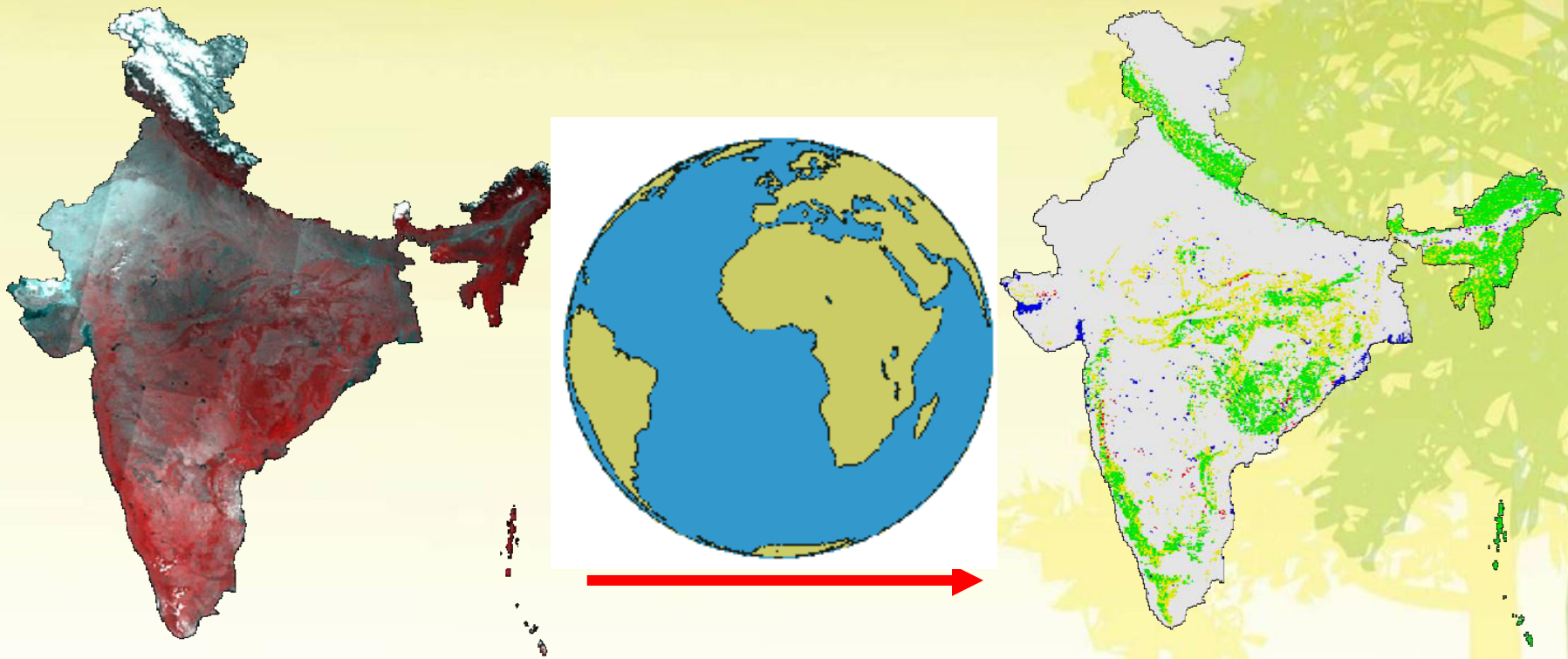# REDD+ MRV and Forest Carbon Accounting in India

Forest and Climate Change
17 – 18 October, 2016, IGNFA, Dehradun

Requirement of Forest carbon accounting

- **It is required for understanding Climate Change dynamics**

- **Climate change mitigation options**

  CDM projects, REDD+ etc

- **International Reporting - UNFCCC, GFRA etc.**

- **It is one of the Eco-System-Service**

- **Information being USED**

  - **Calculation of NPV,**

  - **Calculation of Green GDP and,**

  - **XIV Finance Commission for fund allocation to states**

Definitions

- **Forest -** Forest is defined structurally on the basis of

  - **Crown cover** percentage: Tree crown cover - 10 to 30 % (India 10%)

  - **Minimum area** of stand : area between 0.05 and 1 ha (India 1.0 ha), and

  - **Minimum height** of trees: Potential to reach a minimum height at maturity in situ of 2 to 5 m (2m)

   - *(Decision 19/CP9) - Kyoto Protocol definition)*

Definitions

- **Deforestation**–"Permanent removal of forest cover and withdrawal of land from forest use, whether deliberately or circumstantially."

  (Intergovernmental Panel on Climate Change, 2000)
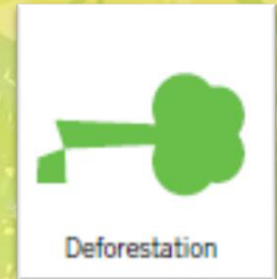
Deforestation

- **Forest Degradation** - "Changes within the forest class that negatively affect the stand or site and, in particular, lower the production capacity. Thus, degradation is not reflected in the estimates of deforestation"
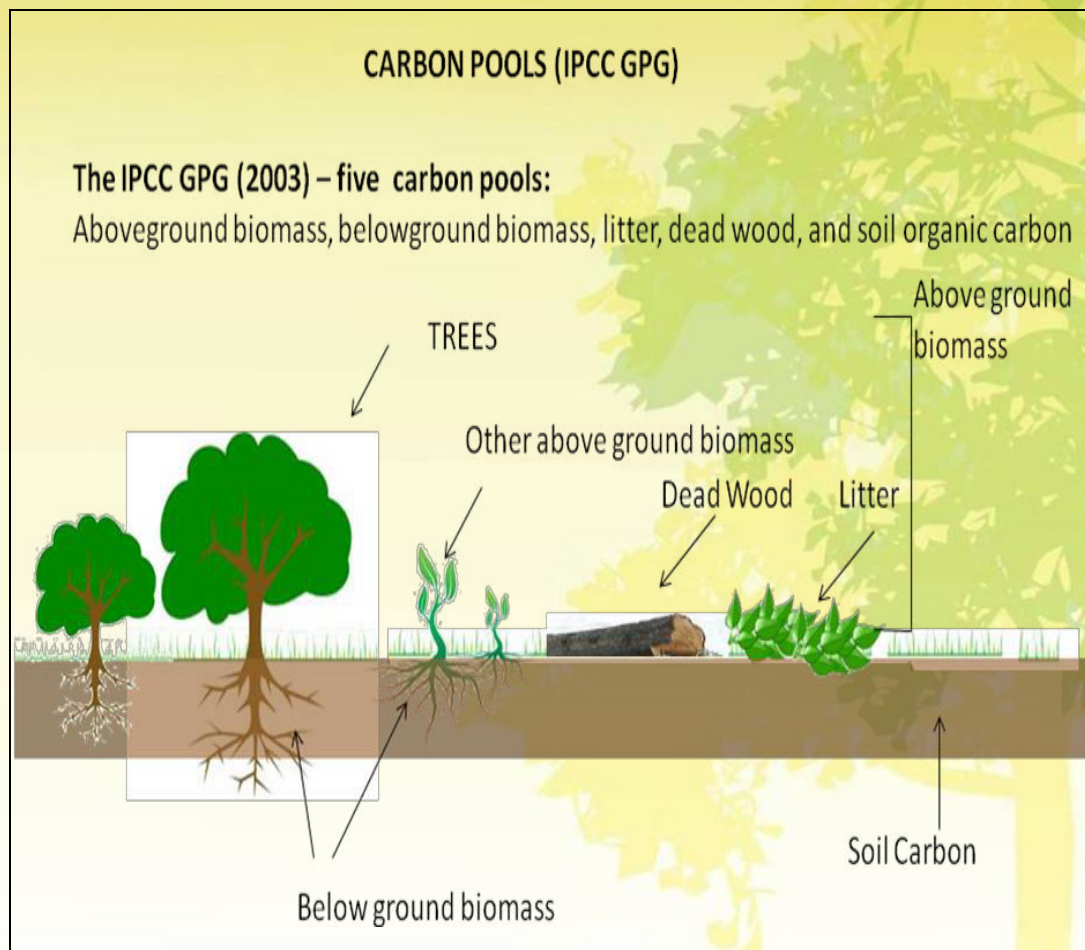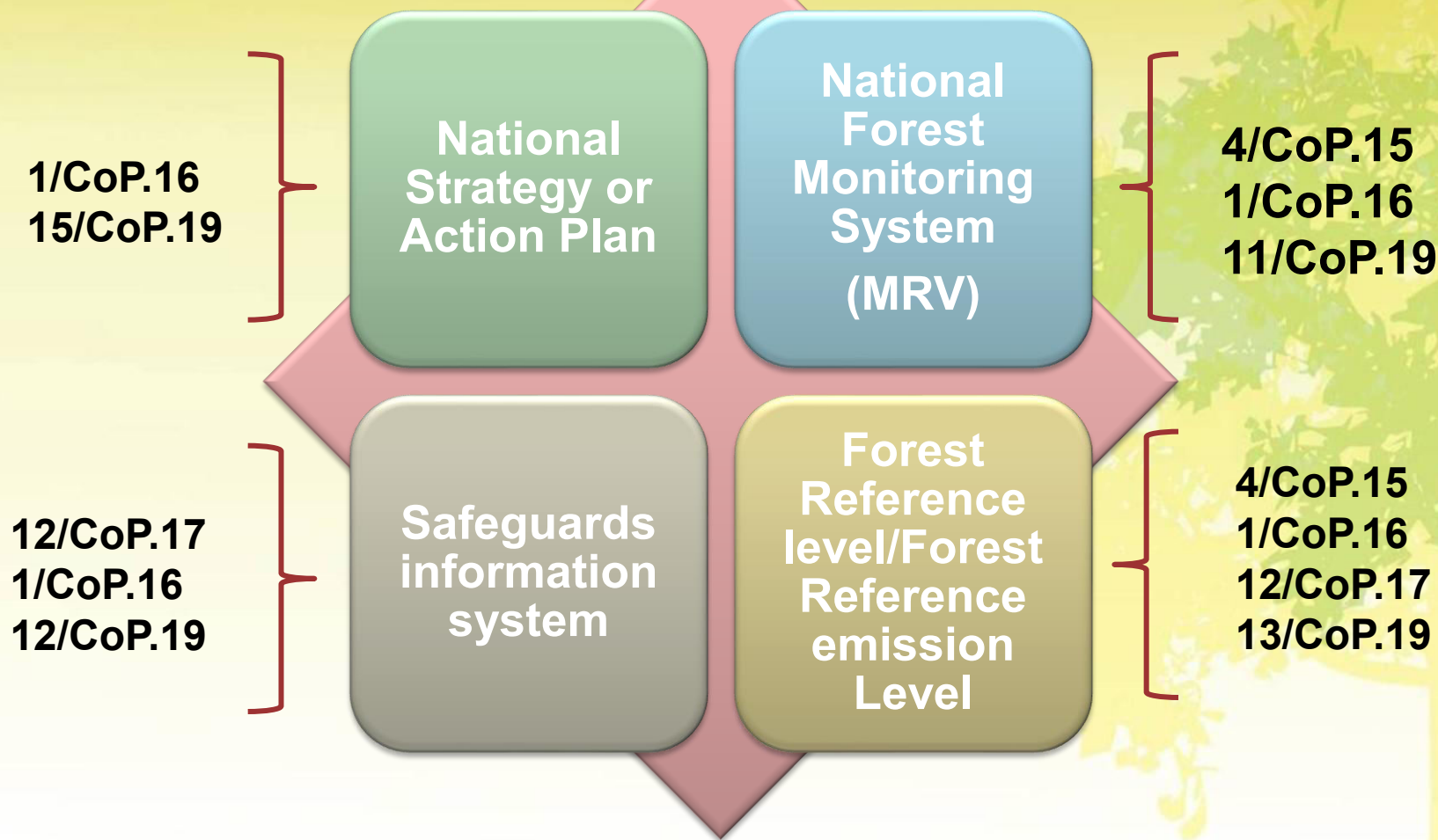
  (Food and Agriculture Organization, 1995b)

Degradation
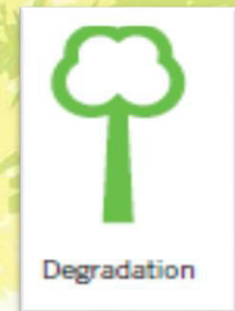
Various Forest Carbon Pools

UNFCCC recognizes following 5 pools

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

CARBON POOLS (IPCC GPG)

The IPCC GPG (2003) – five carbon pools:
Aboveground biomass, belowground biomass, litter, dead wood, and soil organic carbon

TREES

Other above ground biomass

Dead Wood   Litter

Above ground biomass

Soil Carbon

Below ground biomass

Key Elements of REDD+ and UNFCCC Decisions

1/CoP.16
15/CoP.19

National Strategy or Action Plan

National Forest Monitoring System (MRV)

