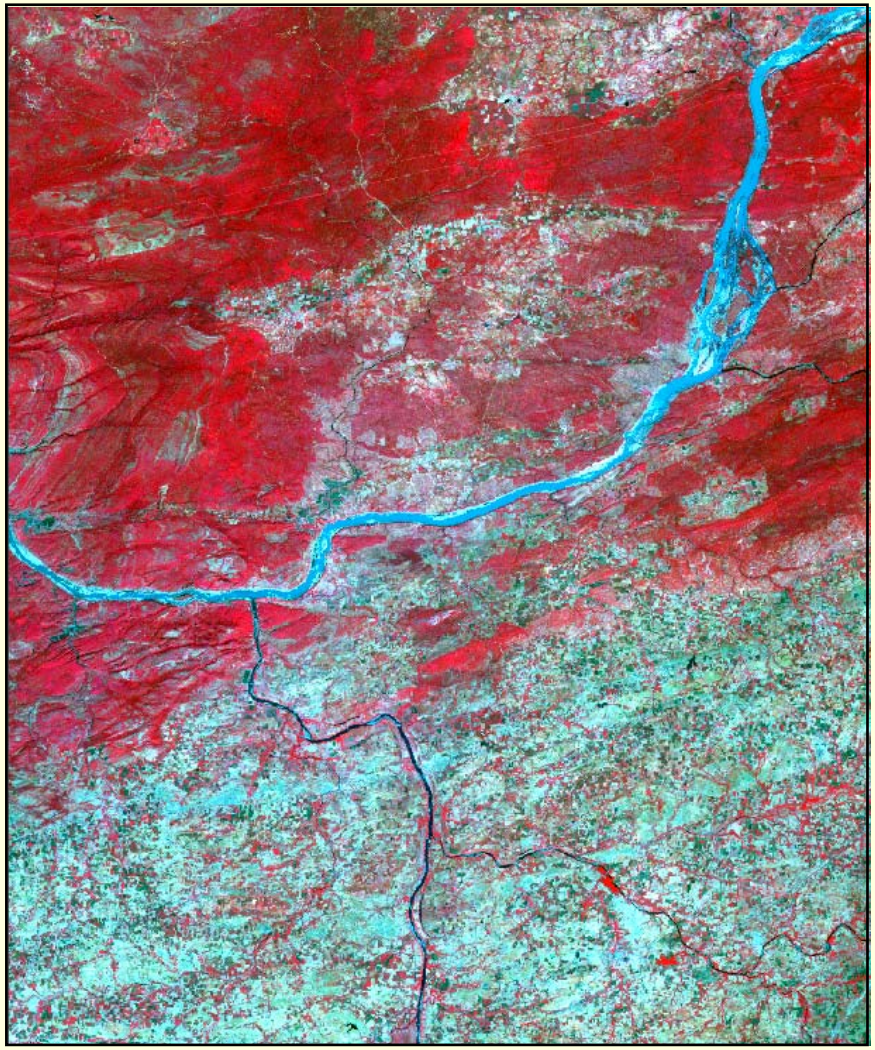
Class	Area (km²)	% of Geo. Area
Forest Cover		
a) Very Dense Forest (more than 70% density)	54,569	1.66
b) Moderately Dense Forest (40% to 70% density)	332,647	10.12
c) Open Forest (10% to 40 % density)	289,872	8.82
Total Forest Cover	677,088	20.60
Non-forest Area		
Scrub	38,475	1.17
Non-forest	2,571,700	78.23
Total Geographic Area	3,287,263	100.00

Change in Forest Cover

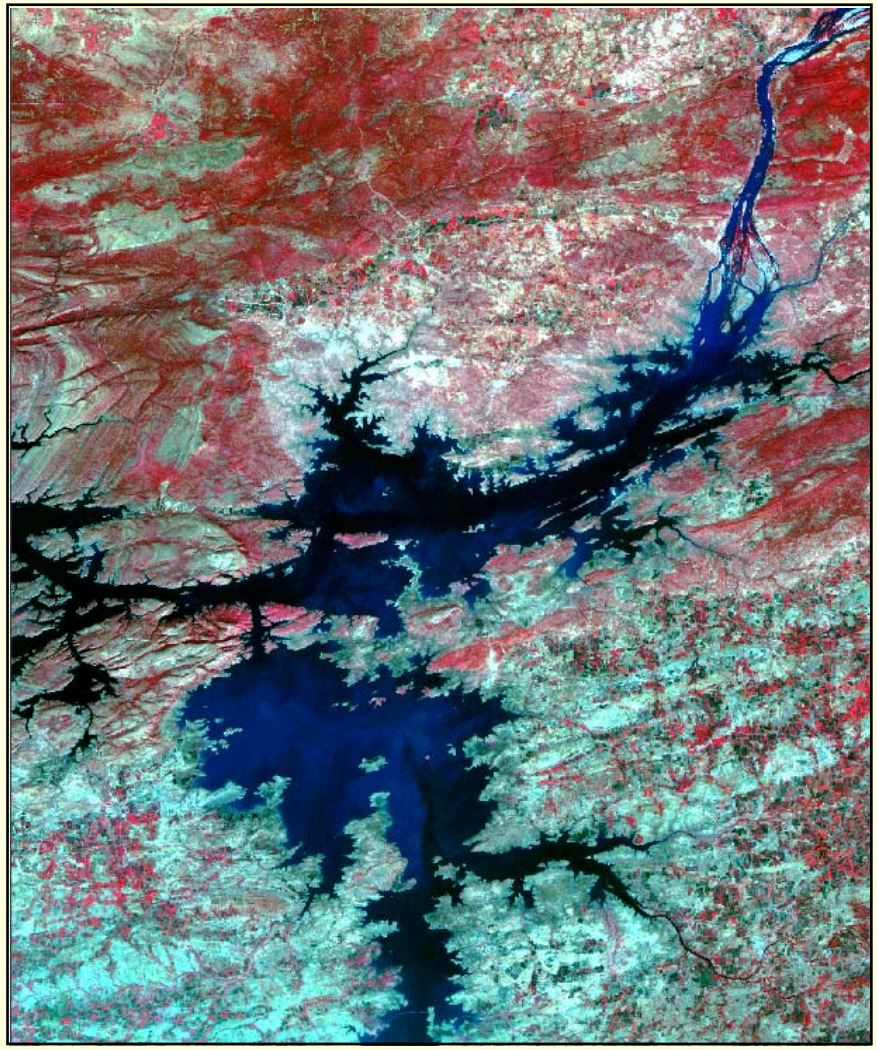
(in km^2)

	2003 Assessment	2005 Assessment	Change +/-
Very Dense Forests	54,518	54,569	51
Moderately Dense Forests	334,056	332,647	- 1,409
Open Forests	289,242	289,872	630
Total	677,816	677,088	- 728

