# Conservation of Protected Areas through carbon finance: Dudhwa Tiger Reserve

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# Conservation of protected area through carbon finance- Dudhwa Tiger Reserve

## Background

- India is home to 50 Tiger Reserves which cover an area of 71,027 sq. km.
- Around 50 million people stay in and around such PAs and depend on forest resources for their livelihood.
- This dependence leads to Human wildlife conflict (HWC) leading to destruction of crops by herbivores and attacks on humans from tigers and leopards.
- Communities face several economic losses resulting in retaliation against wildlife.
- Government has introduced several mitigation schemes like relocation of villagers, ex gratia, supplementary livelihood options and infrastructure measures.

- Lack of finance mechanism hinders the process of mitigation of human wildlife conflict.
- The PAs provide range of services viz., water and air purification, climate regulation, waste decomposition, crop pollination, etc. along with carbon sequestration.
- But mechanism such as A/R CDM only recognises the benefits accrued from carbon sequestered.
- Lack of a specific mechanism to value ecosystem services from the PA is a gap area in documenting the huge potential of PAs.
- Climate, Communities and Biodiversity Alliance (CCBA) Standards contribute in conserving and enhancing ecosystem services such as climate change mitigation, poverty alleviation, biodiversity conservation which help in generating additional credits which can be traded in the voluntary market.

# Aim and Objectives

## Aim

Developing an index to standardize the contribution of co-benefits in PA's of India based on CCBA Standards