4/CoP.15
1/CoP.16
11/CoP.19

Safeguards information system

Forest Reference level/Forest Reference emission Level

12/CoP.17
1/CoP.16
12/CoP.19

4/CoP.15
1/CoP.16
12/CoP.17
13/CoP.19

National Forest Monitoring System - A Dynamic System

National/Sub-National different 'inventory estimates'- GHG/NTFP etc

Policies & Measures

National Forest Inventory: to have 'factor per unit area'

Monitoring function: To track Policies and Measure

RS based Land Monitoring System: to estimate Activity data
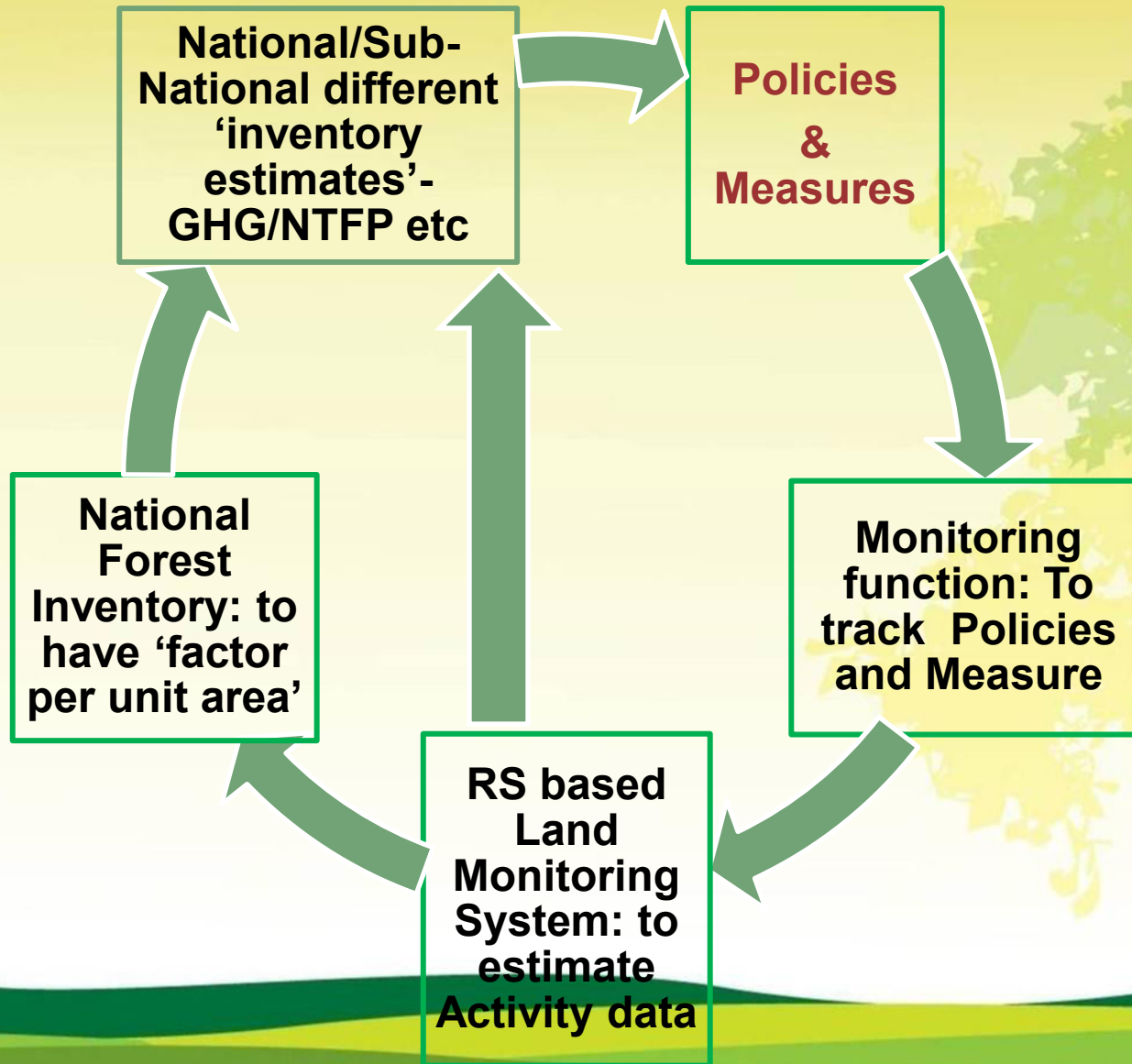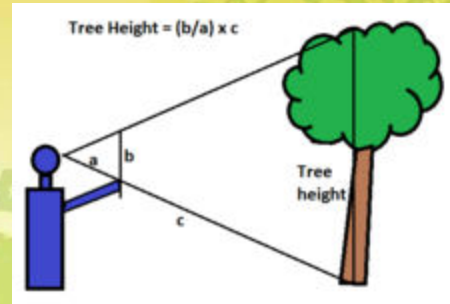
MRV Objectives

- **National REDD+ Reference Levels, Monitoring of result based performance,**
- **Forest Land Use Changes and impacts on carbon,**
- **National Communications to the UNFCCC,**
- **Biennial Reporting,**
- **Project level accounting for voluntary markets**
- **Forest Health and impacts of project activities**

What is MRV?

- **Measurement**
- Field and RS data collection, calculation.

M

- **Reporting**
- Documentation and recording of measured parameters and methodology used.

R

- **Verification**
- Internal and External audits of steps M and R.

V

Measurement, Reporting & verification (MRV)

- **For reporting GHG mitigation performance of REDD+ activities to the UNFCCC the technical requirements are**:

    – Satellite data based land monitoring system (activity data)

    – National forest inventory system (emission factors)

    – GIS interface (for integration)

    – Links to ground-level community monitoring

Three phases approach to REDD+

- **Phase I: development of a national plan, policies and measures, and capacity-building**

- **Phase II: implementation of national plan, policies and measures - demonstrative activities**

- **Phase III: results-based actions with full measurement, reporting and verification**

Measurements

- Activity data
  - Area change data
  - Achieved using satellite remote sensing
- Emission factors
  - Forest carbon stock and carbon stock change data
  - Data are obtained from a national forest inventory (NFI)
- This information provides the basis to compile GHG inventory
- GHG inventory: GHG accounting to determine national mitigation performance

Basic Input information requirement

GHG inventories require information

- **Activity data** on extent of an emission or removal category

- **Emission factors** GHG per unit of area (removal of CO_2 per ha of added forest area)

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

Approaches for activity data

Three different approaches are given in the IPCC GPG

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

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

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

Preparing for REDD+ ? only Approach 3

Tiers that are used for the emission factors

Tiers for emission factors: change in Carbon stocks

Tiers 1: IPCC default values

Tiers 2: Country specific data for key factors

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

Preparing for REDD+?   Only tier 3 may play.

Reporting

- **Reporting GHG mitigation performance to the UNFCCC as part of national communication**

- **Information on emission and removals of GHGs and details of mitigation activities - core element national communications**

- **Frequency: Cancun Agreement**

  - **National communication to COP every four years**

  - **Submit and update reports (BUR) every two years**

Verification

- Independent checking of accuracy of the GHG inventory or the procedures used to generate information

- Coordinated by UNFCCC secretariat

- A team of experts visit the country for 1-2 weeks

- Methods: interviews with key government officials and national NGOs; analysis of reports, media reports, training materials

- REDD+ payments cannot be distributed until verification takes place

MRV in steps

Involves 7 steps

| Land use category and estimate the area | Select the carbon pools | Ensure appropriate tier levels | Quantification of GHG | Reporting | Documentation | Internal and external checking |

MRV Steps 1-2

Identify land use category; estimate area under each land use category.

- Six classes: forest land, cropland, grassland, wetlands, settlements and other land.
- Remote Sensing analysis used.
- Temporal scale defined

Within the categories assess which carbon pools and non-CO_2 gases are significant.

- Carbon pools are broadly classified into five pools which are placed in three categories:
  - **Living biomass**: Above Ground Biomass (AGB) and Below Ground Biomass (BGB).
  - **Dead organic matter**: Dead wood and Litter.
  - **Soil Organic Carbon** (SOC).

MRV Steps 3-5

Ensuring appropriate tier levels are met.

- **Tier 3, tier 2 or tier 1 data to be selected appropriately.**

Quantification of emissions and removals

- **Based on established methodologies.**
- **Also includes estimation of the uncertainty.**

Report emissions and removals estimates.

- **Transparent reporting in tables to be developed.**
- **Shall involve, *inter alia*, methodology applied, procedures on Quality Assurance and Quality Control (QAQC) checks as well as uncertainty calculations.**

MRV Steps 6-7

Archiving all information used to produce the emissions and removals estimates.

- Appropriate procedure for archiving the data.
- Preferable in hard copy and electronically.

Quality control checks, verification, and expert/peer review of the emission estimates.

- Internal and external checks by competent sources to ensure the veracity of the calculations.

Rules of The Game REDD+?

- Complete rules and methods for REDD+ are **yet to be developed** by UNFCCC and IPCC
  - Rules defining reference emission levels (**REL**) and reference levels (**RL**)
  - Agreed upon **methods to measure** and monitor GHG emissions and removals in REDD+
  - **Safeguards** to protect the forests and forest-dependent people
- **Voluntary** markets for REDD+ are **forging** ahead while the **UNFCCC moves slowly**

Assessment of Forest Carbon Stock for India

- **Forest cover maps,**

- **Forest types maps,**

For estimation and stratification of 'Activity data'

- **National Forest Inventory,**

- **Estimation of missing components of forest biomass, and**

For developing 'Emission factors'

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

FOREST COVER ASSESSMENT OF THE COUNTRY

Forest Cover in India – ISFR 2013

Legend:
- Very Dense Forest
- Mod. Dense Forest
- Open Forest
- Scrub
- Water Body
- Non-Forest
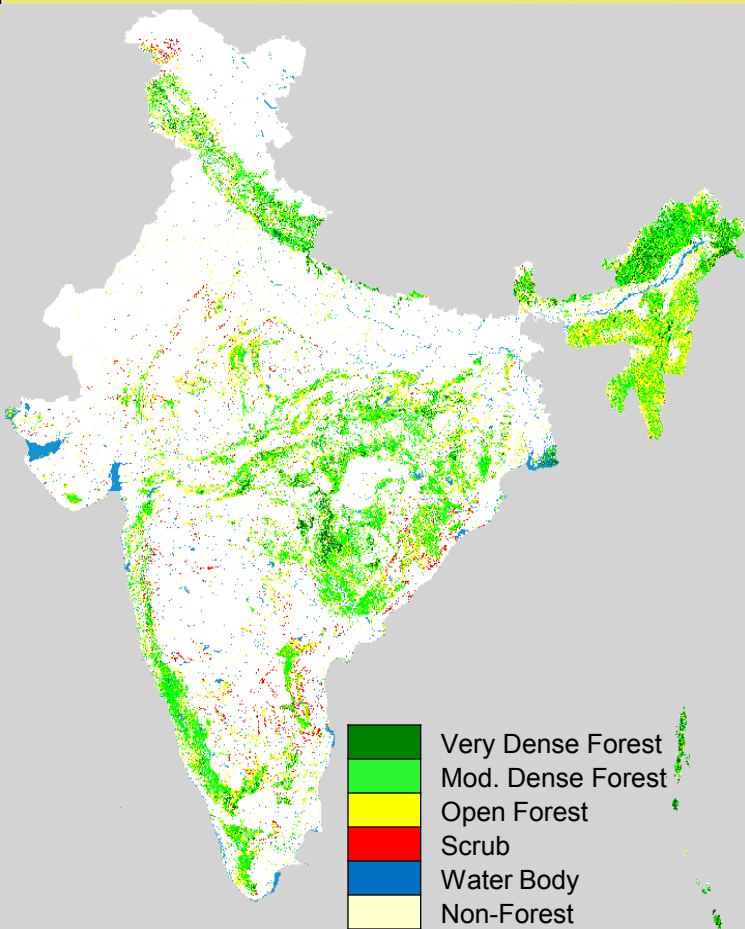
Class	Area (km²)	% of Geo. Area
Forest Cover		
a) **VDF** (>70 %)	83,502	2.54
b) MDF (40-70%)	318,745	9.70
c) **OF (10-40%)**	295,651	8.99
Total Forest Cover	**697,898**	**21.23**
Scrub	41,383	1.26
Other Non-forest	2,547,982	77.51
Total Geo. Area	**3,287,263**	**100.00**

FOREST TYPE ZONES OF INDIA
(Based on Champion & Seth Classification)