Submergence of Forest Area in Harda, East Nimar & Dewas Districts

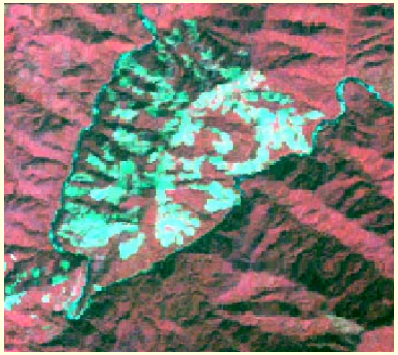


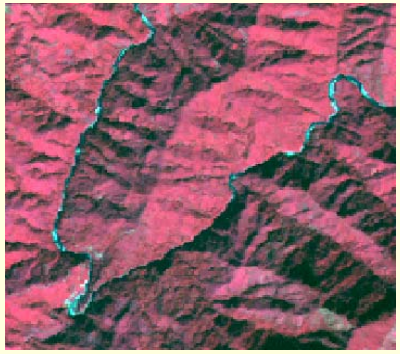
2003



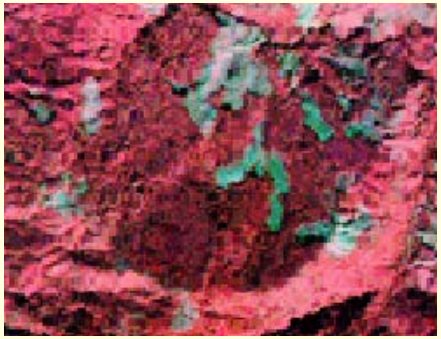
2005

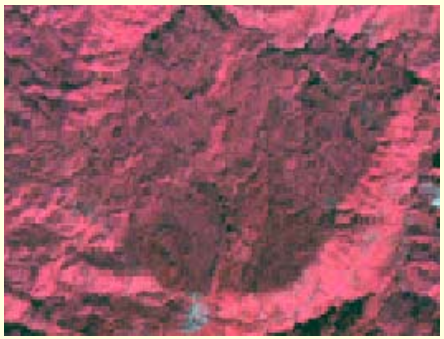
Shifting Cultivation



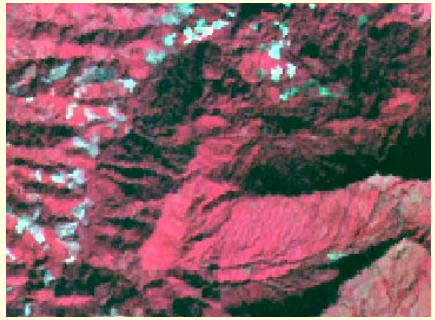


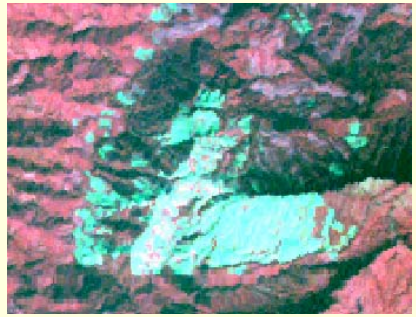
2003 2005



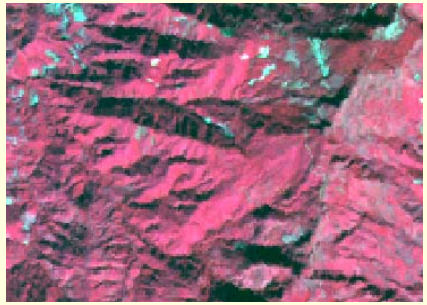


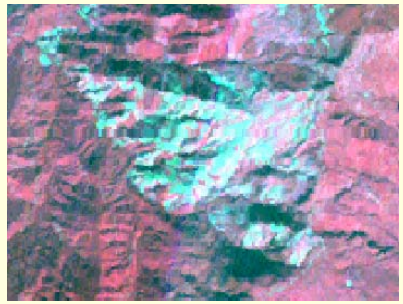
Improvement





2003 2005





Degradation

History of Forest Inventory in India

- With the start of scientific management of forests in India in 1863 field inventory on a systematic basis started for the preparation of the “Working Plans” at the divisional level.
- This was extended to almost entire forest area of the country and is continuing even today. But the inventories were for limited forest area of a division which was to be worked during next 10-15 years and was for different time frame.
- Further, these inventories were not organised to generate estimates at state/national level for a given time frame.

National Forest Inventory

Field inventory of unexplored forest areas started after the launch of a FAO/UNDP/GOI project named as Pre-Investment Survey of Forest Resources (PISFR) in 1965 which led the foundation of NFI

From 1965 to 1981

- **Forest Inventory was confined to project areas for setting up wood based industries**
- **Sampling design was adopted as per prevailing condition of areas but were based on systematic sampling**

Since 1981 NFI was launched with the creation of the FSI

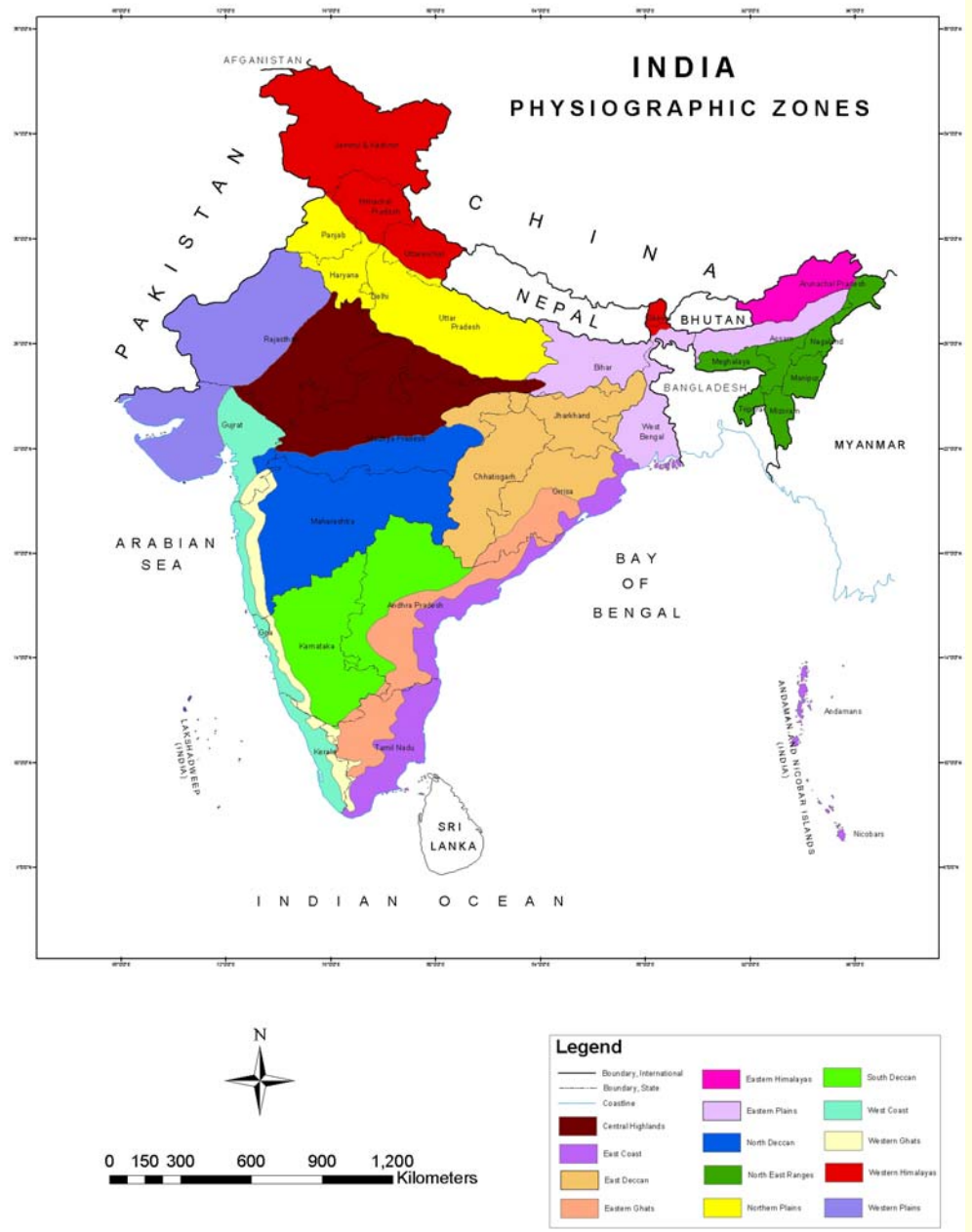
- **The country was divided into grids of 2.½' x 2.½' and Systematic sampling was followed by taking two plots of 0.1 ha in each grid.**
- **Each year only selected districts were covered due to limitation of manpower and reports were produced**
- **About 3/4th of the country's forests were inventoried in 20 years but no reliable estimate at national level of growing stock could be generated .**

Revised Methodology of NFI since 2001

- The basic goal is to estimate growing stock of forests and TOF on a two year basis and improve the estimate in subsequent cycles. However,all the districts of the entire country will be covered in 20 years.
- For this purpose, the country has been stratified into 14 physiographic zones
- Ten percent (60) districts are covered in every two year cycle.
- The districts are selected randomly within each zone with probability proportion to size.
- Along with the Forest inventory, vegetation survey of herbs and shrubs is also carried out.
- Measurement of soil and litter carbon is also carried.