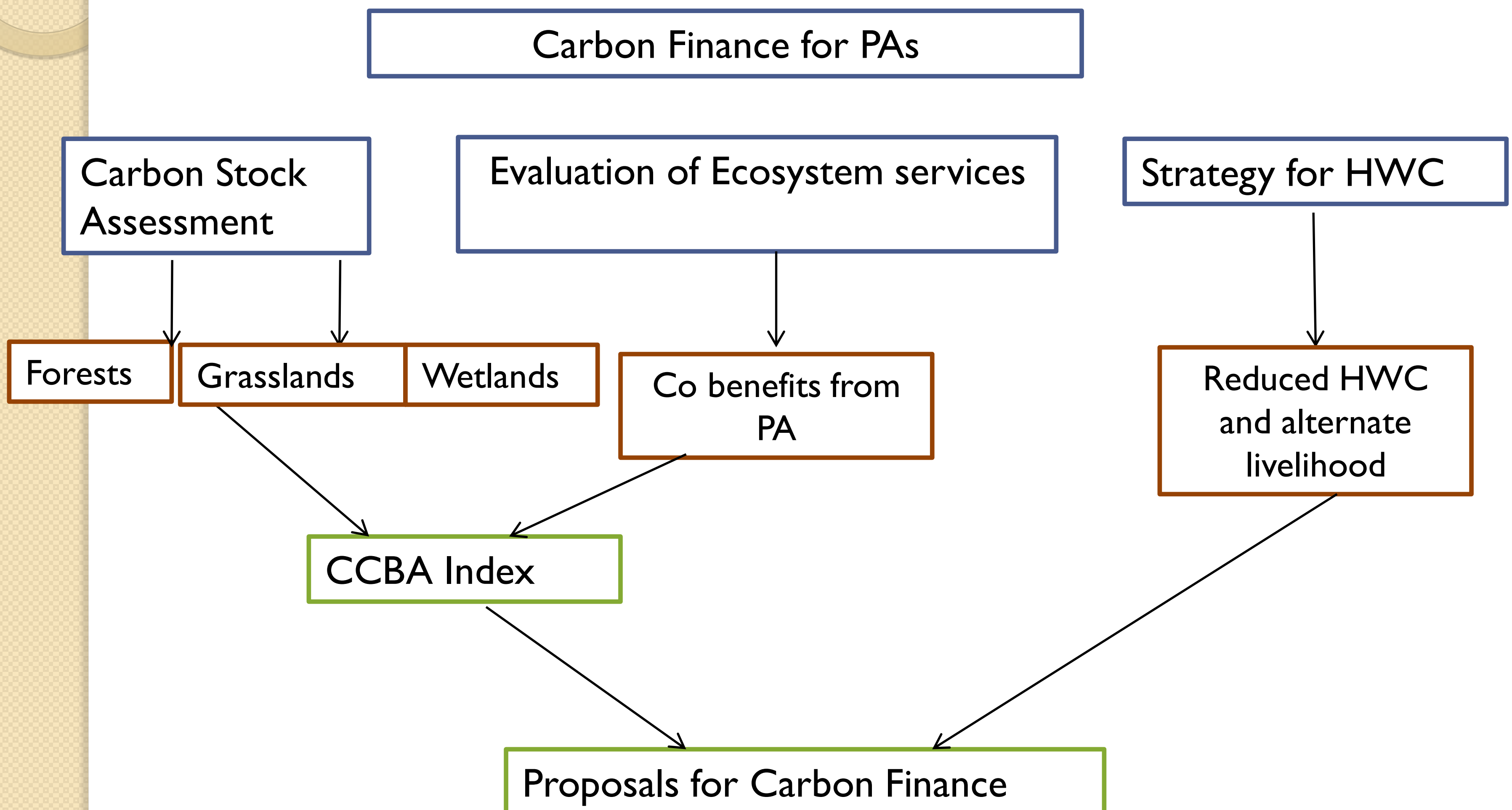
## Objectives

- Mechanism for obtaining finance through carbon sequestration in PAs
- Methodology for measuring wetland carbon stock
- An index to standardize the contribution of co - benefits of biodiversity conservation and livelihood enhancement in PAs of India based on CCBA Standards

# Key Activities

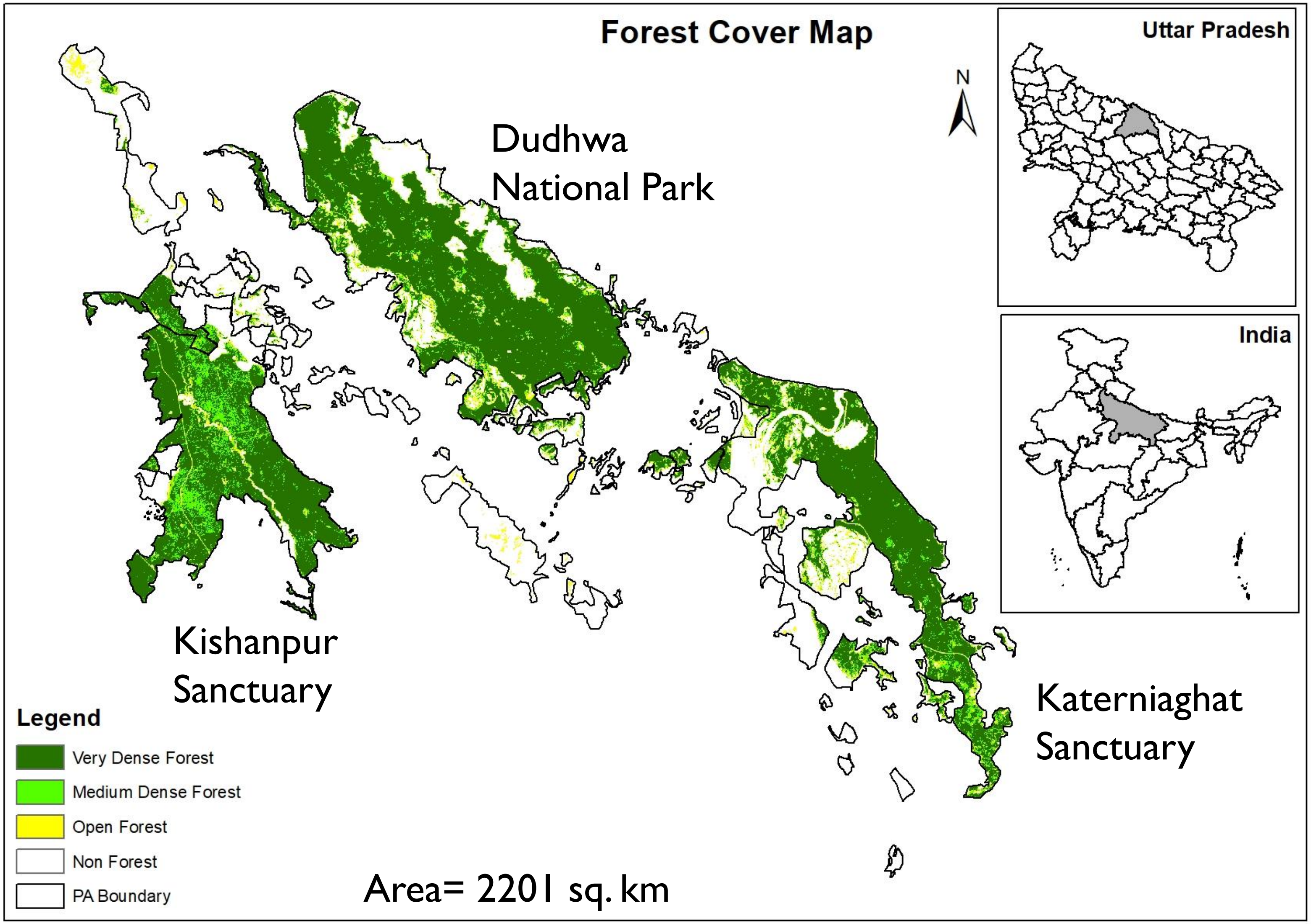
- Assessment of 5 pools of carbon for Woodlands, 3 pools of carbon for Grasslands and Wetlands in Dudhwa Tiger reserve
- Evolving methodology for measuring carbon stock of the wetlands
- Capacity building of forest personnel's of Dudhwa Tiger Reserve on the assessment of carbon stock
- Addressing the issue of HWC through livelihood enhancement strategies
- Developing an index to standardize the contribution of co-benefits of biodiversity conservation based on (CCBA) index