Mapping of Forest Types of India
(based on Champion & Seth Classification, 1968)
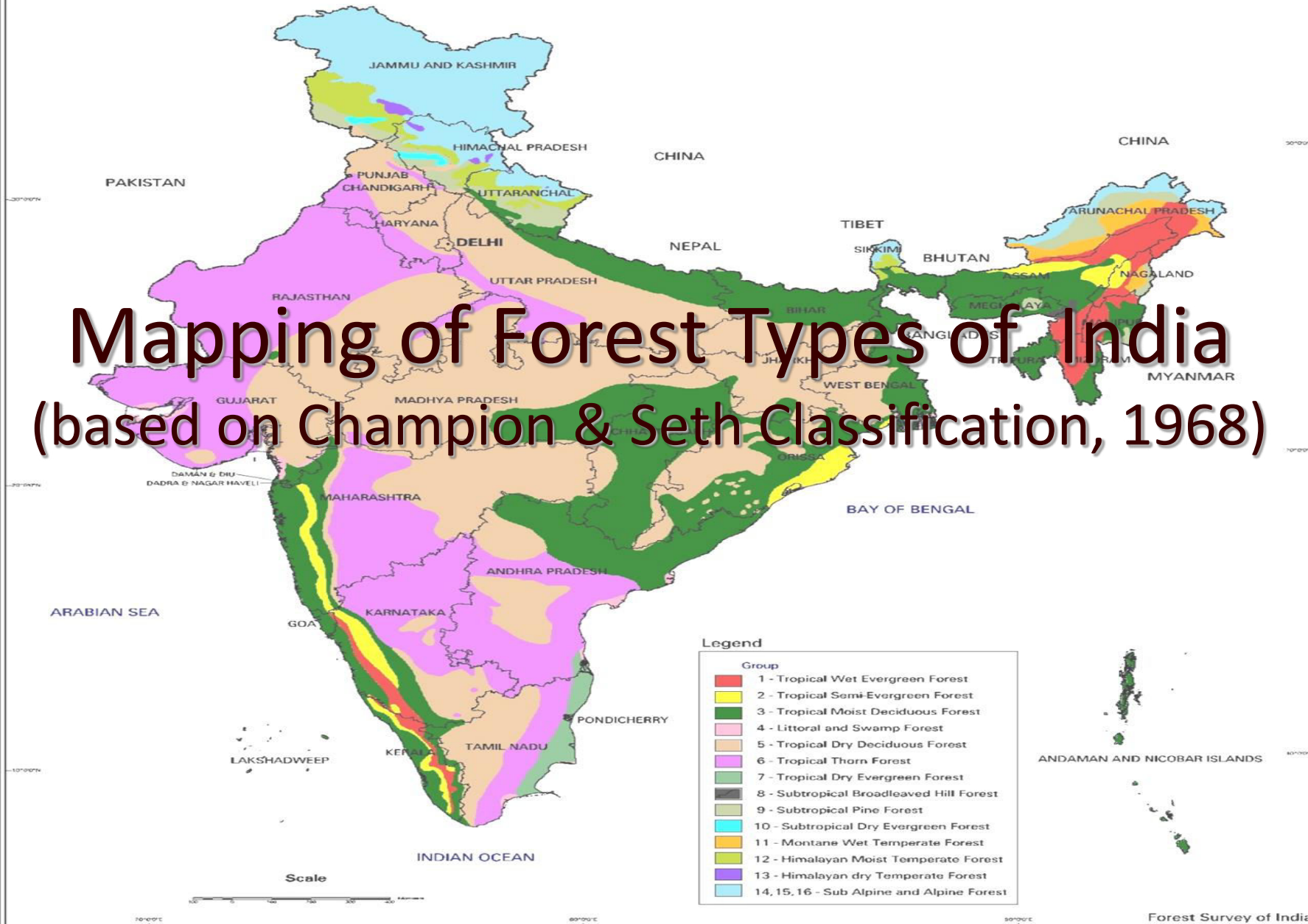
Legend

Group

1 - Tropical Wet Evergreen Forest
2 - Tropical Semi-Evergreen Forest
3 - Tropical Moist Deciduous Forest
4 - Littoral and Swamp Forest
5 - Tropical Dry Deciduous Forest
6 - Tropical Thorn Forest
7 - Tropical Dry Evergreen Forest
8 - Subtropical Broadleaved Hill Forest
9 - Subtropical Pine Forest
10 - Subtropical Dry Evergreen Forest
11 - Montane Wet Temperate Forest
12 - Himalayan Moist Temperate Forest
13 - Himalayan dry Temperate Forest
14, 15, 16 - Sub Alpine and Alpine Forest

Forest Survey of India

Forest Types of India*

MAJOR GROUPS (climate)

1. **Moist Tropical Forests**

2. **Dry Tropical Forests**

3. **Montane Temperate Forests**

4. **Montane Subtropical Forests**

5. **Sub Alpine Forests**

6. **Alpine Scrub**

TYPE GROUPS (temp. & moisture)

Group 1-Tropical Wet Evergreen Forests

Group 2-Tropical Semi-Evergreen Forests

Group 3-Tropical Moist Deciduous Forests

Group 4-Littoral And Swamp Forests

Group 5-Tropical Dry Deciduous Forests

Group 6-Tropical thorn Forests

Group 7-Tropical Dry Evergreen Forests

Group 8-Southern Subtropical Broadleaved Hill Forests

Group 9-Subtropical Pine Forests

Group 10- Subtropical Dry Evergreen Forests

Group 11-Montane Wet Temperate Forests

Group 12-Himalayan Moist Temperate Forests

Group 13-Himalayan Dry Temperate Forests

Group 14-Sub Alpine Forests

Group 15-Moist Alpine Scrub

Group 16- Dry Alpine Scrub

SUB-GROUPS (location)

Sub-group- 22 Nos.

TYPES (local edaphic cond.)

Types - 200 Nos.
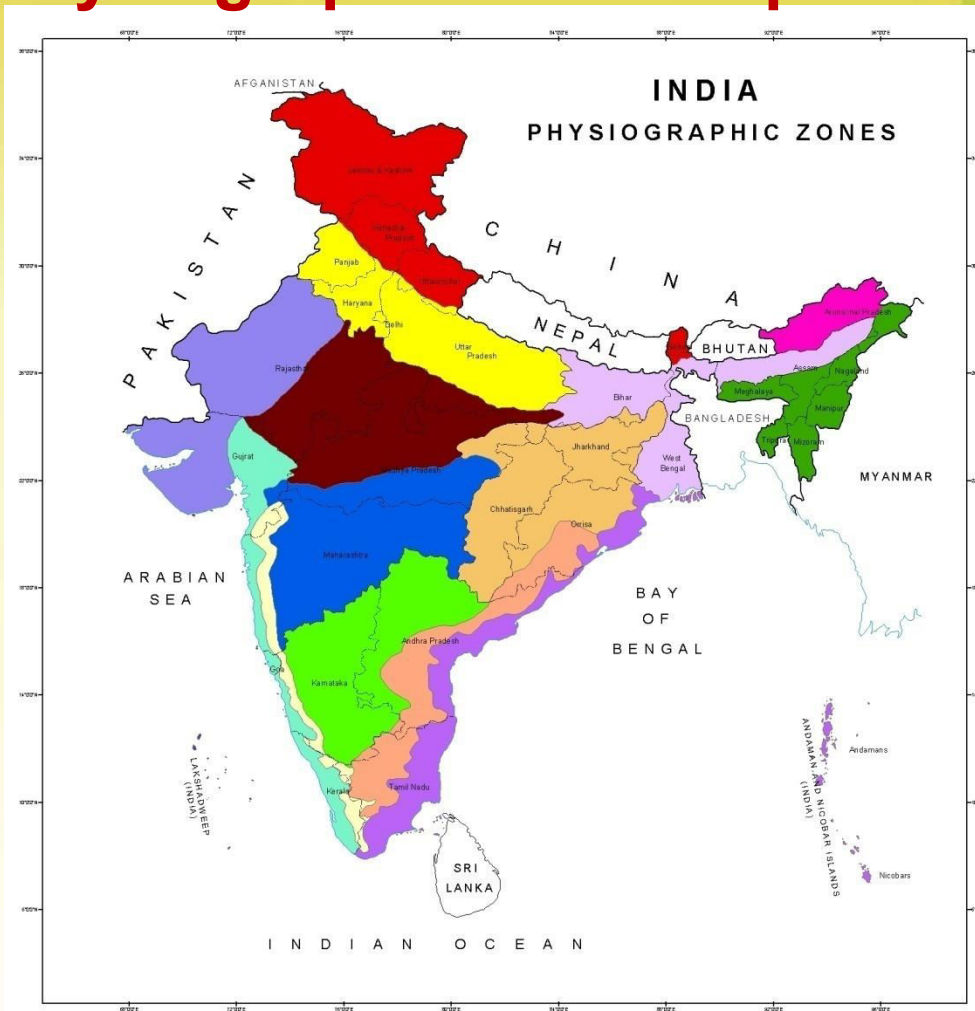
*As per Champion and Seth classification(1968)

Forest Cover in Different Forest Type Groups

FOREST TYPES OF INDIA
(Based on Champion & Seth Classification)

Forest Survey of India
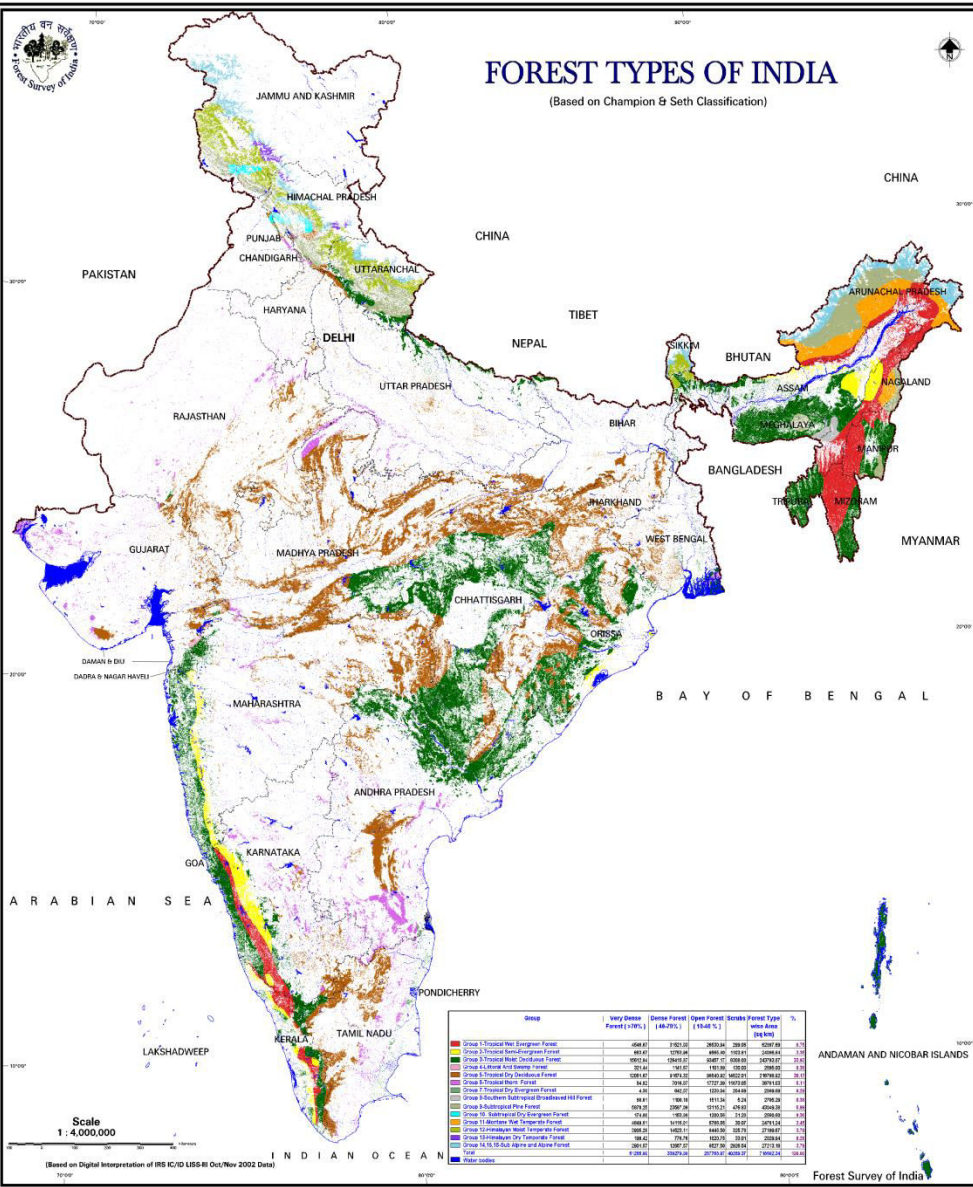
Type Group	%
Group 1 Tropical Wet Evergreen	2.92
Group 2 Tropical Semi-Evergreen	13.79
Group 3 Tropical Moist Deciduous	19.73
Group 4 Littoral & Swamp	0.69
Group 5 Tropical Dry Deciduous	41.87
Group 6 Tropical Thorn	2.25
Group 7 Tropical Dry Evergreen	0.13
Group 8 Subtropical Broadleaved Hill	2.69
Group 9 Subtropical Pine	2.63
Group 10 Subtropical Dry evergreen	0.03
Group 11 Montane Wet Temperate	0.69
Group 12 Himalayan Moist Temperate	4.12
Group 13 Himalayan Dry Temperate	0.84
Group 14 Sub-Alpine Forests	1.89
Group 15 Moist Alpine Scrub	0.23
Group 16 Dry Alpine Scrub	0.43
Sub Total	94.93
Plantation/TOF	5.07
Total*	100.0