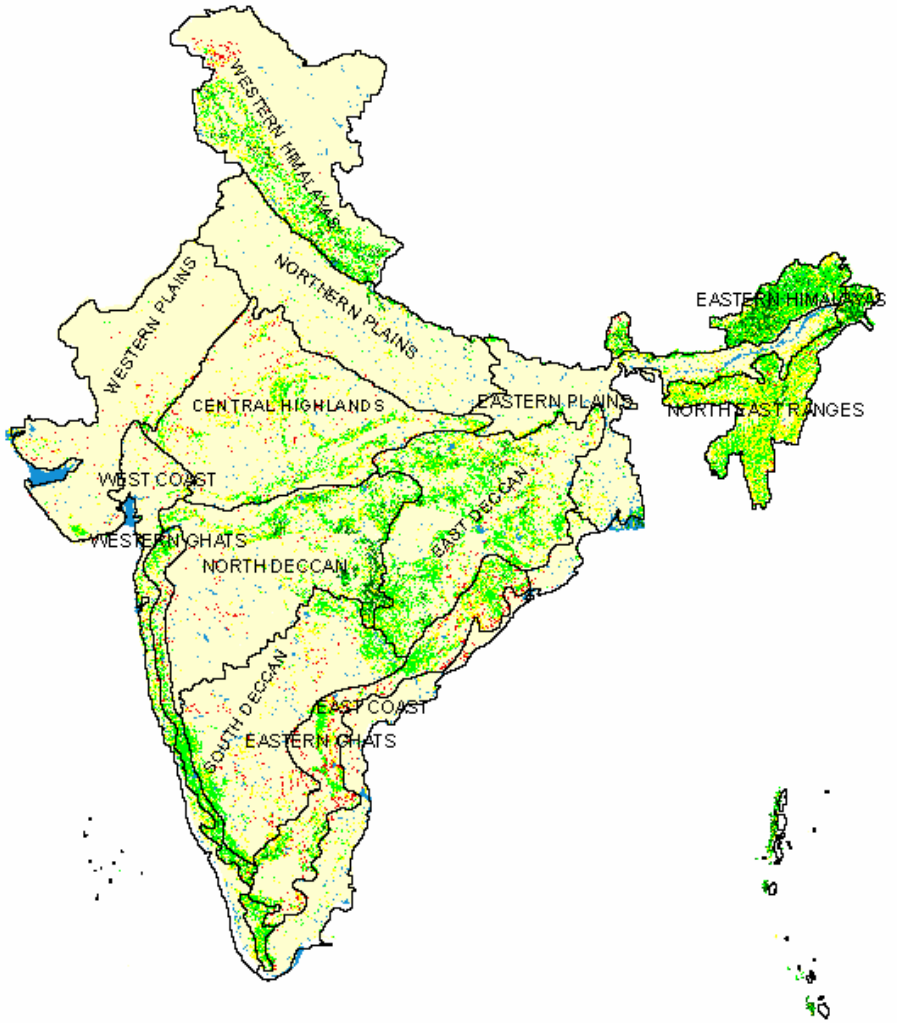
Revised Methodology of NFI--contd

Physiographic Zone Map of India



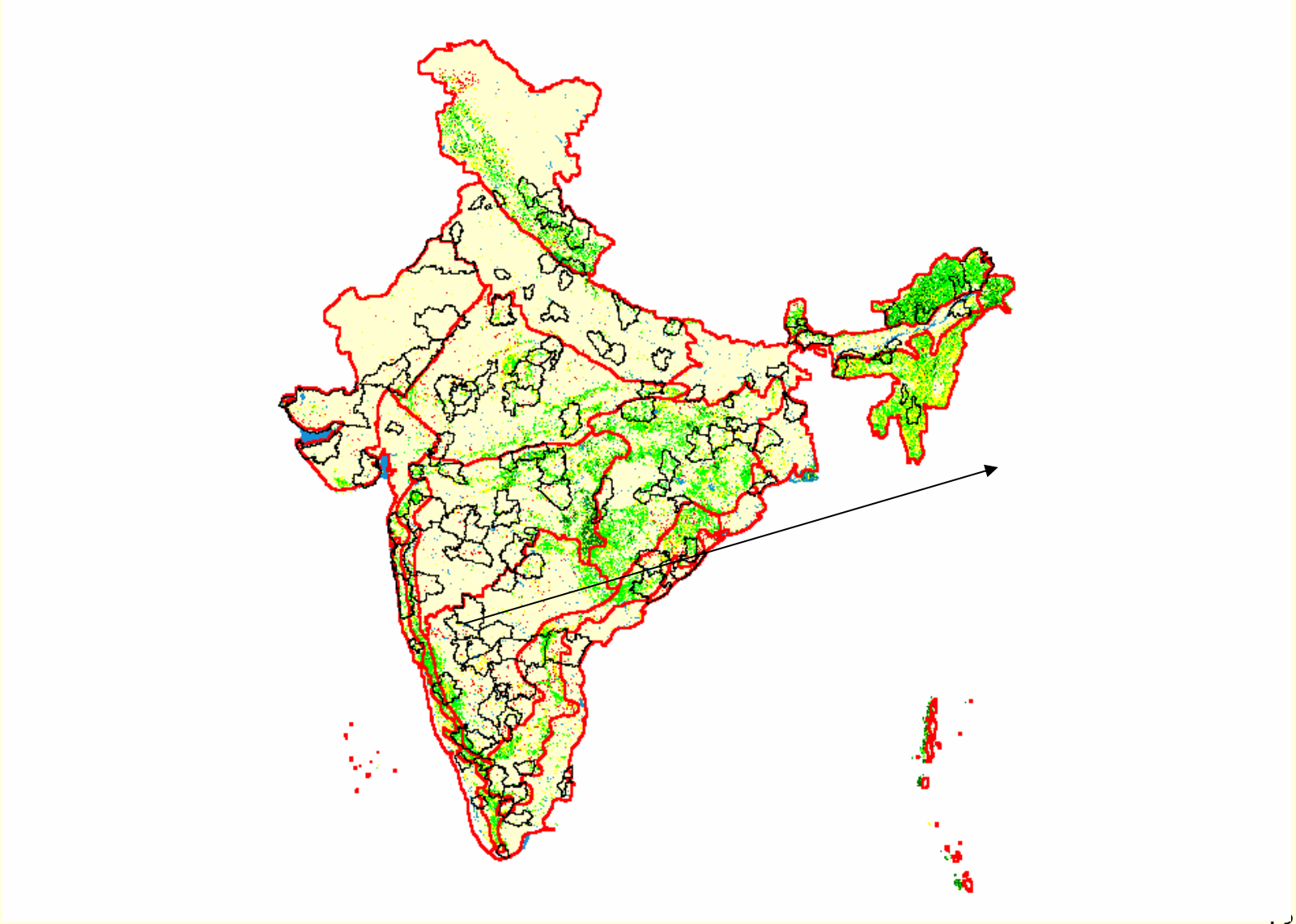
Revised Methodology of NFI--contd

Physiographic Zones on Forest Cover



Revised Methodology of NFI--contd

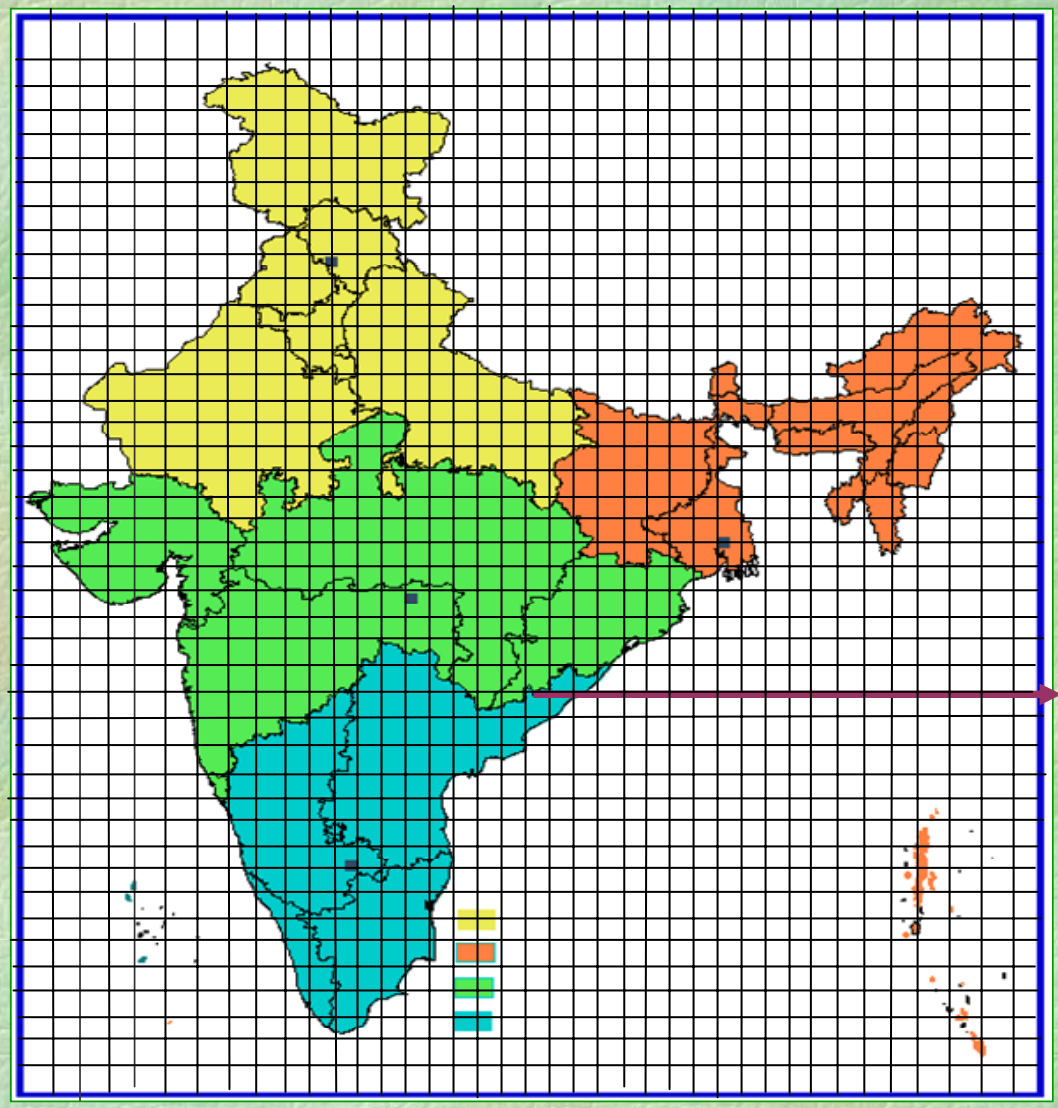
Randomly Selected 60 districts



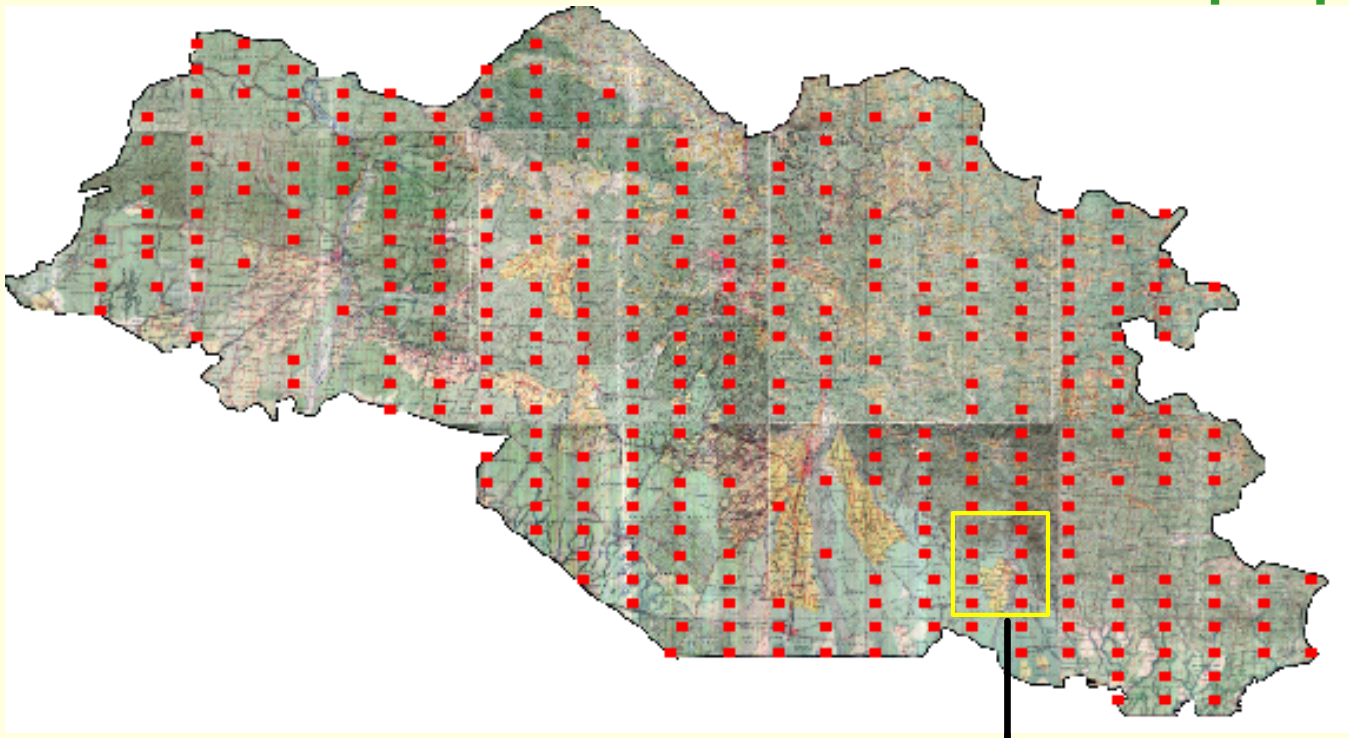
Revised Methodology of NFI --contd