# Approach



Carbon Finance for PAs
Carbon Stock Assessment
Evaluation of Ecosystem services
Strategy for HWC
Forests
Grasslands
Wetlands
Co benefits from PA
Reduced HWC and alternate livelihood
CCBA Index
Proposals for Carbon Finance

# Dudhwa Tiger Reserve



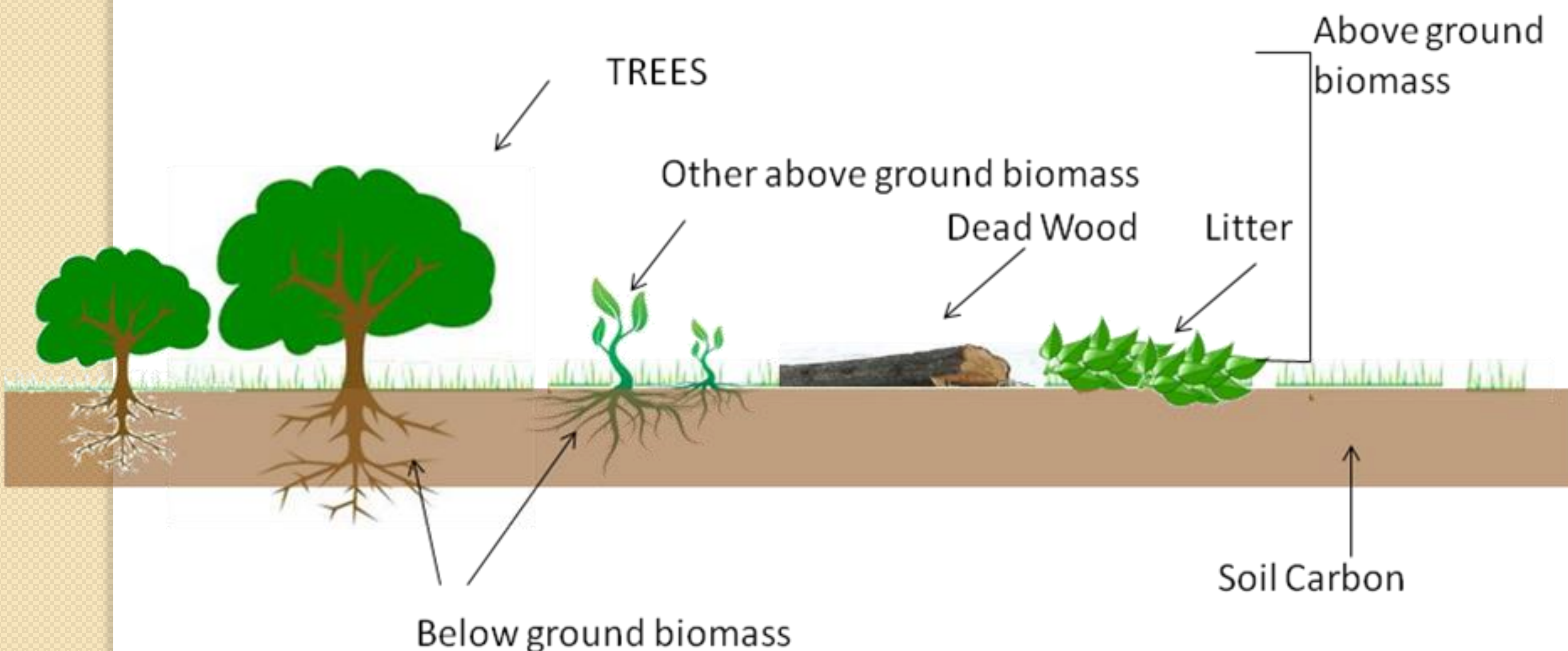

Woodlands: 63%   Grasslands: 22%   Wetlands: 15%

# Woodlands

# Woodland Carbon Stock

**CARBON POOLS (IPCC GPG)**

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



# Carbon assessment Process

1. Delineation of project Boundary
2. Stratification, Mapping and Sampling Design
3. Pilot Inventory
4. Identification of Carbon pools (ABG, BGB, Litter, deadwood & SOC)
5. Field measurements in the permanent plots
6. Data Analysis

# Delineation of project boundaries

**Tools available for identifying and delineating project boundaries**

- Satellite images
- GPS
- Topographic maps
- Land records
- Software (Arc GIS)
- Participatory Rural Appraisal (PRA)