National Forest and Tree Resource Inventory on a two year cycle

National Forest Inventory
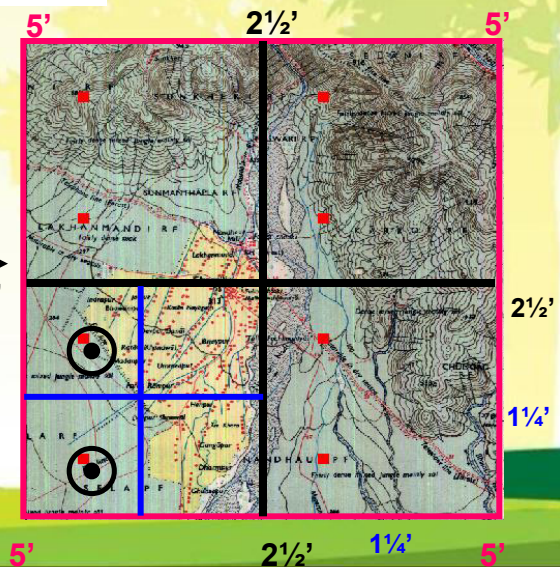# Physiographic Zone Map of India

National Forest Inventory

Randomly Selected 60 districts
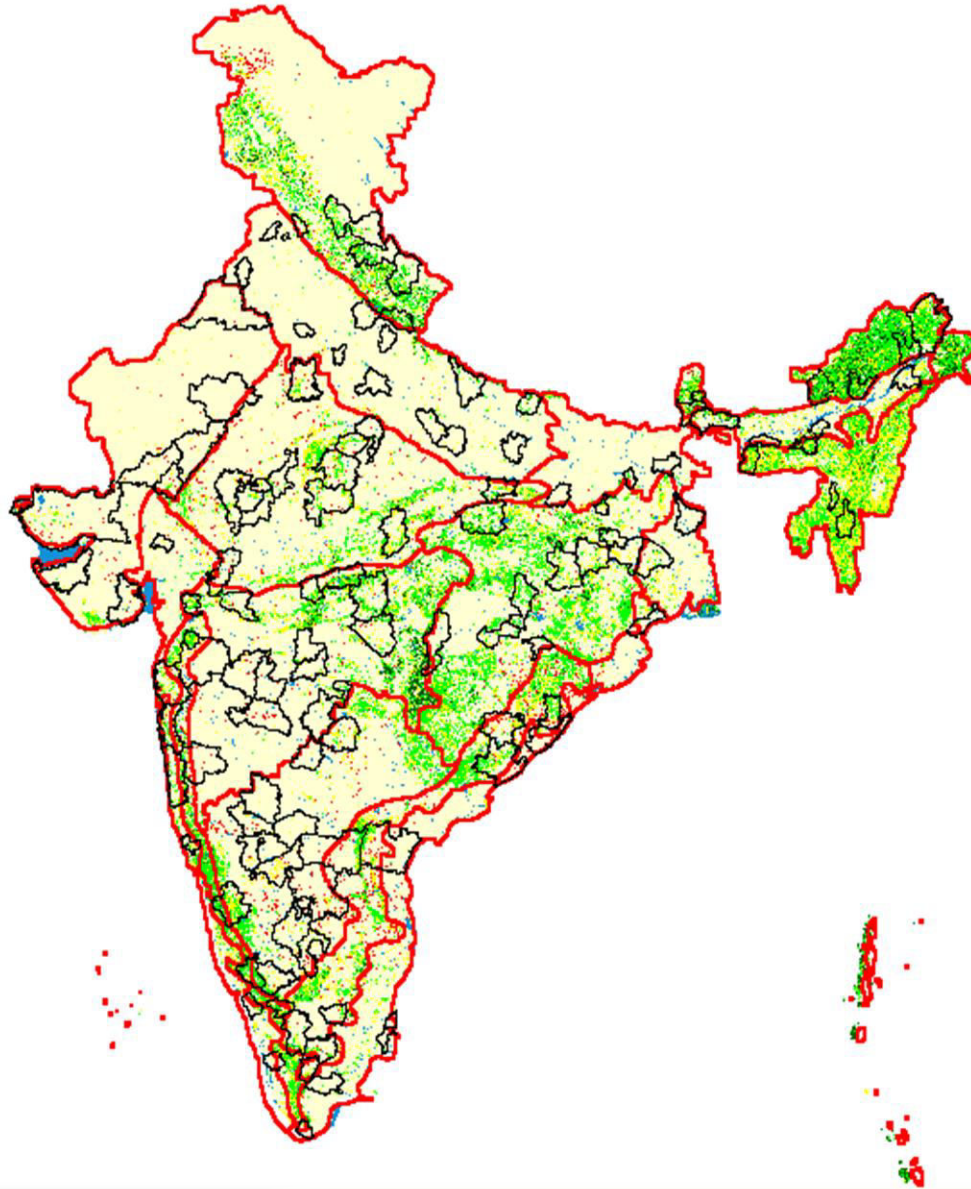
Forest inventory points of Nainital district
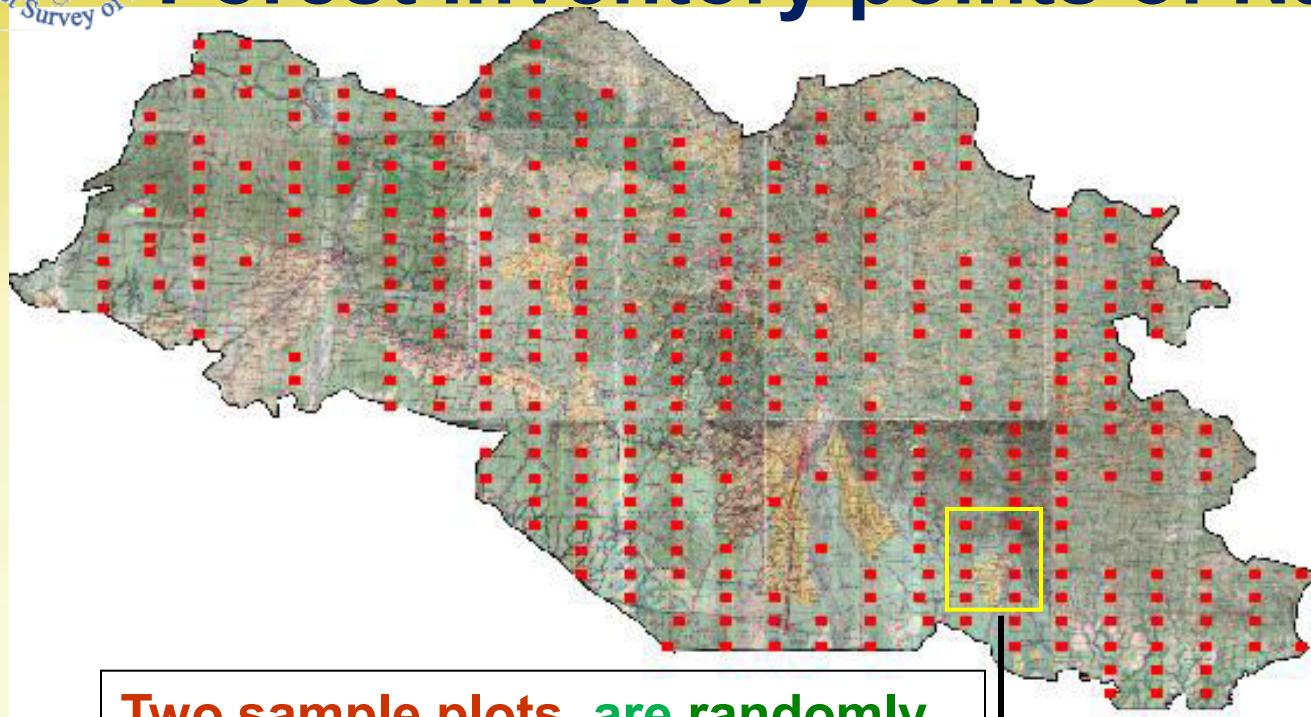
Two sample plots are randomly selected. Thereafter, every alternate 1¼'X 1¼' GRID is systematically selected to form two systematic samples. At center of selected 1¼'X 1¼' SUB GRID, sample plots of 0.1 ha is laid out.

Data Collection

Square Plot

    Length of diagonal= 44.8 M

    Length of side   = 31.6 M

Circular Plot

    Radius of circle   = 80 M

Soil depth

Rockiness

Humus

Origin of stand

Crop Composition

Bamboo density

Bamboo quality

Plantation potential

Size class

Biotic influence

2.0 Ha Circular plot for qualitative information like – land use, crop composition, origin of stand, fire incidence, soil, regeneration, grazing etc.