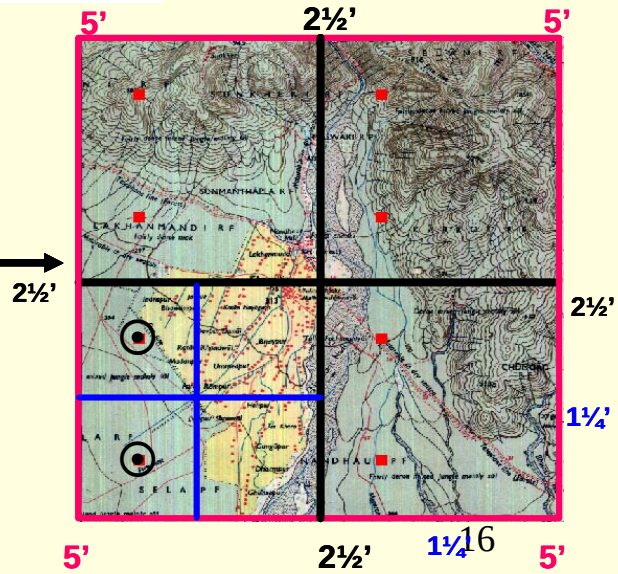
- Topographic sheets of 1:50,000 scale forms the base map for the inventory.
- Firstly, the topographic is divided into grids of 2 ½′ × 2 ½ ′.
- Within each such grid, four sub grids of size 1 ¼ ′ × 1 ¼ ′ are laid.
- Two sub grid are then randomly selected.
- Sample plots are then laid in each sub-grid at the intersection of the diagonals.