**If high resolution satellite images are unavailable, most accurate method is GPS tracking .**

## SAMPLING STRATEGY

**Identification of precision level**
**(95% confidence interval is frequently used)**

↓

**Selection of location of sampling plots per stratum**
**(Random selection or random selection from preset grid of sampling plots)**

↓

**Calculation of Standard deviation of carbon for all plots (Mg C/ Ha)**

↓

**Calculation of Number of plots required using statistical equations**

↓

**Biomass estimation on sample plots by field survey**

# Stratification of Project area

Details related to Landuse land cover, vegetation and Topography

↓

Geo referencing of data on base map

↓

Land cover classification and forest stratification using ERDAS Imagine

↓

Preliminary field visit for improvement of accuracy and precision

↓

Identification of strata e.g. Forest types, dominant tree species, density of trees, physical boundary, etc.

## STRATIFICATION BASED ON CANOPY COVER

| Forest crown cover | Strata |
|---|---|
| 1 – 40 % | Open Shrub land |
| 41 – 70 % | Moderate Dense Forest |
| 71 – 100 % | Dense Forest |

# Number of Sample plots

$$n = \frac{N * t_{VAL}^{\ 2} * \left( \sum_i w_i * s_i \right)^2}{N * E^2 + t_{VAL}^{\ 2} * \sum_i w_i * s_i^{\ 2}}$$

*Where;*

*n = Number of sample plots required for estimation of biomass stocks within the project boundary; dimensionless*

*N = Total number of possible sample plots within the project boundary (i.e. the sampling space or the population); dimensionless*

*E = Desired level of precision*

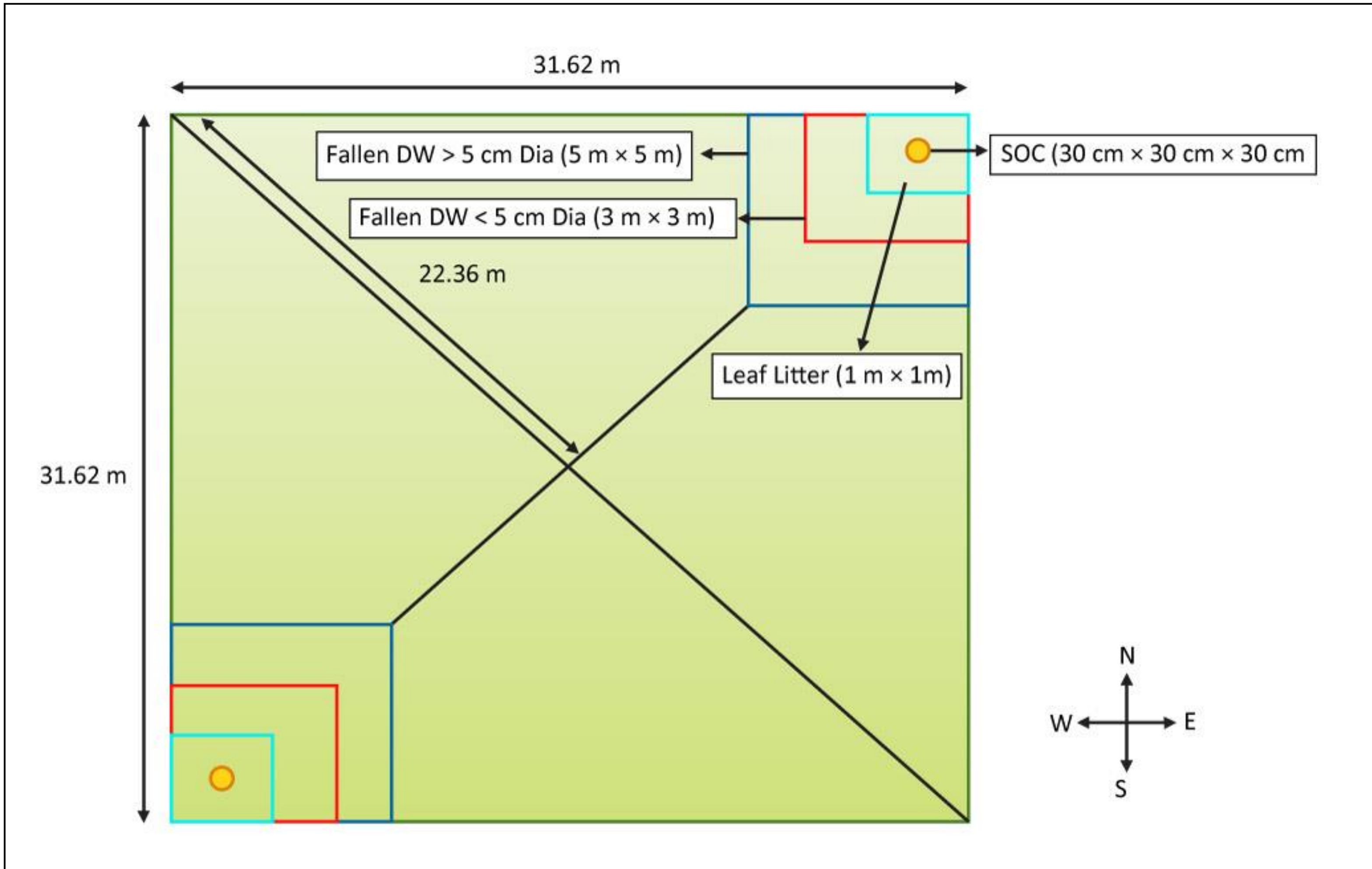
*tVAL = Two-sided Student's t-value, at infinite degrees of freedom, for the required confidence level; dimensionless*