0.1 Ha Square plot for tree measurements - like dbh, height, species name, crown-diameter etc.

Area under different **land use** classes

Intensity of regeneration

Incidence of fire

Injuries to crop

Grazing
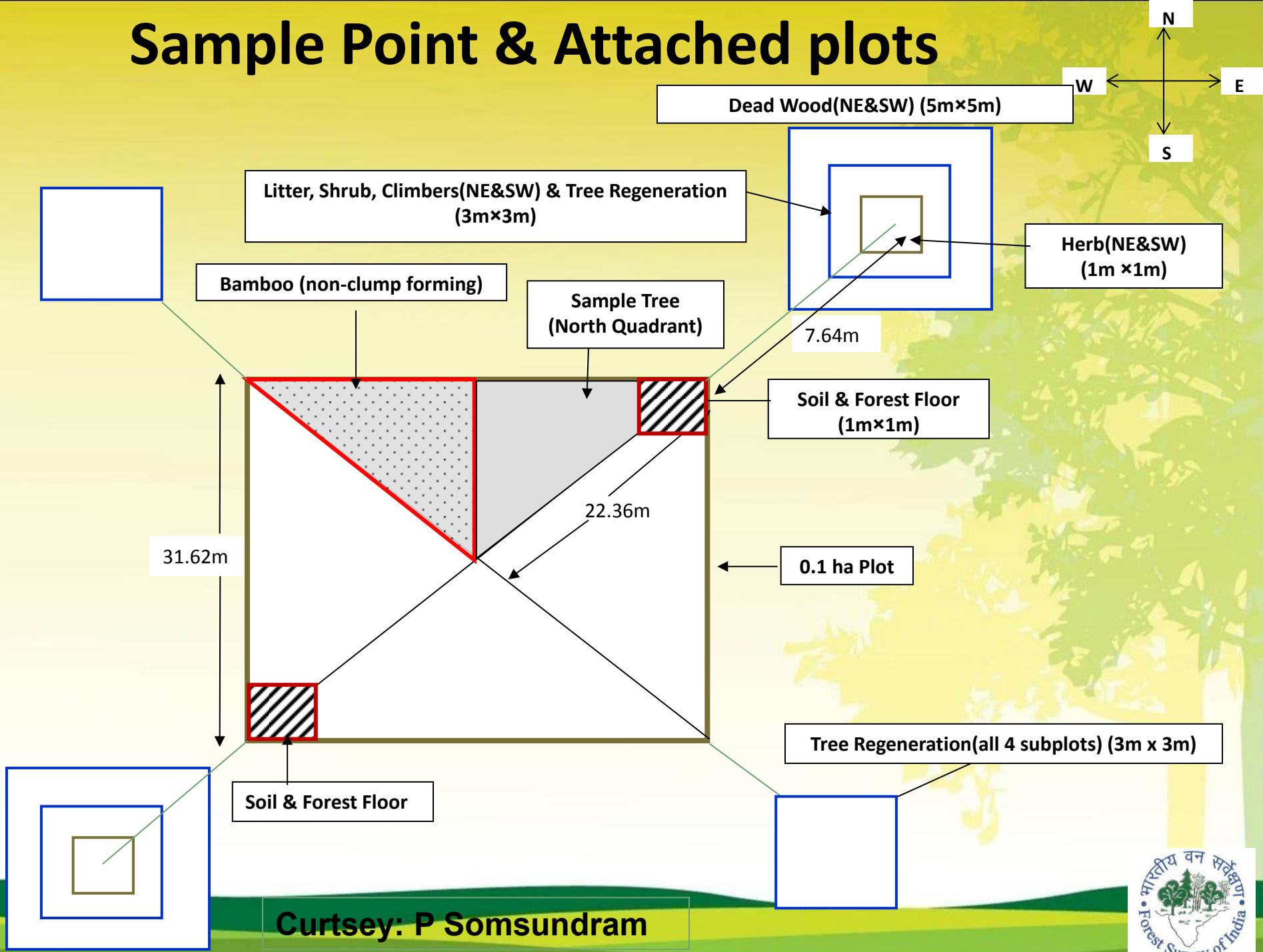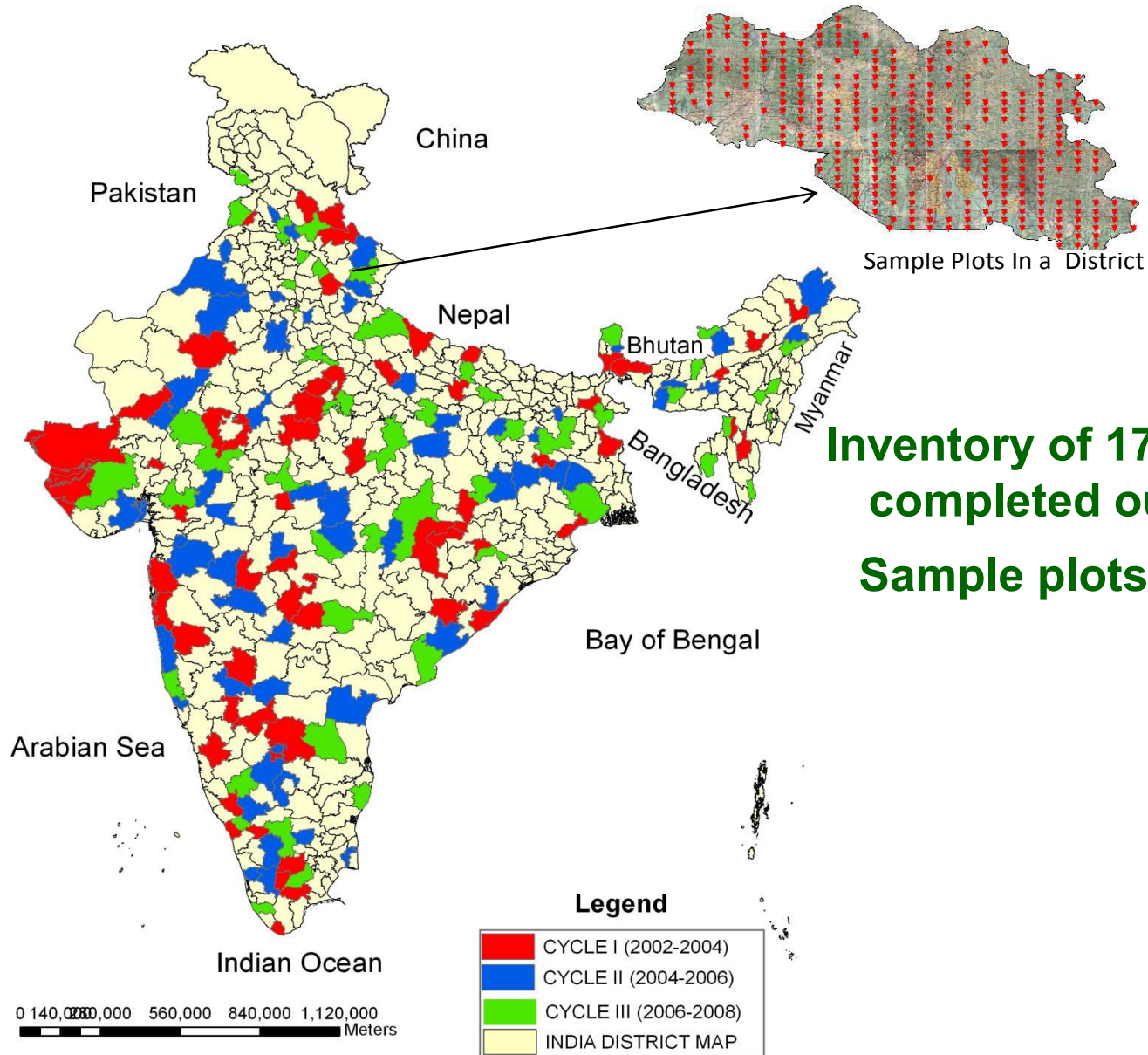
Presence of weeds

Presence of grass

Soil erosion

Sample Point & Attached plots

N / W / E / S (compass)

Dead Wood(NE&SW) (5m×5m)

Litter, Shrub, Climbers(NE&SW) & Tree Regeneration (3m×3m)

Herb(NE&SW) (1m ×1m)

Bamboo (non-clump forming)

Sample Tree (North Quadrant)

Soil & Forest Floor (1m×1m)

7.64m

31.62m

22.36m

0.1 ha Plot

Soil & Forest Floor

Tree Regeneration(all 4 subplots) (3m x 3m)

Curtsey: P Somsundram

Districts Completed Under National Forest Inventory

Sample Plots In a District

Inventory of 178 districts completed out of 593

Sample plots = 22,000

China

Pakistan

Nepal

Bhutan

Myanmar

Bangladesh

Bay of Bengal

Arabian Sea

Indian Ocean

0 140,000 280,000 560,000   840,000 1,120,000
Meters

Legend

🟥	CYCLE I (2002-2004)
🟦	CYCLE II (2004-2006)
🟩	CYCLE III (2006-2008)
⬜	INDIA DISTRICT MAP

Remaining Components of Forest Biomass

The following biomass components are not generally measured under NFI

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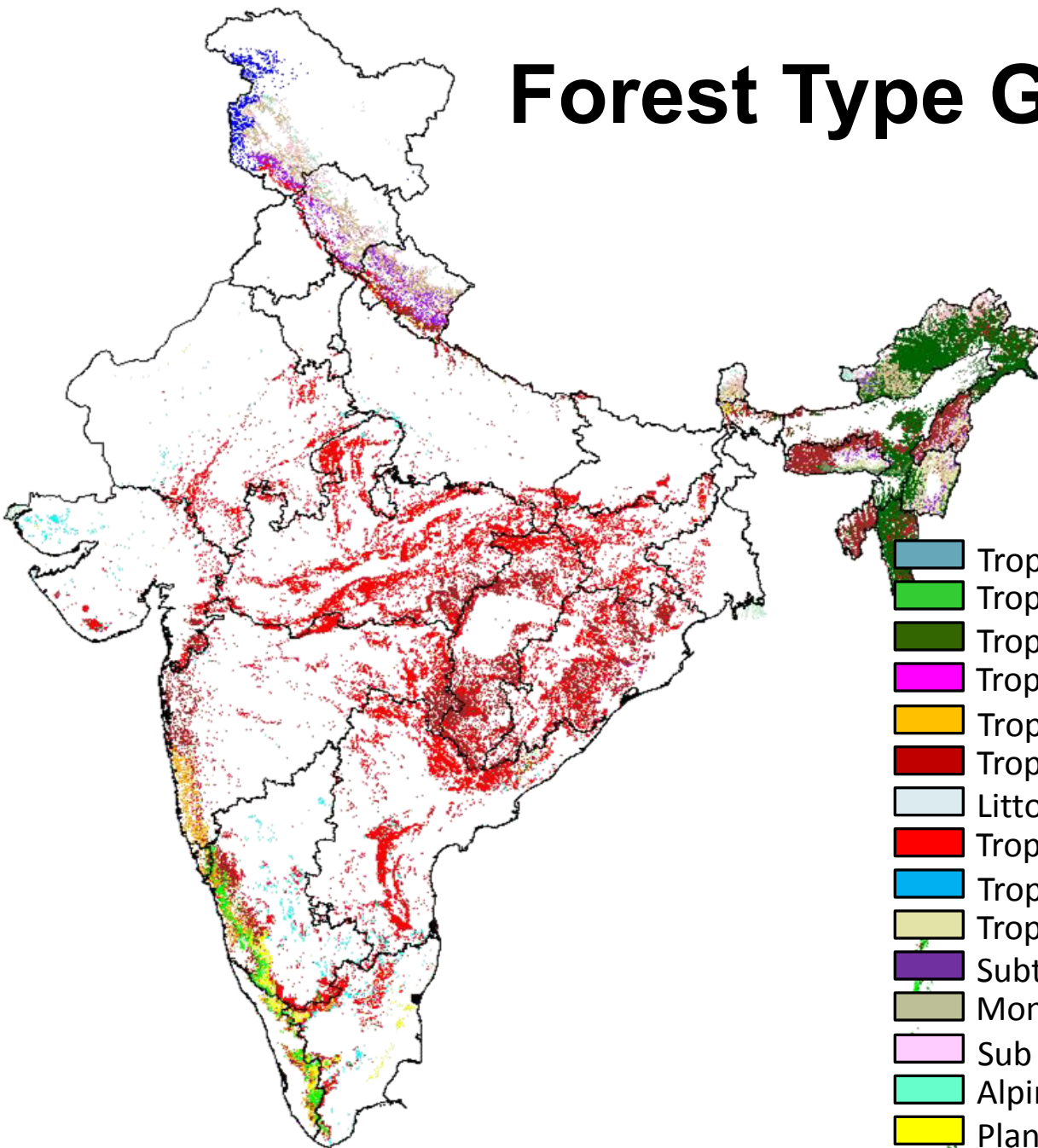- Below ground root biomass