Forest inventory grids- 171,000



Distribution of sample plots in a District



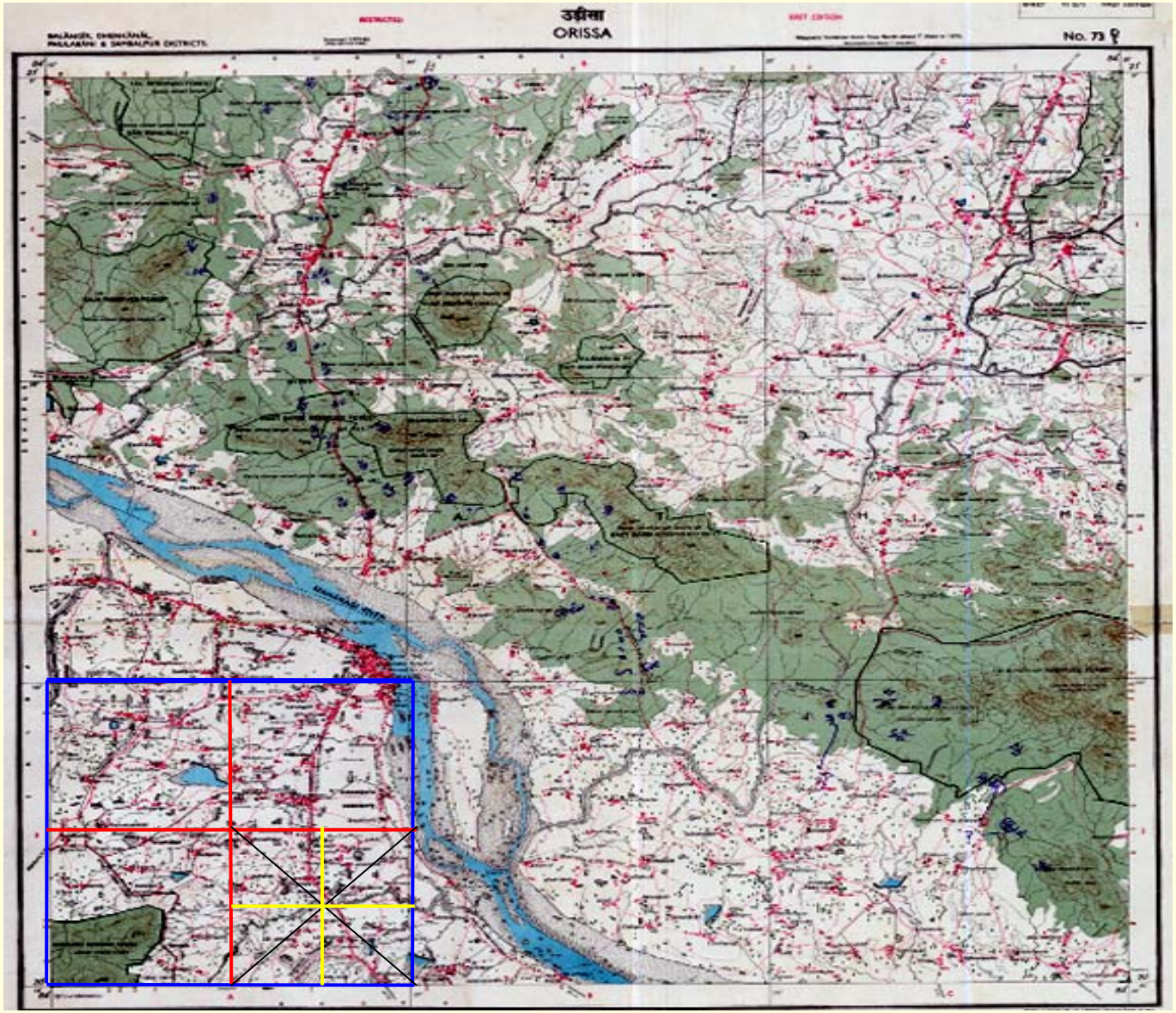


TWO SAMPLE PLOTS

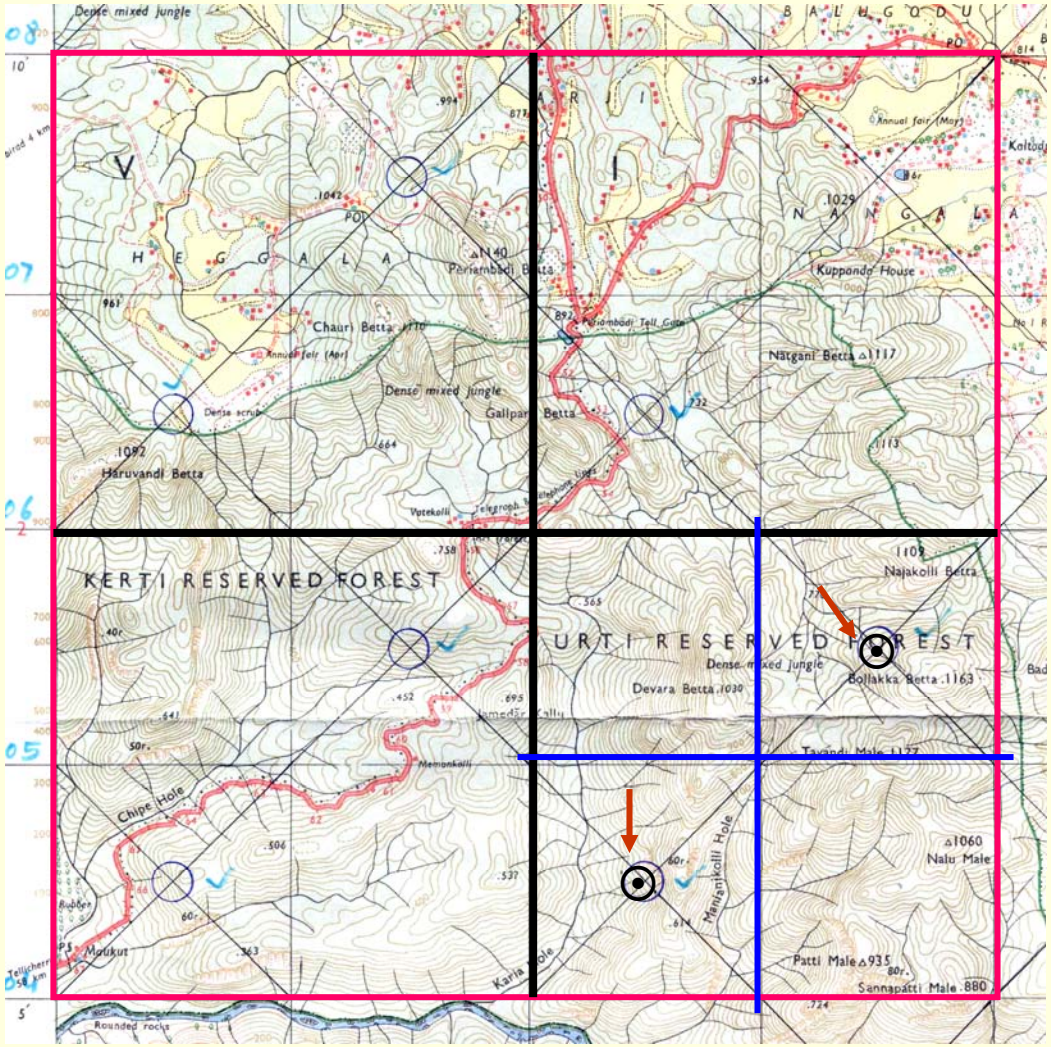
ARE SELECTED BY TAKING

CENTER OF 1¼'X 1¼' GRID

Topographic sheets on scale 1:50,000 (15'×15' Grid)



Marking of Plots

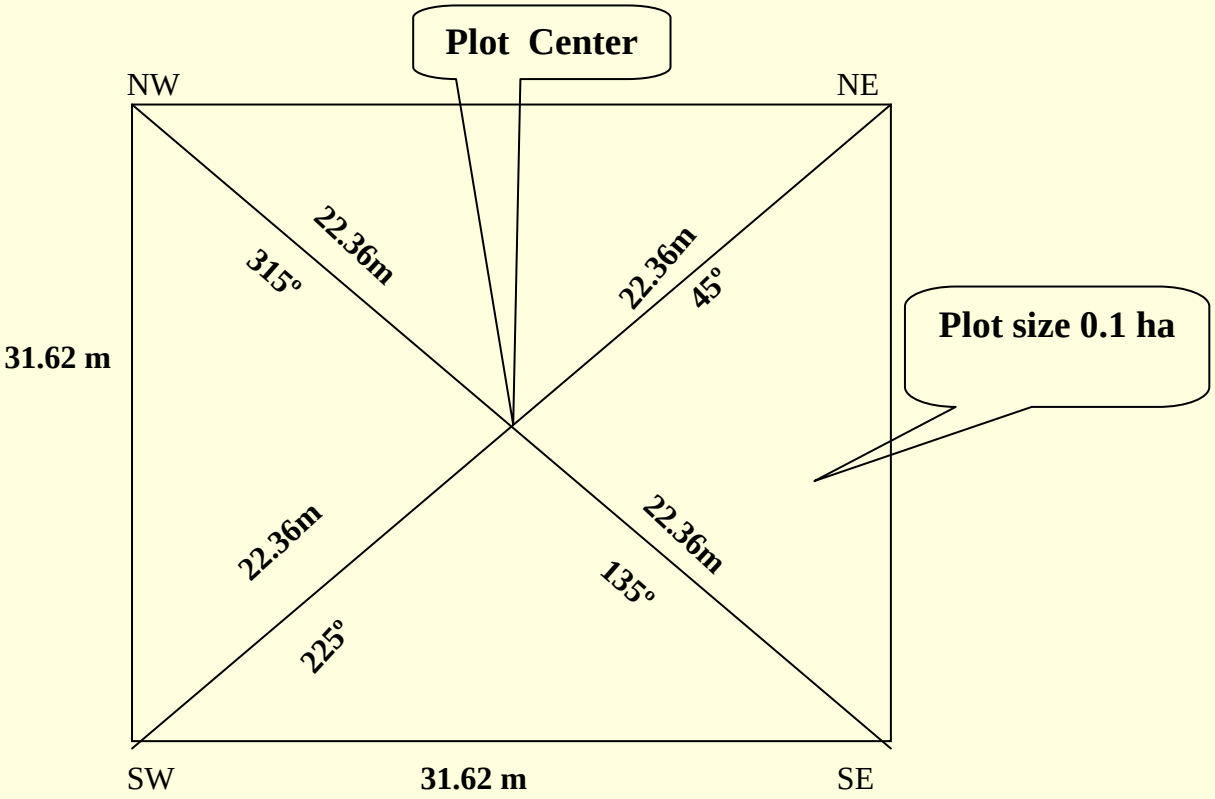


Out of four **1¼'X 1¼'** grids made from **2½' X 2½'** grid only **TWO SAMPLE PLOTS** are selected at the grid centres of **1¼'X 1¼'**

Revised Methodology of NFI -- contd

- At grid centre a square plot of 0.1 ha is laid out
- Measurement of various parameters like dbh, species name, crown-diameter etc.for all trees above 10 cm dbh are carried out.
- For litter and humus and soil carbon, two sub plots of 1 sq. m are laid out on opposite corners of the inventory plot (0.1 ha).
- Samples of litter and humus and soil are then collected from all the sub-plots.