*wi = Relative weight of the area of stratum i (i.e. the area of the stratum i divided by the project area); dimensionless*

*s = Estimated standard deviation of biomass or volume (t d.m. ha-1) in stratum i (when it is not available, instead 50% of the estimated volume, biomass, etc. Good Practice Guidelines, 2003).*

*i = 1, 2, 3, Biomass stock estimation for strata i within the project boundary.*

# Permanent Sample Plot



# MEASUREMENT OF AGB and LL

**All living biomass above the soil including stem, stump, branches, bark, seeds and foliage.**

**Basic Information:**

- *Tree species:* Local name and scientific name
- *Tree status:* Live standing: Leaning in/out of the plot; Live fallen: Fallen in/out of the plot
- *Stem status:* Forked above/below measurement level; Number of stems (stems measured separately)
- *Tree girth* at breast height i.e. 1.37 m using diameter tape
- *Tree height* using Ravi Altimeter/ Marked bamboo sticks

## MEASUREMENT OF LEAF LITTER (LL)

**Includes non living biomass with a diameter less than a minimum diameter chosen by the country (for FSI 5 cm), lying dead, in various states of decomposition above the mineral or organic soil**

Collection of samples from four randomly selected 1 sq.mt. plot within the main plot

↓

Mixing of all the litter collected from four different plots

↓

Weighing of composite sample and recording the fresh weight

↓

Drying of sample at 70 degree celsius for 48 hours and recording the dry weight

# Estimation OF AGB and BGB

## ESTIMATION FOR AGB

**Above Ground Biomass (AGB) = Volume * Wood Density (WD) * Biomass expansion Factor(BEF)**

Volume of the Tree = ($\pi r2h$), $\pi$ = 3.14

(More accurately through Volume equations)

**Carbon stock density = Biomass Stock density *IPCC default carbon fraction of 0.47**

**Where, IPCC Default value for WD = 0.67 & BEF = 3.4**

**BEF value**
Open Forest – 1.14
Moderately dense forest – 2.5
Dense Forest – 3.4

## ESTIMATION FOR BGB

- Root Shoot Ratio: 1:0.27 (IPCC, Good Practices Guidelines, 2006)
- Below ground biomass is approx 20% of above ground biomass

**BGB = AGB * 0.27 (IPCC Default value)**

- Where:
- BGB = below ground biomass and
- AGB = above ground biomass

# MEASUREMENT OF DW and SOC

## MEASUREMENT OF DEAD WOOD (DW)

Dead wood with diameter ≥ 5cm should be measured within the 250 $m^2$ plot
Branches with diameters 2-4 cm should be measured within 100 $m^2$ plots
Thinner branches should be measured within 1 $m^2$ plot

**Measurement of standing and fallen dead wood & stumps**

## SOIL ORGANIC CARBON

Includes organic carbon in mineral and organic soils (including peat) to a specific depth chosen by the country (for FSI 30cm) and applied consistently through the time series.

Samples collected from default depth – 30 *30*30cm (ISFR2017)

↓

Standardized 100 or 300 $cm^3$ metal soil sampling corer

↓

200 gm sample collected from one plot and labelling the sample bag properly

↓

Samples sent to laboratory for analysis

# Estimation OF LL, DW and SOC

## ESTIMATION FOR LL AND DW

Leaf litter (LL) and Dead wood (DW) could be calculated through physical weighing in the field

$$LHG = w_{field}/A * w_{dry}/w_{wet} * 1/1000$$

Where,

LL & DW = biomass of leaf litter & dead wood

Wfield = weight of fresh field sample

A = Size of the area

Wdry = Weight of oven dry sample

Wwet = Weight of fresh sample taken to lab to determine moisture content

## ESTIMATION OF SOC

$$SOC = r_b * d * \%C$$

where,

SOC = soil organic carbon stock per unit area (t/ha)