Approach

Forest Cover 2007

Forest Type

Stratification

Overlaying sample plots of NFI

Synthesis & Estimation

Woody biomass

Other components

Carbon Stock 2007
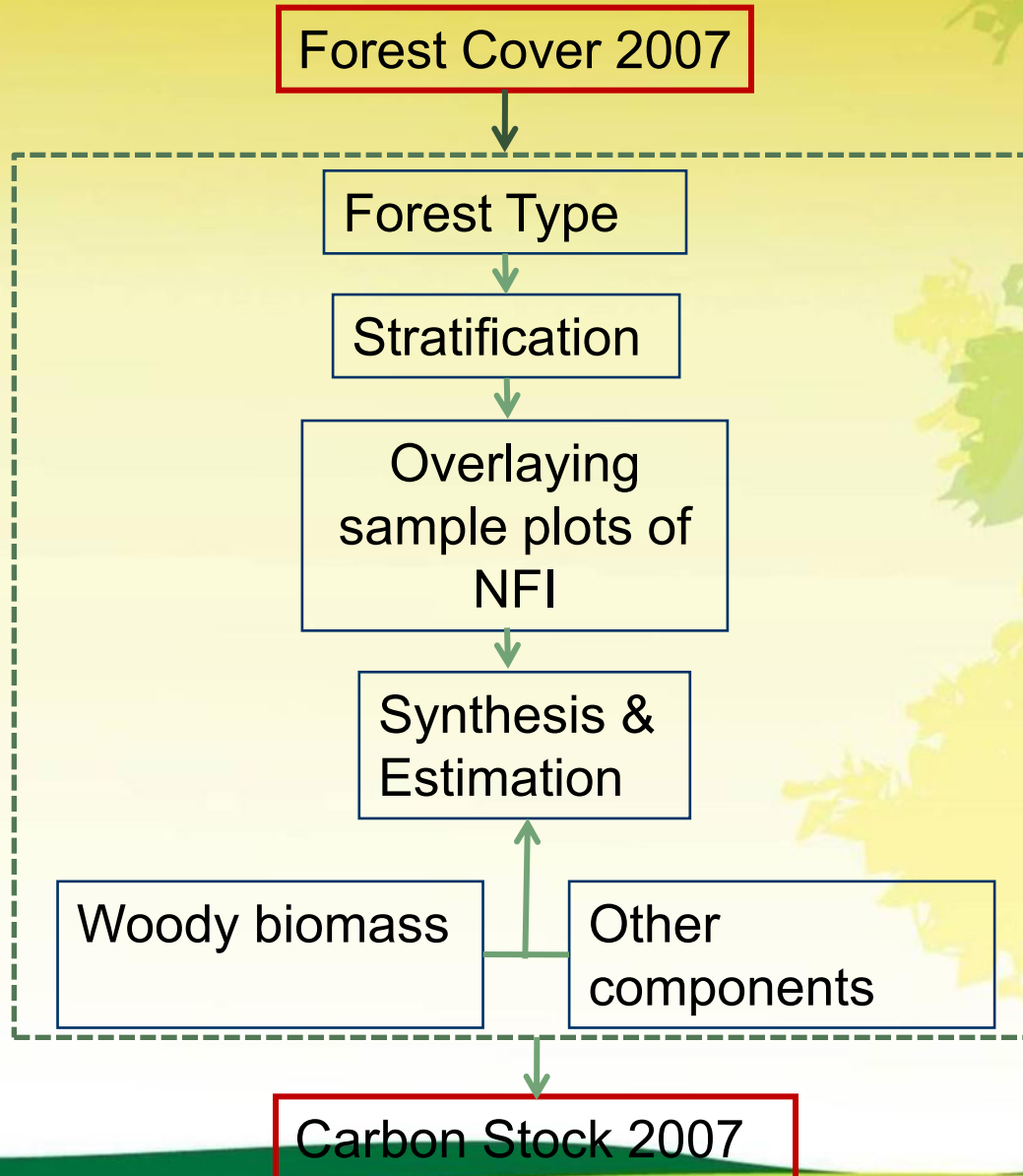
Forest Cover
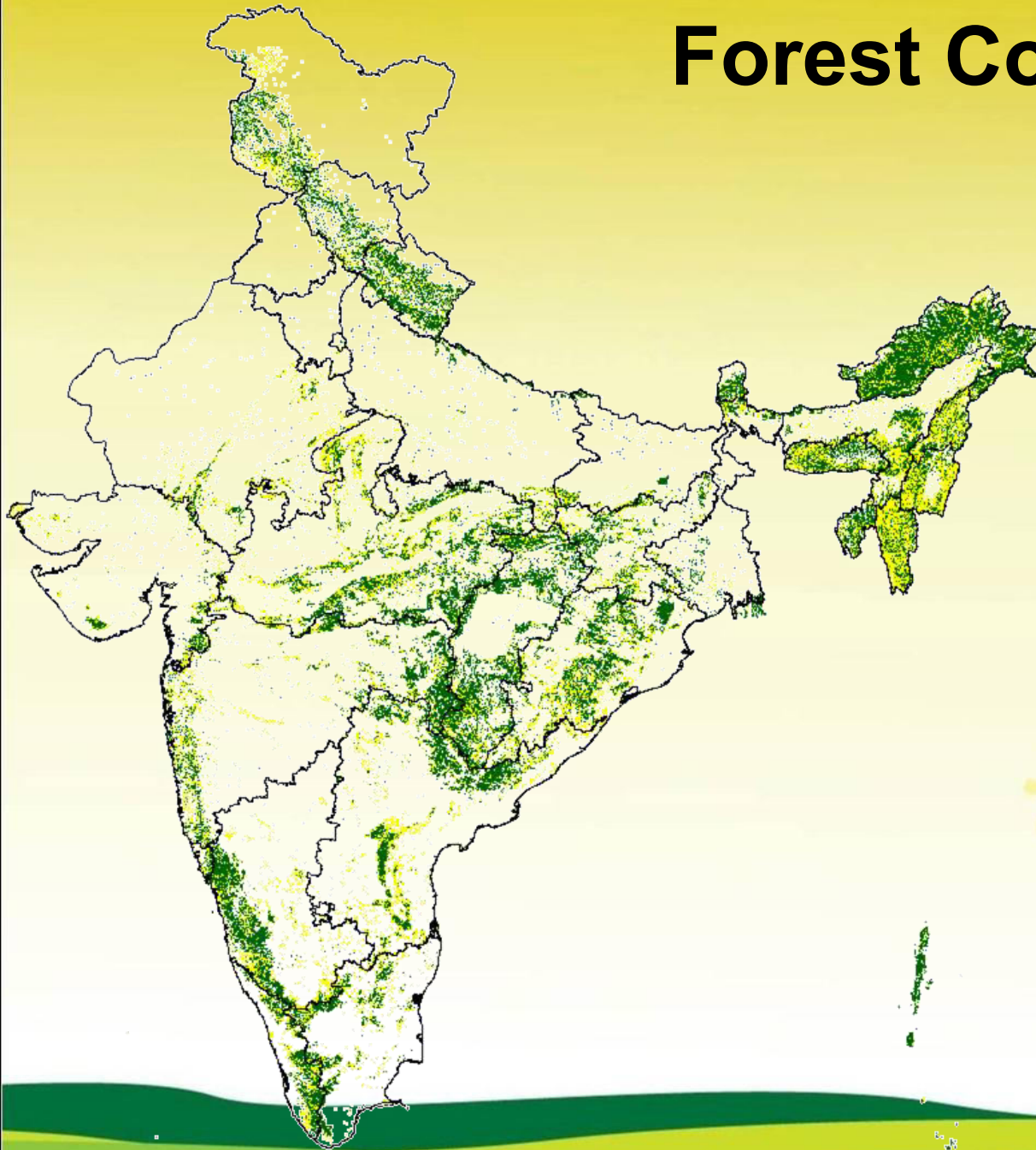

Dense Forest
Open Forest

Forest Type Groups

- Tropical Wet Evergreen-North East
- Tropical Wet Evergreen-Western Ghats
- Tropical Semi Evergreen-North East
- Tropical Semi Evergreen-Eastern Deccan
- Tropical Semi Evergreen-Western Ghats
- Tropical Moist Deciduous Forests
- Littoral & Swamp Forests
- Tropical Dry Deciduous Forests
- Tropical Thorn Forest
- Tropical & Subtropical Dry Evergreen Forests
- Subtropical Pine Forests
- Montane Moist Temperate Forest
- Sub Alpine & Temperate Forest
- Alpine Scrub
- Plantation/TOF
- Non Forest

# Strata based on forest type and forest cover
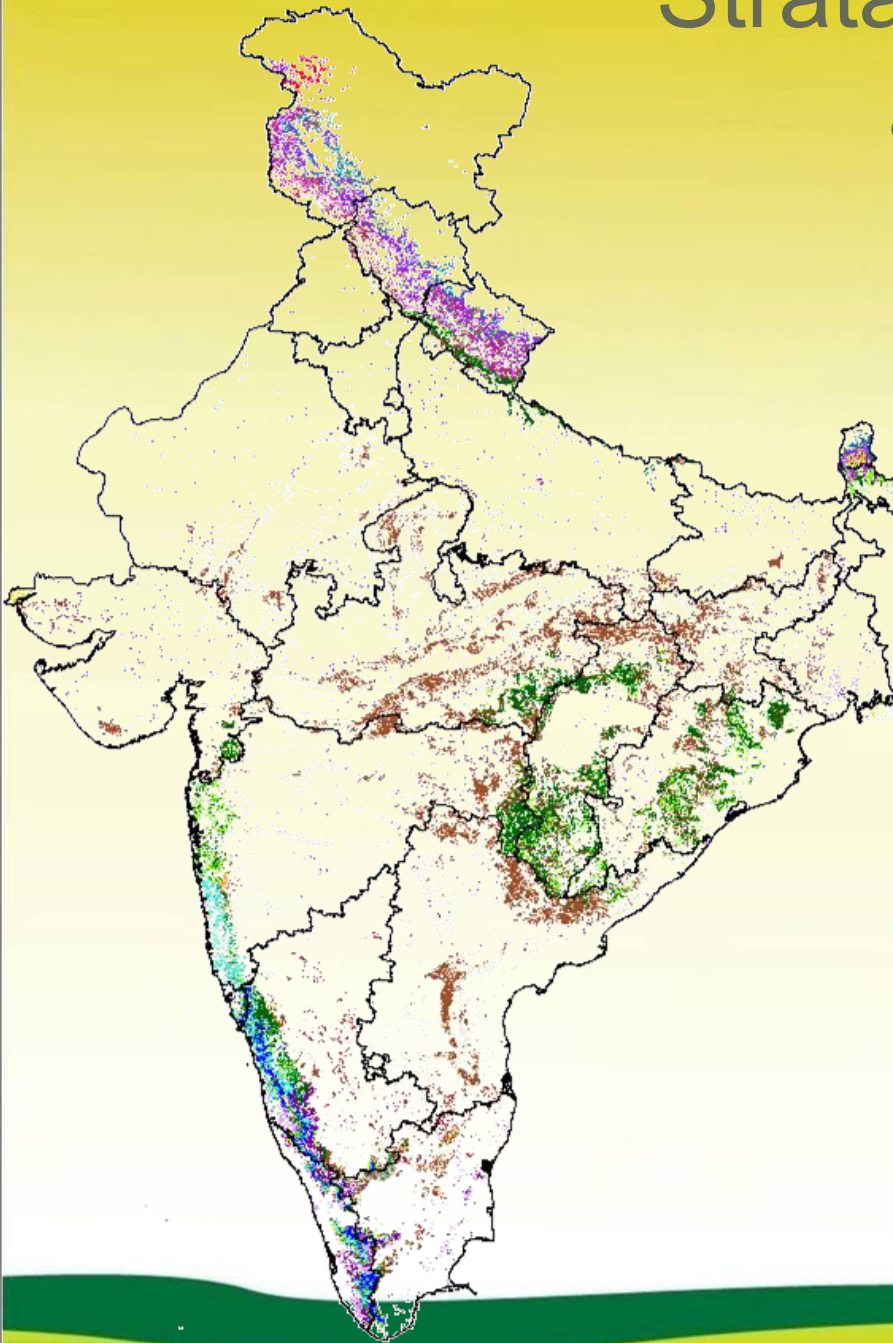
Legend:
- 🟥 Tropical Wet Evergreen-North East- Dense Forest
- 🟩 Tropical Wet Evergreen-North East- Open Forest
- 🟦 Tropical Wet Evergreen-Western Ghats- Dense Forest
- 🟩 Tropical Wet Evergreen-Western Ghats- Open Forest
- 🟪 Tropical Semi Evergreen-North East- Dense Forest
- 🟨 Tropical Semi Evergreen-North East- Open Forest
- ⬜ Tropical Semi Evergreen-Eastern Deccan- Dense Forest
- ⬜ Tropical Semi Evergreen-Eastern Deccan- Open Forest
- 🟩 Tropical Semi Evergreen-Western Ghats- Dense Forest
- 🟩 Tropical Semi Evergreen-Western Ghats- Open Forest
- 🟩 Tropical Moist Deciduous Forests- Dense Forest
- 🟩 Tropical Moist Deciduous Forests- Open Forest
- ⬜ Littoral & Swamp Forests- Dense Forest
- 🟧 Littoral & Swamp Forests- Open Forest
- 🟫 Tropical Dry Deciduous Forests- Dense Forest
- ⬜ Tropical Dry Deciduous Forests- Open Forest
- ⬜ Tropical Thorn Forest- Dense Forest
- 🟥 Tropical Thorn Forest- Open Forest
- 🟧 Tropical & Subtropical Dry Evergreen Forests- Dense Forest
- 🟪 Tropical & Subtropical Dry Evergreen Forests- Open Forest
- ⬜ Subtropical Pine Forests- Dense Forest
- 🟪 Subtropical Pine Forests- Open Forest
- 🟪 Montane Moist Temperate Forest- Dense Forest
- 🟩 Montane Moist Temperate Forest- Open Forest
- ⬜ Sub Alpine & Temperate Forest- Dense Forest
- ⬜ Sub Alpine & Temperate Forest- Open Forest
- 🟥 Alpine Scrub- Dense Forest
- ⬜ Alpine Scrub- Open Forest
- 🟪 Plantation/TOF- Dense Forest
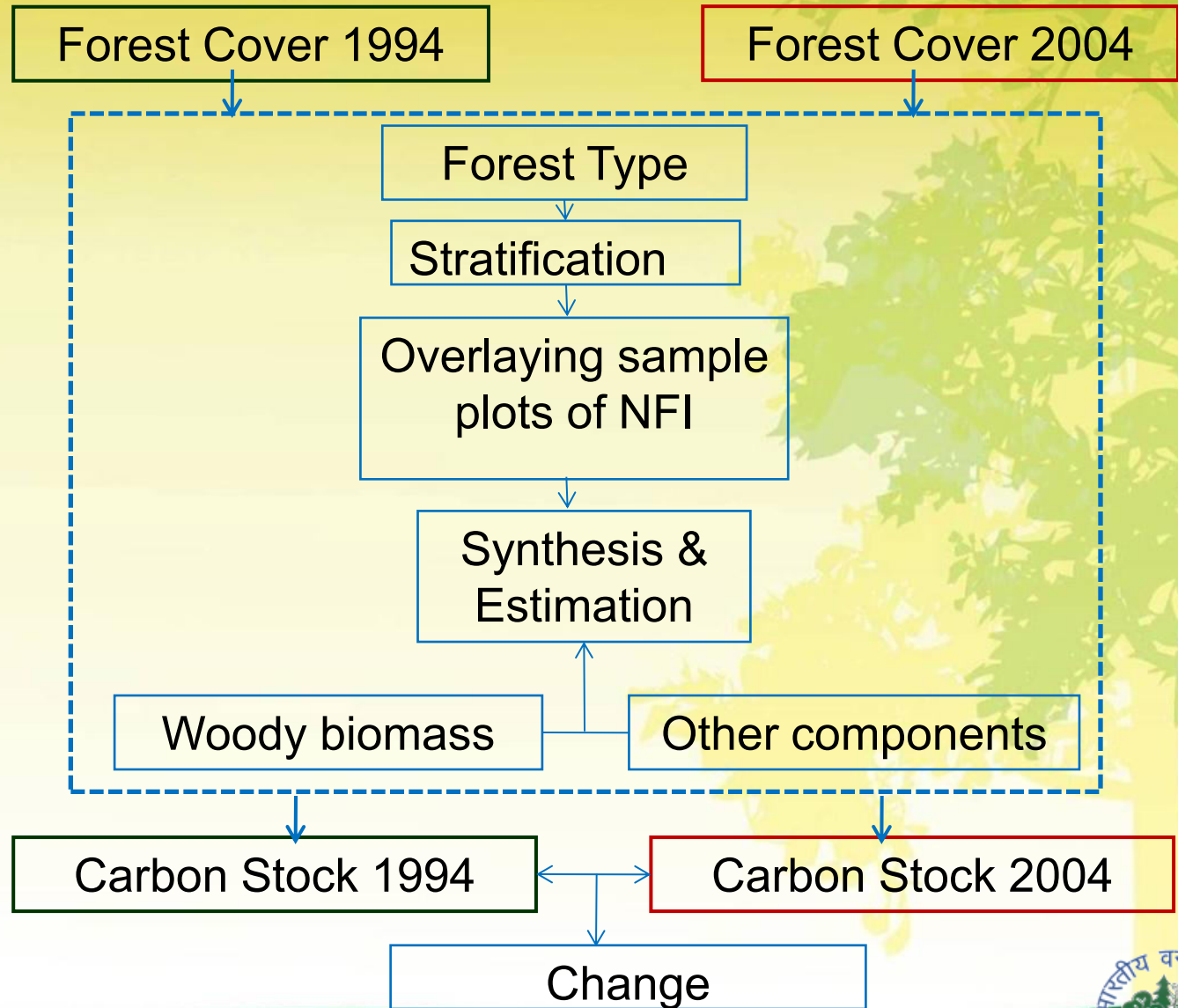- 🟪 Plantation/TOF- Open Forest
- ⬜ Non Forest