Laying out of the main sample plot



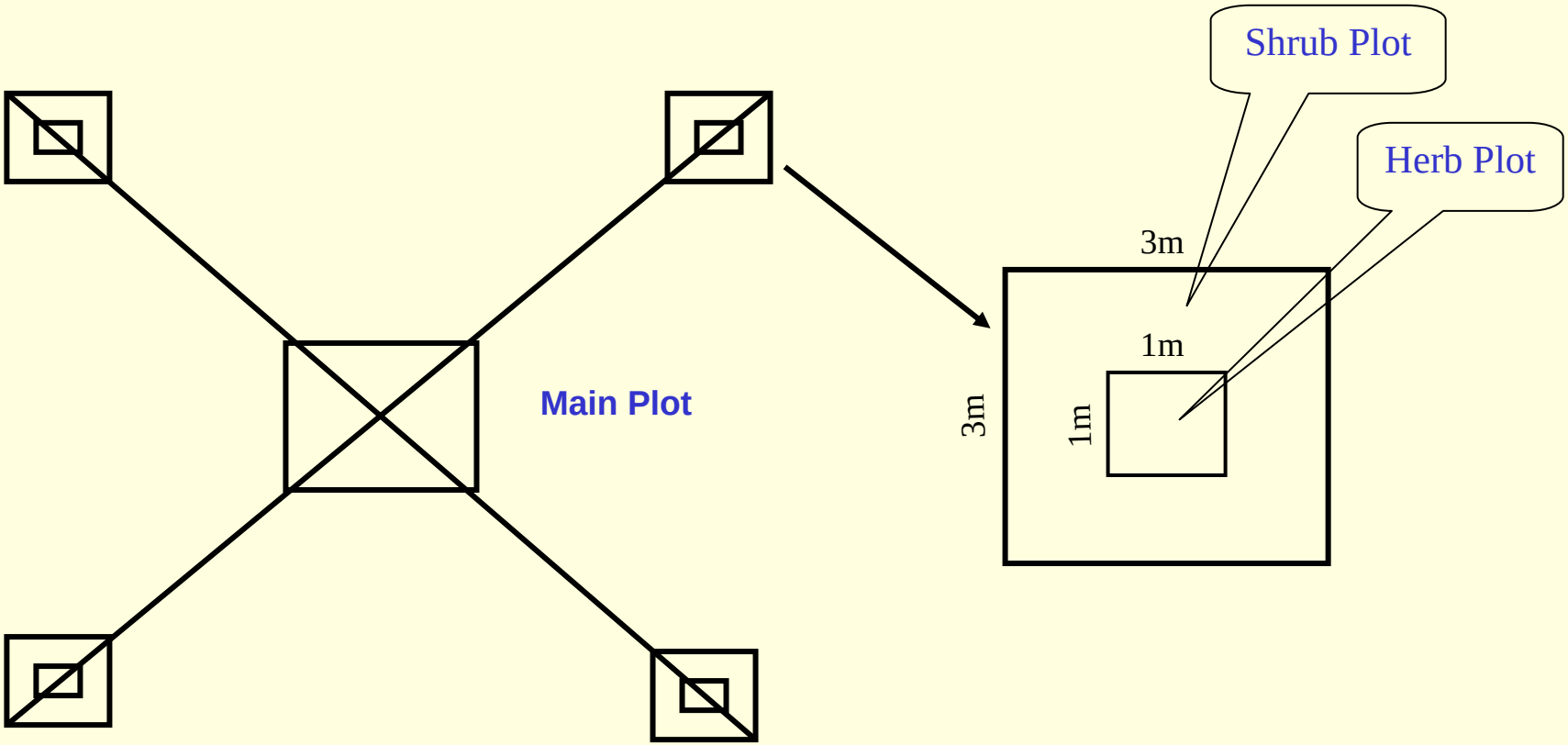
Revised Methodology of NFI--contd

- Further, from the centre of the plot measurements are done along the diagonals in all the 4 directions and points are marked at a distance of 30 meters

- Nested quadrats of 3m $\times$ 3m for shrubs and 1m $\times$ 1m for herbs are then laid out. Regeneration Survey is also carried out in 3m x 3m plots.

- Besides regeneration status it provides information about Plant biodiversity, distribution & abundance.

Nested quadrates with main plot for measuring additional parameters



ORGANISATION

FSI (Headquarters)
DEHRADUN

Zonal Offices

- **North Zone** Shimla
- **East Zone** Kolkatta
- **Central Zone** Nagpur
- **South Zone** Bangalore

Revised Methodology of NFI -- contd

- Data collection, data entry and data checking is done by the four zonal offices located in different part of the country
- Partial data checking, data processing, analysis and output production is done in the headquarters at Dehradun
- More than 250 volume equations developed covering most of the tree species growing in different physiographic zones are used for estimating growing stock.
- The estimated cost of inventory and data processing of a sample plot is about US$ 200.00 per plot of which about US$110.00 is spent on travel to sample plot, field measurement including checking by supervisors and the rest on field preparation, equipment, designing, data entry, processing etc

Measuring forest degradation

- **Since NFI is carried out in India since 1981, many districts have been revisited by now.**
- **Inventory results are available for measuring the broad degradation status (growing stock, no. of tree stems and tree species) of the revisited districts between the two periods.**

Comparison of two time inventory results of selected districts

Sl. No.	District	Year of Inventory	Veg. Area (km^2.)	Crop Comp.(tree species)	Vol/ha (m^3)	Stems/ha
1	West Kameng (Arunachal Pradesh)	1982 - 83	2,427	Broad Leaves (75%), Pine (25%)	143	208
		2005 - 06	3,411	Misc. (38%), Oak (25%), Upland HW (23%), Pine (9%), Bamboo (5%)	118	266
2	Bijnore (Uttar Pradesh)	1981 - 83	493	Misc. (80%), Sal (16%), Teak (4%)	85	261
		2003 - 04	401	Misc. (47%), Khair (17%), Sal (14%), Teak (11%), Lowland HW (11%)	99	316
3	Jhabua (Madhya Pradesh	1981 - 82	1,268	Misc. (54%), Teak (38%), Salai (8%)	27	161
		2005 - 06	998	Misc. (54%), Teak +Misc. (29%), Teak (17%)	22	104
4	Shimoga (Karnataka)	1983 - 84	3,871	WGSE (44%), Deciduous (26%), WGE (22%), Teak (8%)	75	196
		2003 - 04	2,970	Misc. (64%), LowlandHW (20%), Mixed Bamboo (8%), Teak with misc. (8%)	114	301
5	West Garo Hills (Meghalaya)	1986 - 88	2,065	Misc. (85%), Sal (11%), Teak (3%)	92	183
		2004 -05	1,093	Misc. (74%), Bamboo (21%), Teak (2%), Sal+Misc. (1%), Mixed Bamboo (1%)	32	142
6	Thane (Maharastra)	1984 - 85	2,806	Teak (54%), Misc. (46%)	46	189
		2002 - 03	3,165	Teak+Misc. (44%), Misc. (37%), Teak (16%), Lowland HW (2%)	39	191

Inventory of Trees Outside Forests (TOF)

- **TOF resource has become most important in today's context in India as most of timber requirement of industries have to met from TOF**
- **In the present methodology, high resolution satellite data (5.8 m) is used to identify TOF patches and stratify the same into**