$r_b$ = soil bulk density (g/cm$^3$) – Default value is 1.2

d = total depth at which sample was taken (cm)

%C = carbon concentration

*Source:*

*Pearson et al (2005)*

In this equation, C must be expressed as a decimal fraction i.e 2.2% C is expressed as 0.022

# Total Carbon Stock Density

$$TC = C_{AGB} + C_{BGB} + C_{LL} + C_{DW} + SOC$$

Where

TC= carbon stock density

C(AGB) = carbon in above ground biomass

C(BGB) = carbon in below ground biomass

C(LL) = carbon in leaf litter

C(DW) = carbon in deadwood

SOC = soil organic carbon

**Tons of $CO_2$ equivalent = 3.67* total carbon stock (Pearson et al. 2007)**

# Grasslands

# Carbon Stock Assessment

- Carbon pools in the study was estimated using "Plot method" which is most suitable, cost-effective and commonly adopted by IPCC 2006.

- Methodologies for assessment of Carbon stock in the three main pools of grassland: Above ground biomass, below ground biomass and soil organic carbon is described below.

# Measurement Of Above Ground Biomass

Plot size of 5m x 5m is considered to be most suitable for grassland carbon inventory for above ground biomass assessment (IPCC 2006)

↓

Wooden sampling frame will be placed to mark 1m$^2$ square within the main plot for above ground biomass harvesting.

↓

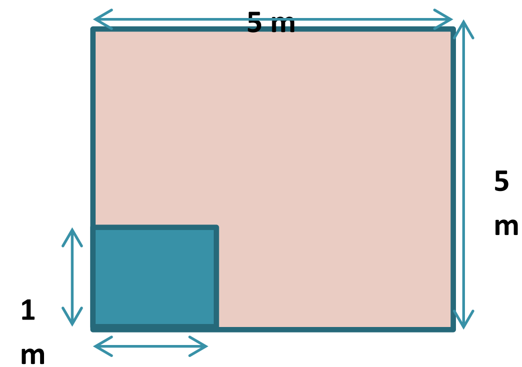
Sample of approximately 100 gm will be collected.

↓

The field data collected needs to be recorded on a working sheet.

↓

The collected sample will be further sent to laboratory for analysis in order to calculate the total dry weight.




Size of sample plot (5m x 5m)

Wooden sampling frame for measurement of above ground biomass assessment (UNDP 2014)

# Calculation for Above ground Biomass

**Total dry weight (kg/ m$^2$)**

Total fresh weight (kg) x Subsample dry weight (g) x Sample area (m$^2$) / Subsample fresh weight (g)

$\mathbf{C_{AGB}}$ =Total dry weight x 0.47

Source: IPCC 2006

# Measurement Of Below Ground Biomass

- For the estimation of below ground biomass, a simplified approach based upon below-ground to above-ground biomass ratios will be used (IPCC 2006).
- Expansion factors are often used to estimate below-ground biomass from above-ground biomass

**Default expansion factors of the ratio of below ground biomass to above ground biomass (R) for the major grassland ecosystems of the world (IPCC 2006)**

| Land use category | Vegetation type | R (tonne d.m. below ground biomass/ tonne d.m. above ground biomass) |
|---|---|---|
| Grassland | Steppe/ tundra/ prairie grassland | 4.0 |
| | Semi-arid grassland | 2.8 |
| | Sub-tropical/ tropical grassland | 1.6 |
| Other | Woodland/ Savannah | 0.5 |
| | Shrubland | 2.8 |

**Below Ground Biomass = 0.5 * Above Ground Biomass**

**$C_{BGB}$ = Total below ground biomass x 0.47**

# Measurement Of Soil Organic Carbon (SOC)

**Includes organic carbon in mineral and organic soils (including peat) to a specific depth chosen by the country (for FSI 30cm) and applied consistently through the time series.**

Two subplots of 1m x 1m in size are laid out within the main plot of 5m x 5m

↓

Samples collected from default depth – 30 *30*30cm (ISFR, 2017)

↓

200 gm sample collected from one plot and labelling the sample bag properly

↓

Samples sent to laboratory for analysis

SOC is calculated from soil organic matter (SOM) by multiplying by the carbon content of SOM.