22,000 sample plots of National Forest Inventory
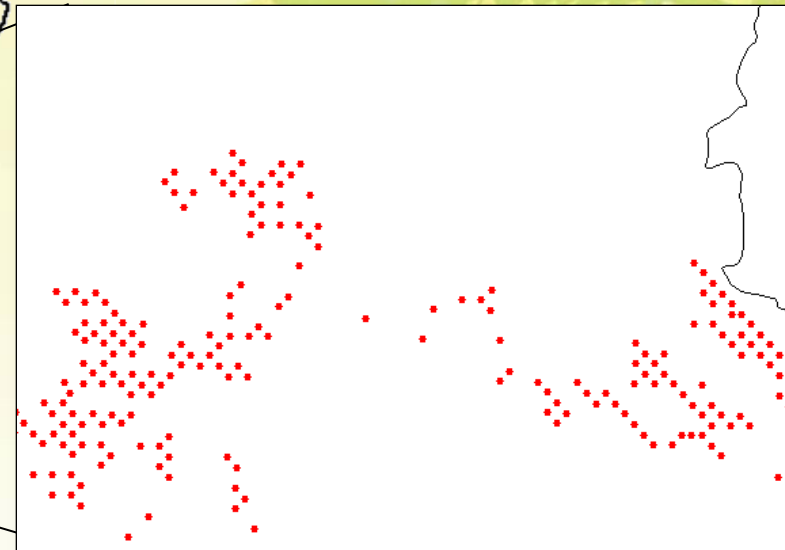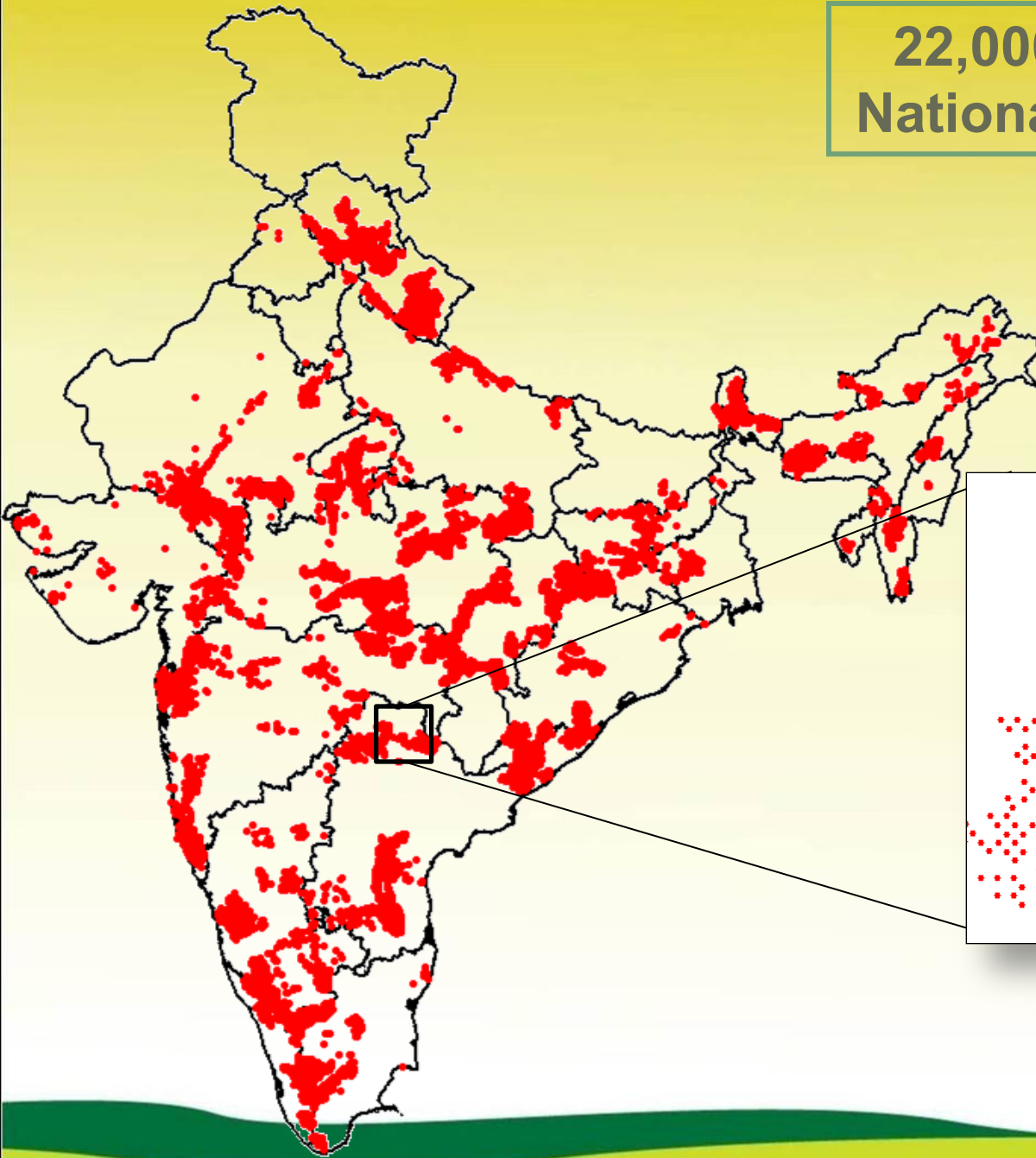
Sample plots overlaid on the strata layer
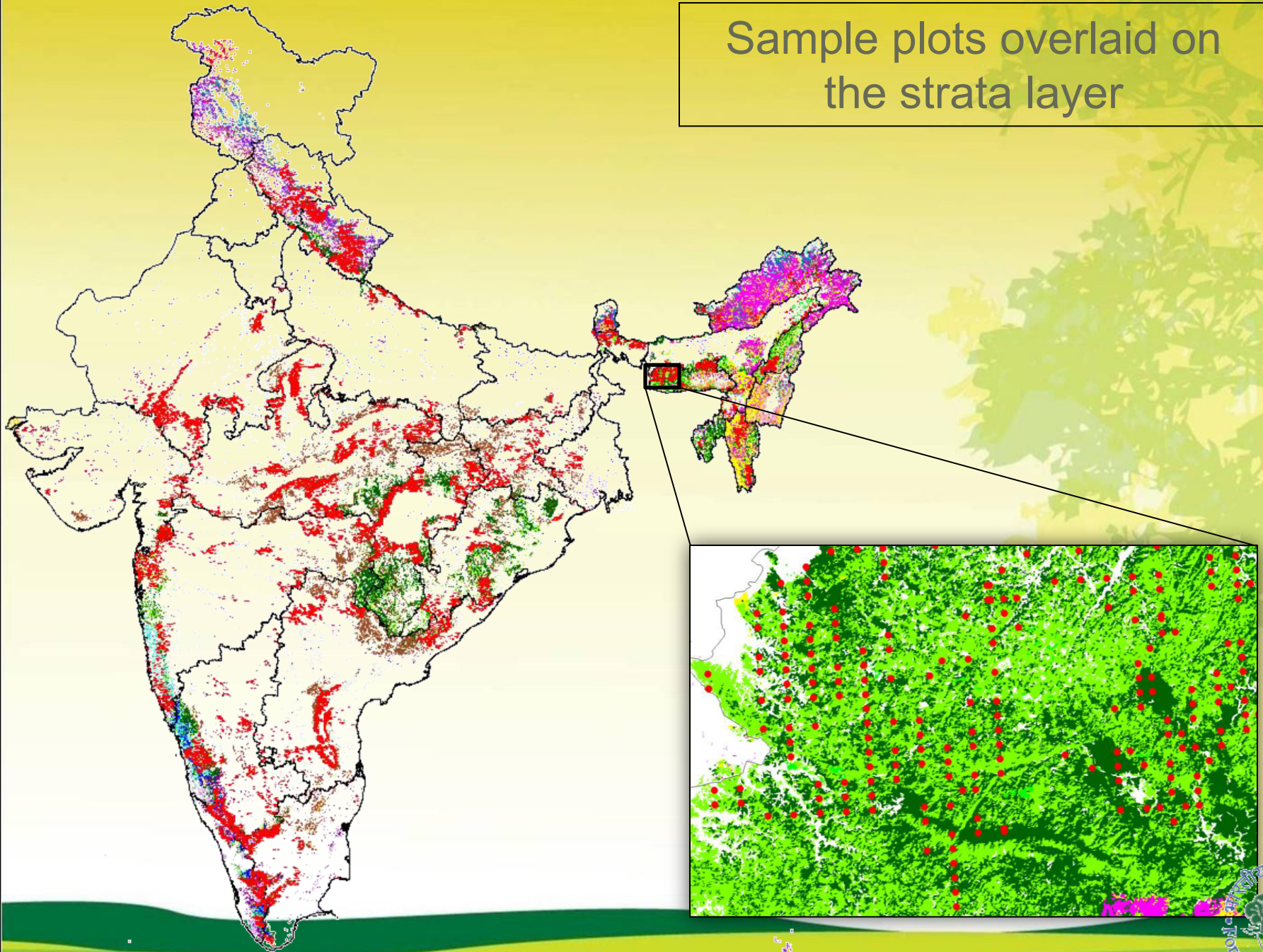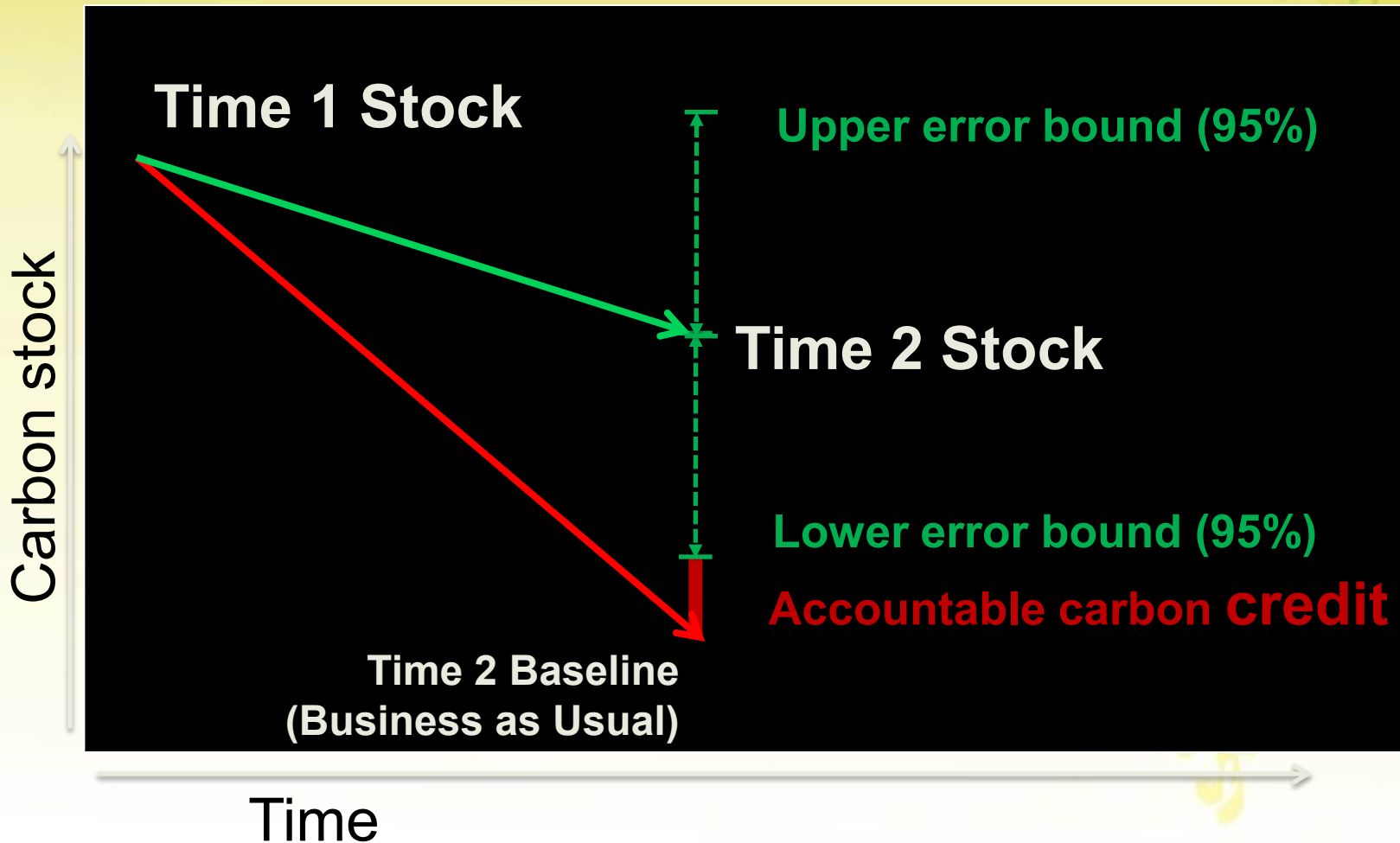
Approach for change – Stock difference method