  -block,

  -linear and

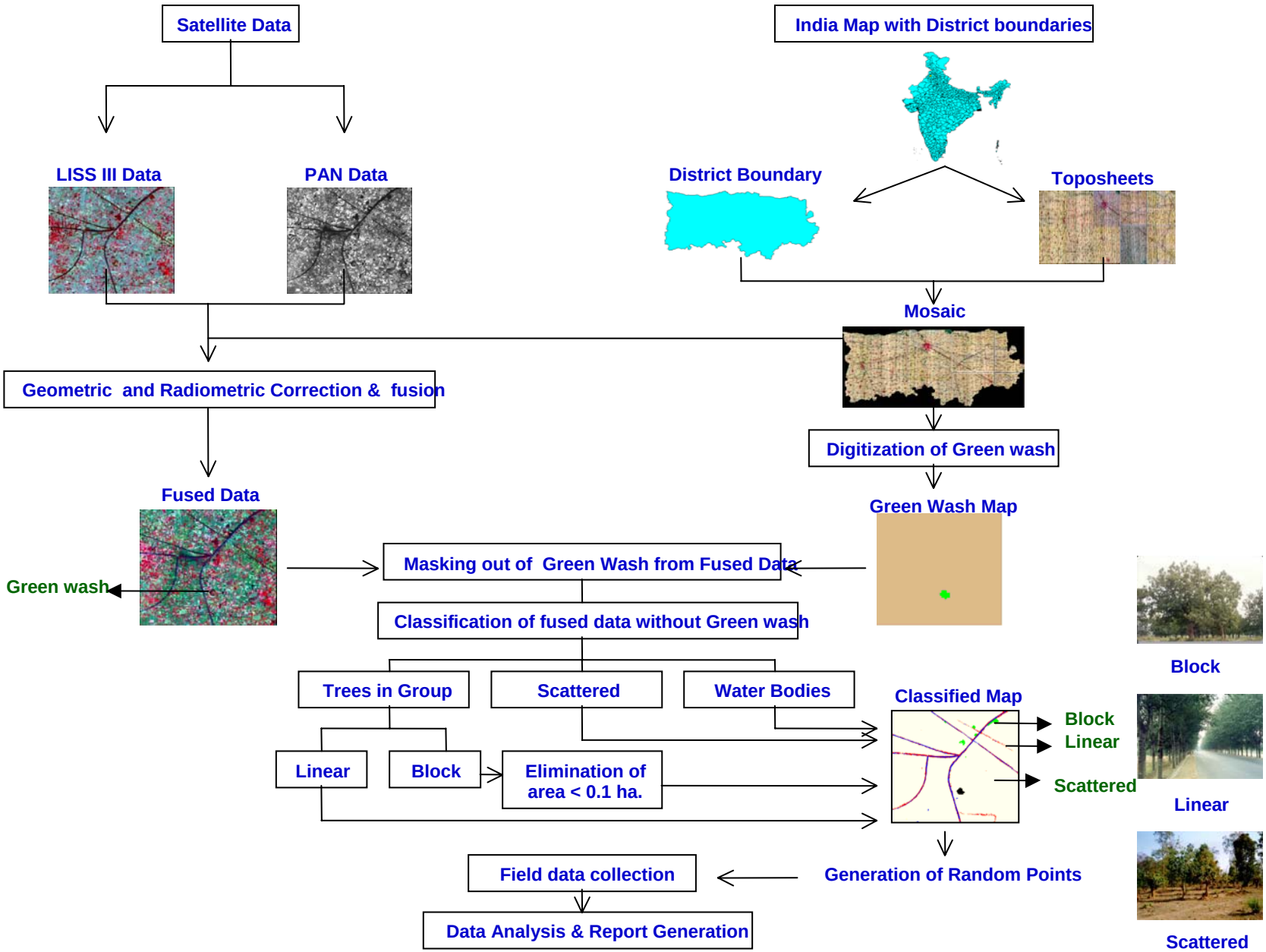
  -scattered strata
- **After the stratification appropriate sample plots are laid on the ground for field inventory.**
- **On average 4000 sample plots are laid every year.**

TREES GROWING IN AGRICULTURAL FIELDS

AILANTHUS EXCELSA & ACACIA NILOTICA ON FARM BUNDS

Casurina in private land

METHODOLOGY FOR ASSESSMENT OF TREE OUTSIDE FOREST USING REMOTE S ENSING DATA



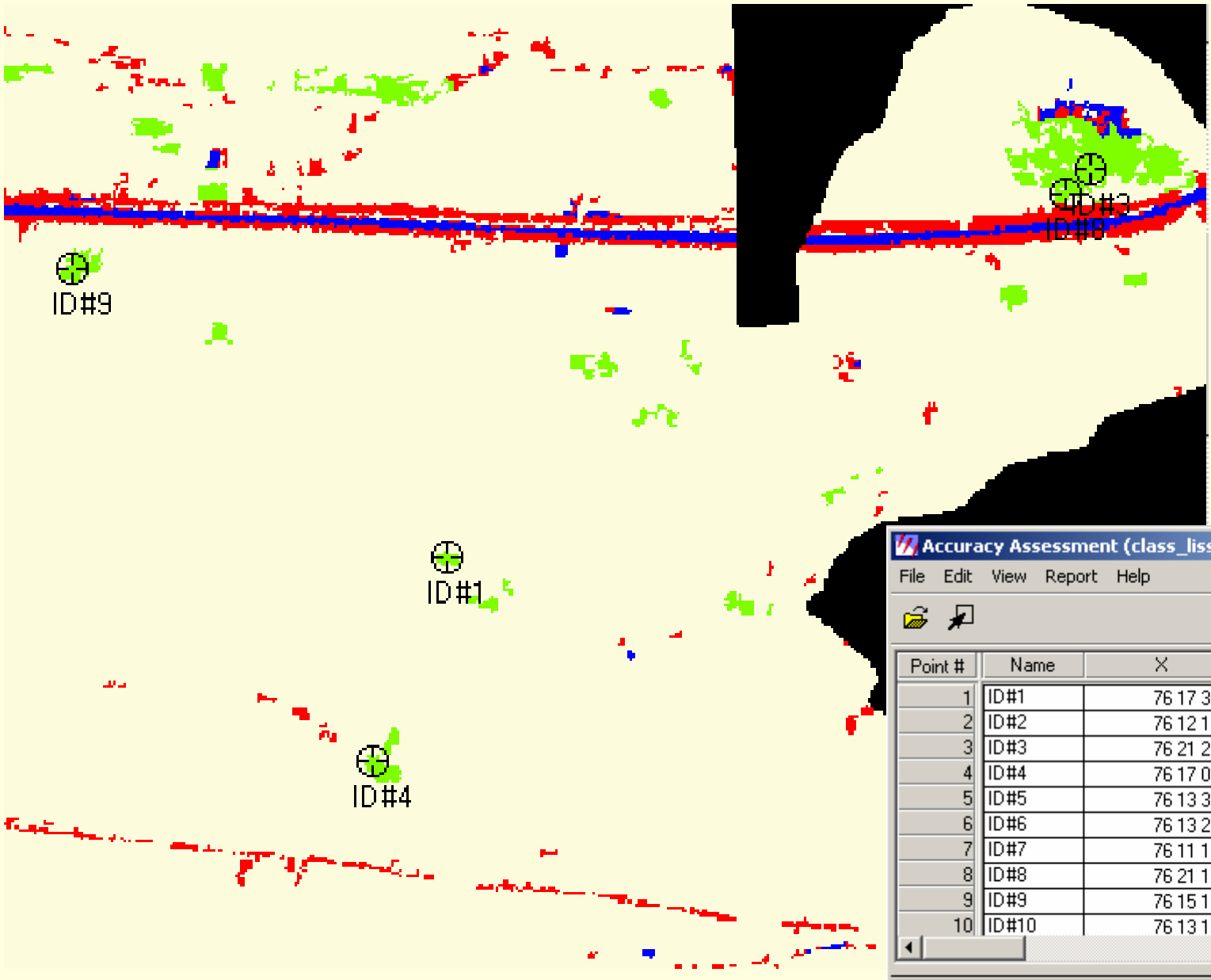
Plot Size & Number of Samples in rural TOF per district

Strata	Plot size	No. of samples
Block	0.1 ha	35
Linear	10x125 m	50
Scattered	3.0 ha	50
Scattered (Hill)	0.5 ha	95

- Random points for block, linear & scattered stratum along with coordinates communicated to field parties for survey

- Sample points in field are approached by using GPS & data recorded in prescribed formats

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



Accuracy Assessment (class_liss.img) - Viewer# 1

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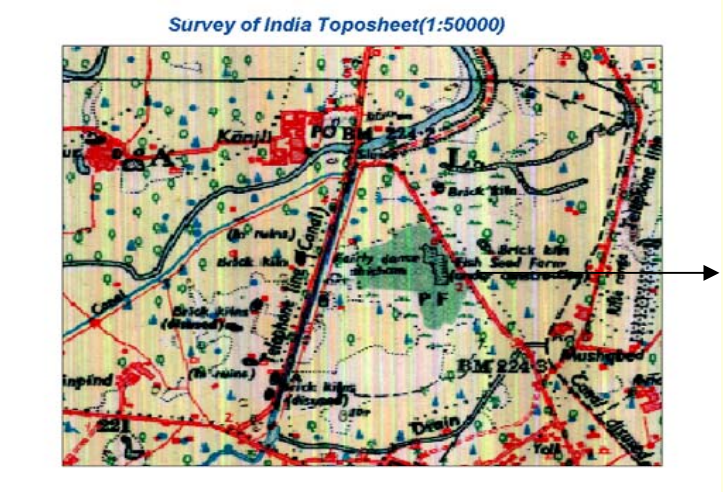
Point #	Name	X	Y	Class
1	ID#1	76 17 31 E	30 51 18 N	
2	ID#2	76 12 14 E	30 48 54 N	
3	ID#3	76 21 28 E	30 53 42 N	
4	ID#4	76 17 02 E	30 50 02 N	
5	ID#5	76 13 30 E	30 58 58 N	
6	ID#6	76 13 22 E	30 57 50 N	
7	ID#7	76 11 16 E	30 59 52 N	
8	ID#8	76 21 18 E	30 53 31 N	
9	ID#9	76 15 10 E	30 53 02 N	
10	ID#10	76 13 12 E	30 59 02 N	

- The green wash area (forest) is digitized from the toposheet and is masked out from the merged image.