**SOC (t/ha) = [soil mass in 0-30 cm layer SOC concentration (%)] / 100** (IPCC 2006)

# Total Carbon Stock Density for Grasslands

$$C = C_{AGB} + C_{BGB} + SOC$$

Where,

$C$ = carbon stock density

$C_{AGB}$ = carbon in above-ground biomass

$C_{BGB}$ = carbon in below-ground biomass

$SOC$ = soil organic carbon

Tons of $CO_2$ equivalent = 3.67* total carbon stock (Pearson et al. 2007)

# Wetlands

# Wetland Carbon Stock Assessment

| Sr. No | Compartment | Types |
|---|---|---|
| 1. | Lake/ River Bed area (Soil Organic Carbon) | Vegetated and Unvegetated Soil |
| 2. | Water Column | Phytoplanktons and Algae |
| 3. | Lake Area (Green Carbon) | Emerged Vegetation |
| | | Reed beds (AGC and BGC) |
| | | Water edges and shores |
| 4. | Surrounding area (Riparian) | Terrestrial sediments and Vegetation Carbon stock |

# Approach for wetland carbon stock

1
- **Delineation of project Boundary**

2
- **No. of sample plots**

3
- **Identification of Carbon pools (SOC, Vegetation and Water)**

4
- **Field measurements in the permanent plots**

5
- **Data Analysis**

# Soil Organic Carbon

- Soil sample from the water would be collected at 30 cm depth using a soil corer.

- Soil sample on the banks or riparian zone would be collected as specified and calculated in the Woodland carbon stock section.

# Total SOC

$$\rho_{sj} = \frac{m_j}{v_j}$$

## Soil Bulk Density

where psj is soil bulk density (g cm_3) of the jth horizon, mj is mass of soil sample (g) of the jth horizon dried at 105 _C and vj is volume of soil sample (cm3) of the jth horizon.

## Soil Organic content

% of SOC= 3.951/g × (1-T/S)

## Total SOC

Total organic carbon= %SOC× Bulk density× soil horizon (m) expressed into tons per ha

# Vegetation carbon Analysis

- Carbon stock for sample present on the riparian zone would be calculated as mentioned in the Woodland carbon assessment method.

- In case of vegetation present inside the waterbody,
  - samples of the plant would be collected  and dried for two weeks
  - dry weight values of the plant biomass are then multiplied by a factor of 0.5

# Water carbon stock

- The water samples would be collected following is sterilised plastic bottles and would be preserved by adding HCL to determine the carbon content.
- Total Organic Carbon (TOC) would be measured with the help of TOC analyzer (Shimadzu TOC-VE Total Organic Carbon Analyzer).
- TOC analyzer would be based on 680 °C Combustion Catalytic Oxidation Method.
- Dissolved Organic Carbon (DOC) would be further calculated by multiplying TOC by 0.9 (Wetzel 2001) and Particulate Organic Carbon (POC) would be calculated by subtracting DOC from TOC.

# Total Carbon Stock of Wetlands

$$C = C_{water} + C_{Vege} + SOC$$

Where,

| | | |
|---|---|---|
| $C$ | = | carbon stock density |
| $C_{water}$ | = | carbon in water |
| $C_{vege}$ | = | carbon in vegetation |
| SOC | = | soil organic carbon |

Tons of $CO_2$ equivalent = 3.67* total carbon stock (Pearson et al. 2007)

# Carbon Stock

| Ecosystem s | Area (ha) | Carbon stock (tonnes) | Carbon stock (Mt) | Percentage of carbon stock |
|---|---|---|---|---|
| **Forests** | 142301.79 | 67543237.6 | 67.55 | 77.1 |
| **Grassland s** | 47708.28 | 4751935.52 | 4.75 | 5.4 |
| **Wetlands** | 34042.77 | 15319246.5 | 15.32 | 17.5 |
| **Total** | **224052.84** | **87,614,420** | **87.62** | |

# Capacity building of forest personnel's on carbon estimation

# Assessment of 5 pools of carbon

# Human wildlife conflict

Objectives:

- To assess the nature and extent of human-wildlife interaction in the Dudhwa Tiger Reserve landscape.
- Socioeconomic assessment of local communities living in and around Dudhwa Tiger Reserve and understanding their perception towards wildlife and conservation.
- To assist the Uttar Pradesh Forest Department by providing mitigation strategies to decrease the human wildlife conflicts, which inturn would enhance the income of the forest-fringe communities, affected by the conflicts.