Change in forest carbon stock During 2004 - 2011

Carbon Pools	C Stock in 2004 (million tons)	C Stock in 2011 (million tons)	Percent carbon in pool	Net Change in C Stock (million tons)
Above Ground biomass	2101	2,192	31.6	91
Below ground biomass	663	694	10	31
Dead wood	25	27	0.4	2
Litter	121	130	1.9	9
Soil	3753	3,898	56.1	145
Total	6,663	6,941	100.0	278

Change in forest carbon stock During 2011 - 2013

Carbon Pools	C Stock in 2011 (million tons) ISFR 2013	C Stock in 2013 (million tons) ISFR 2015	Net Change in C Stock (million tons)
Above Ground biomass	2,192	2,220	28
Below ground biomass	694	695	1
Dead wood	27	29	2
Litter	130	131	1
Soil	3,898	3,969	71
Total	6,941	7,044	103

The "Conservative Principle" for Accountable Carbon Credits

Carbon stock

Time 1 Stock

Upper error bound (95%)

Time 2 Stock

Lower error bound (95%)

Accountable carbon **credit**

Time 2 Baseline
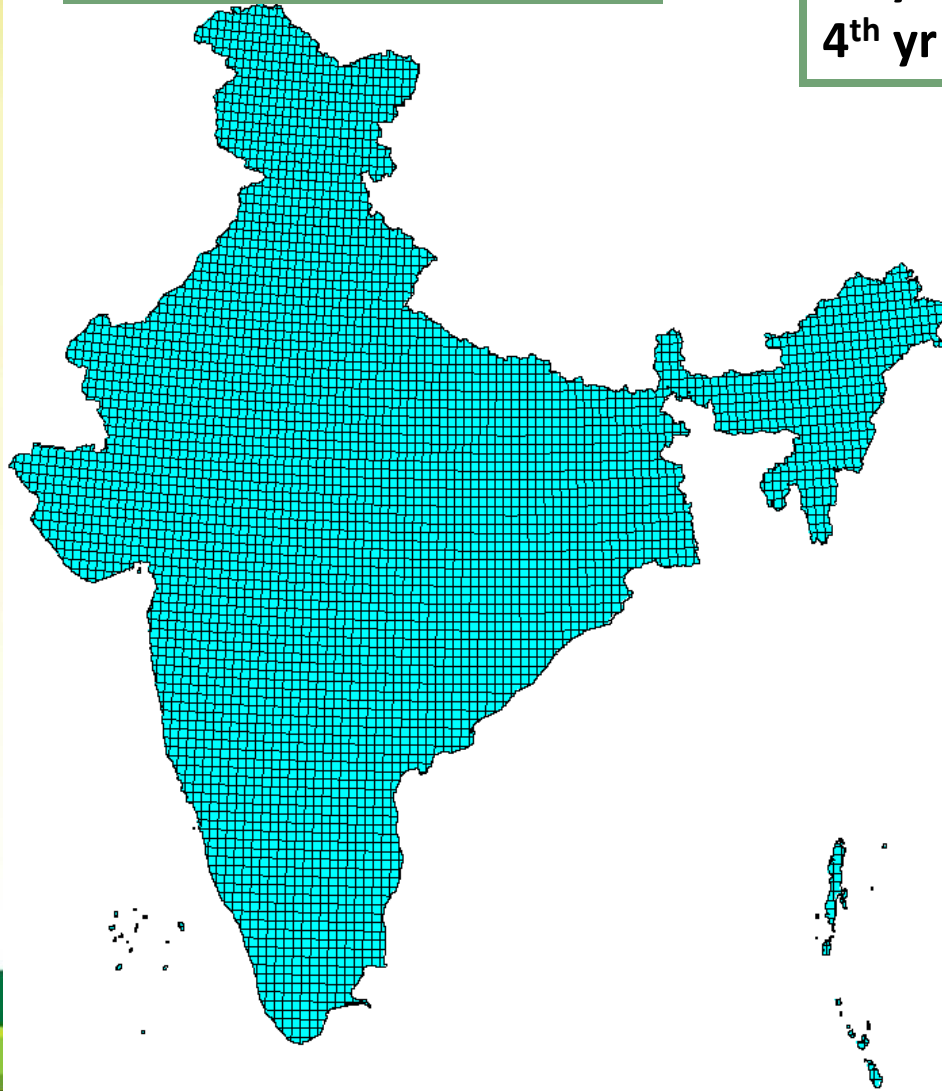(Business as Usual)

Time

Modification of NFI design

- **Limitations of NFI**

    – **It does not provide state level estimates.**

    – **The revisit time to same place with the old design is 20 years.**
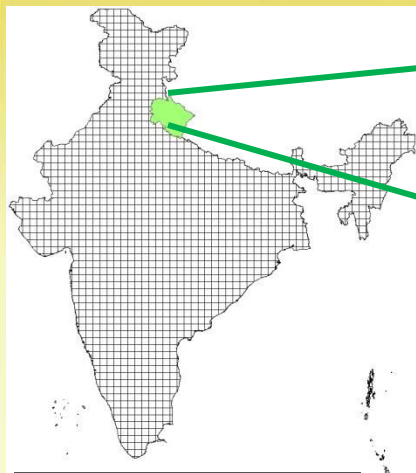
Coverage of Modified NFI

India map
5x5km grids

Sampling of grids on 5 yr cycle

1st yr – all 1s   2nd yr- all 3s   3rd yr – all 5s
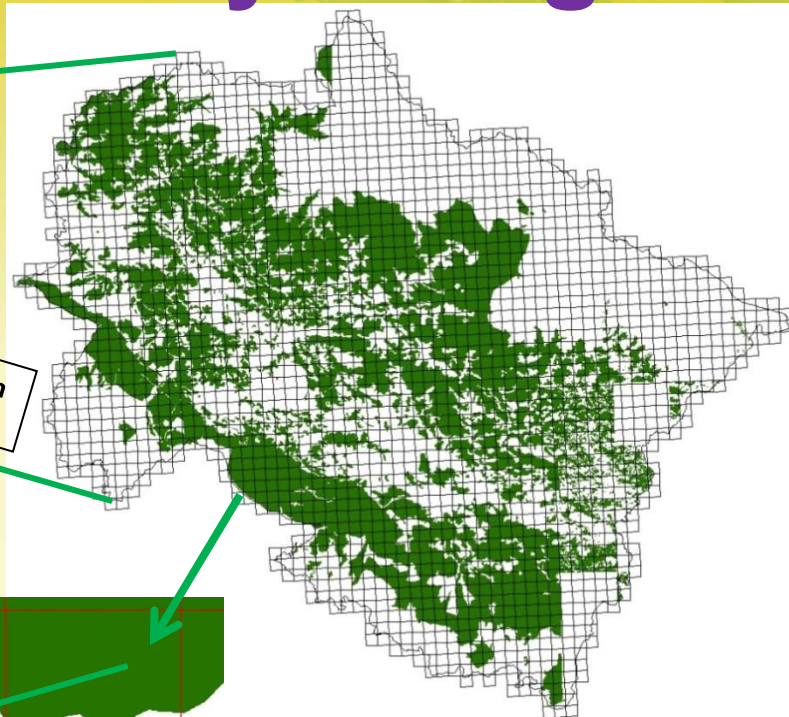4th yr – all 2s   5th yr- all 4s   6th yr- all 1s
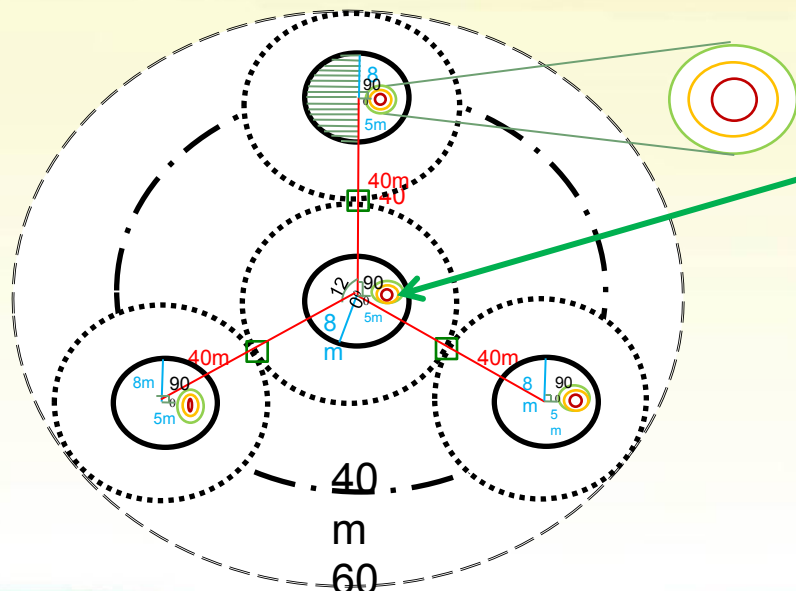
National Forest Inventory Design

INDIA GRID 5Km x 5Km

Uttarakhand 5Km x 5km grid overlaid on Forest Boundary

Single Grid of 5Kmx 5Km

NFI Plot Design

	Subplot	8.0 m radius
	Annular plot	20 m radius
	Lichens plot	40 m radius
	Description plot	60 m radius
	Hub vegetation plot	0.6 m radius
	Shrub regeneration litter plot	1.7 m radius
	Deadwood plot	2.8 m radius
	Soil and forest floor sample plot	1m X 1m at mid point between subplots
	Non clump forming bamboo plot	

Additional Parameters

- **Availability of water source in vicinity of plot**
- **Invasive spps**
- **Incidence of Disease (tree)**
- **Incidence of Insect (tree)**
- **Mortality**
- **Inventory of important NTFPs**
- **Dead standing tree**
- **Rotten/missing cull**
- **Compacted crown ratio**
- **Decay Class**
- **Bark void**

NFI Plot Design

⬭	Subplot	8.0 m radius
⬭ (dotted)	Annular plot	20 m radius
⌒ (dashed)	Lichens plot	40 m radius
⌒ (dash-dot)	Description plot	60 m radius
○ (red)	Hub vegetation plot	0.6 m radius
○ (yellow)	Shrub regeneration litter plot	1.7 m radius
○ (green)	Deadwood plot	2.8 m radius
▢	Soil and forest floor sample plot	1m X 1m at mid point between subplots
◍	Non clump forming bamboo plot	

Permanent Observational Plots

- ❖ **In each Forest Type Group (16)**
- ❖ **60 m circular plot (1.13 ha)**
- ❖ **Mapping of all trees**
- ❖ **Climate change indicators(lichen, ozone bio-indicators).**
- ❖ **Repeat measurements.**

It will provide:

- ❖ **Biodiversity and its other characteristics**
- ❖ **Forest structure (diversity of tree locations, dimensions & species)**
- ❖ **Change in biodiversity and structure.**
- ❖ **Species change, if any.**

Journey through Natcoms

Natcom	Approach	Tiers
INC	II	Tier II - AGB(timber), SOC Tier I - all others
SNC	III	Tier II – all but BGB
TNC	III	Tier III – all pools (proposed)

TNC provides opportunity to improve
  a.   Wood density data – more spps.
  b.   Carbon content data – more spps.
  c.   Spps wise BGB
  d.   Soil density at more plots.
  e.   Repeated measurements etc.

Thanks for your attention

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