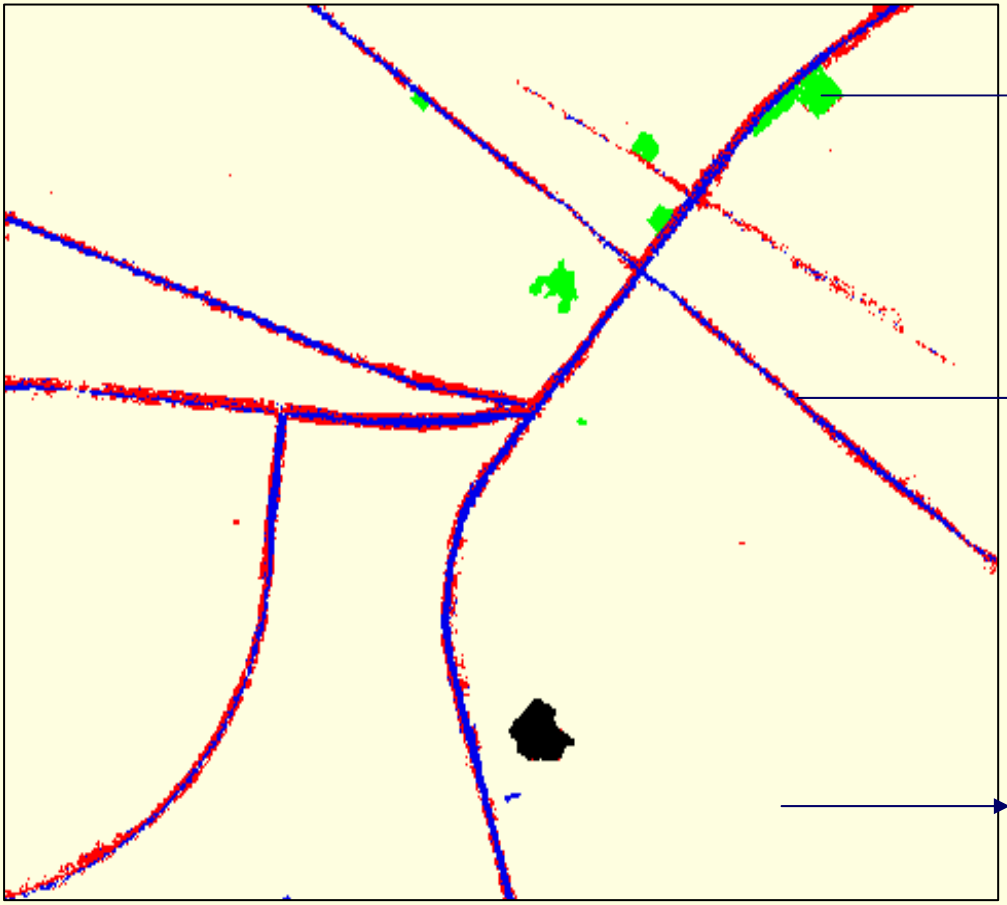


Green wash masked out

Then Unsupervised classification is performed

- 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 Map



Field Inventory of Urban TOF

Urban trees have mainly environmental functions-

- **In India urban areas are categorized into 5 classes (strata) based on population**
- **Urban Frame Survey (USF) blocks of National Sample Survey Organization (NSSO) are taken as sampling units by FSI**
- **Optimum number of UFS blocks are selected in each district for the survey as follows**

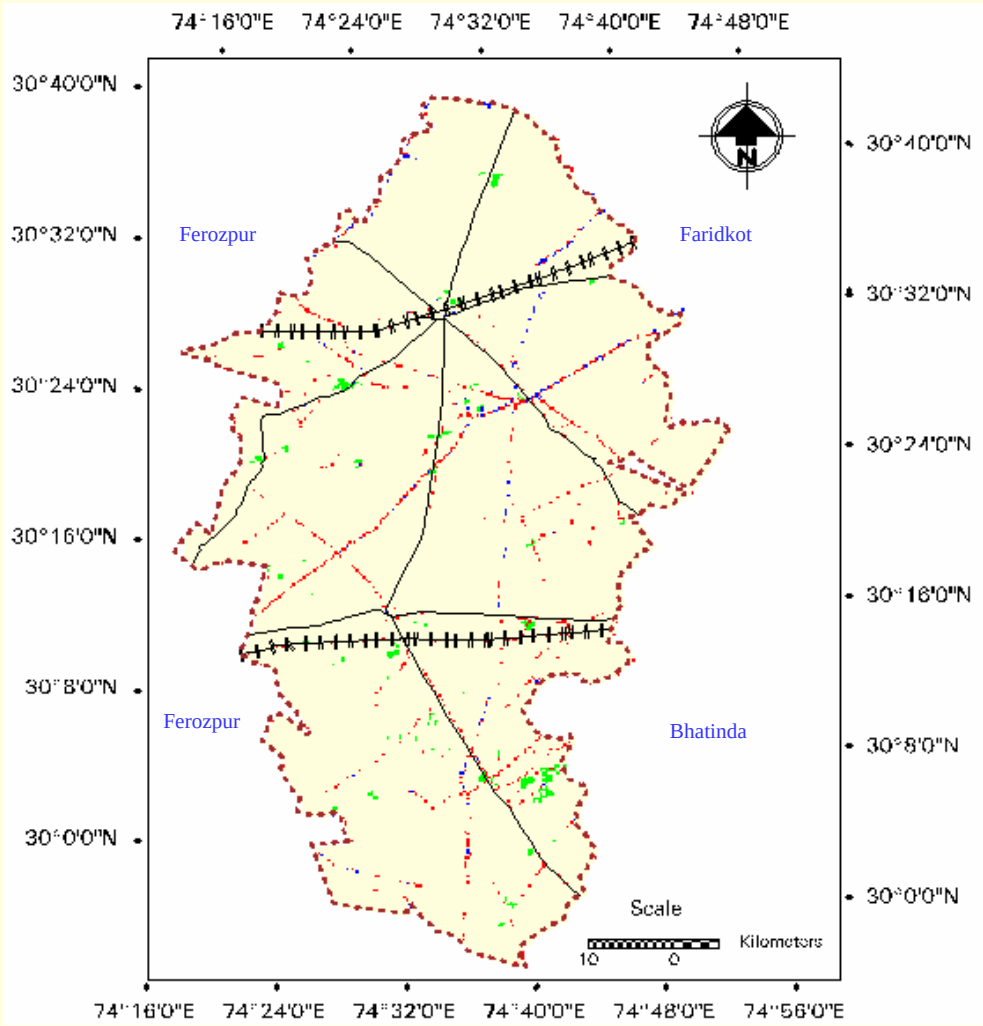
  If UFS blocks < 500 10 % selection
  min 20 blocks

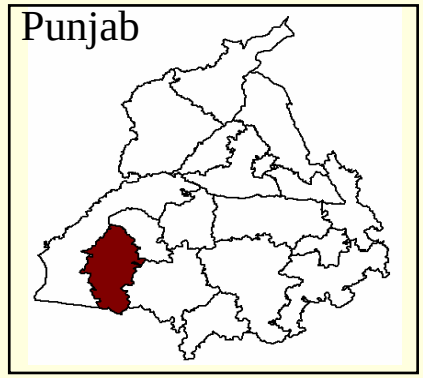
  UFS blocks > 500 5 % selection
  min 50 or max 60 blocks

- **Data is collected on the designed formats on various parameters and all trees are measured**

Trees Outside Forest Map of Muktsar District

Based on Digital Classification of fused data (IRS 1D LISS-III & PAN)





Legends

- Forest Cover (Masked Out)
- Linear Stratum
- Block Stratum
- Scattered Stratum
- Road
- Railway
- Restricted Area
- Water Bodies
- River Bed

ASSESSMENT OF GROWING STOCK, BIOMASS & CARBON IN INDIA'S FOREST AND TREE OUTSIDE FOREST RESOURCES

ACTIVITIES

Forest Inventory

-Growing Stock

-Number of trees

→ Carbon storage in trees

Vegetation Survey
-Plant diversity indices
-Regeneration survey
-NWFP assessment

Soil Carbon
-Soil carbon
-Carbon in forest floor

Assessment of TOF

Rural
-Growing Stock
-Number of trees
→ Carbon storage in TOF rural

Urban
-Growing Stock
-Number of trees
→ Carbon storage in TOF urban

OUTPUT:

- **Estimation of growing stock, biomass of trees within & outside forest**
- **Carbon stored in trees within & outside forest**
- **Carbon stored in soil & forest floor**
- **Regeneration survey**
- **Assessment of NWFPs**
- **Assessment of Plant diversity indices**

Methodology for conversion of Growing Stock into Carbon

Growing stock of species × specific gravity of species = Biomass

Biomass × carbon percentage (species wise) = Carbon content


THANKS /
Merci
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