# VILLAGES SELECTED FOR THE SURVEY

| S. No. | Villages | Total Households | Total Population | Male | Female | Avg. Sex Ratio | Literacy Rate (%) | Tehsil | District | Range | Nearest Forest Division/Protected Area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1` | Bardiya | 467 | 2854 | 1428 | 1426 | 999 | 37.89 | Nanpara | Bahraich | Nishan Gara | Katerniaghat WLS |
| 2 | Bisunapur | 262 | 1752 | 918 | 834 | 908 | 39.77 | Nanpara | Bahraich | Nishan Gara | Katerniaghat WLS |
| 3 | Fakirpuri | 315 | 2157 | 1063 | 1094 | 1029 | 54.10 | Nanpara | Bahraich | Nishan Gara | Katerniaghat WLS |
| 4 | Narang (Salavat Nagar) | 493 | 2356 | 1253 | 1103 | 880 | 51.75 | Gola Gokaran Nath | Kheri | Mailani | South Kheri |
| 5 | Korriyani | 450 | 2000 | ____ | ____ | ____ | ____ | Gola Gokaran Nath | Kheri | Mailani | South Kheri |
| 7 | Gulara | 225 | 1048 | 495 | 553 | 1117 | 9.99 | Palia | Kheri | South Sonaripur | Dudhwa National Park |
| 8 | Sumer Nagar | 596 | 4022 | 2119 | 1903 | 898 | 69.4 | Palia | Kheri | ____ | Dudhwa National Park |
| 9 | Majhoura | 305 | 1502 | 806 | 696 | 864 | 42.15 | Palia | Kheri | ____ | South Kheri FD |
| 10 | Mailani | 354 | 1806 | 941 | 865 | 919 | 53.07 | Gola Gokaran Nath | Kheri | ____ | South Kheri FD |
| 11 | Ellenganj | 227 | 1090 | 575 | 515 | 896 | 61.44 | Palia | Kheri | ____ | South Kheri FD |
| 12 | Chaltua | 50 | | | | | | | | Mailani | Kishanpur |

# GROUP DISCUSSION IN NARANG VILLAGE, KISHANPUR WILDLIFE SANCTUARY


Discussion with Forest Officials and Field Staffs

Discussion with Mr. J. D. Tyagi, Field Expert, DTR

# GROUP DISCUSSION IN FAKIRPURI VILLAGE, KATERNIAGHAT WILDLIFE SANCTUARY

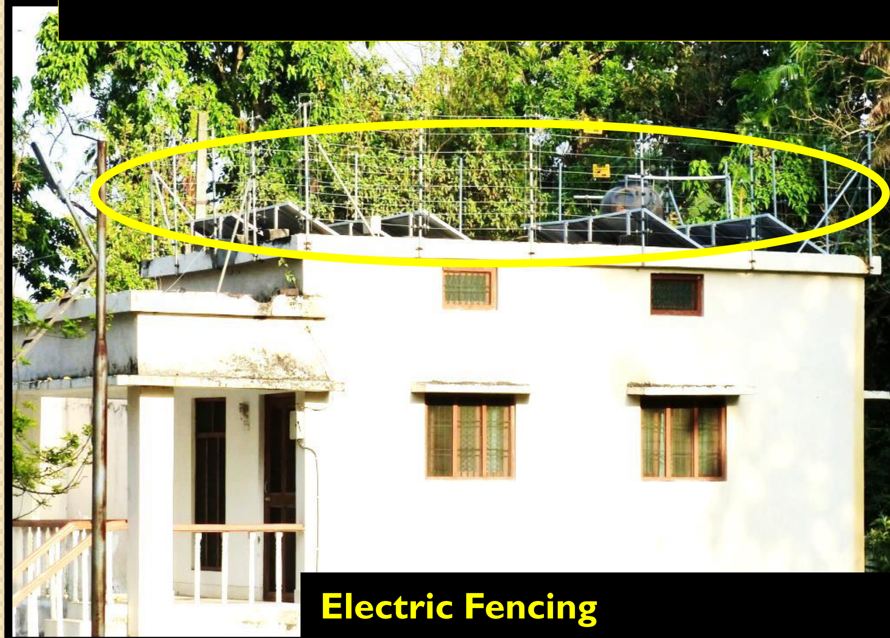
# Issue of Human wildlife conflict

- Around 97% of the households collect fuel wood, 76% collect fodder, 80% collect NTFPs, and about 70% of the households are involved in cattle grazing activities inside forests.
- About 29% of households don't have electricity, 22% don't have bathroom facilities and almost 78% stay in semi-pucca houses.
- **Wild Pig** (95.45%) and **Nilgai** (92.42%) were reported by the respondents to cause maximum damages to crops.
- maximum conflict incidents resulting in injuries and loss of life of livestock as well as human being is due to **Tigers** (92%), **Wild pig** (89.5%) and **leopards** (84%).
- Due to the infrastructure limitations and high dependence on forest, **injuries and deaths due to leopards and tigers were maximum reported**.

# Mitigation Strategies

- LPG can be provided through convergence with ongoing Govt. schemes like *Ujwala.*
- Need to constitute a network of Primary Response Teams (PRTs) consisting of local community members/BMC's.
- Streamline the official procedure for payment of ex-gratia relief to the victims of HWC
- Initiate pilot livestock and crop insurance schemes through agriculture and animal husbandry department
- Arrangements by liasoning with medical treatment centers so that the persons injured by wild animals receive quick and proper medical treatment.
- Cultivating plants like *Mentha* and other essential oil plants like Chamomile, lemongrass, ginger etc. have been reported to prove to be very useful in providing compensation to the farmers

# MITIGATION STRATEGIES ADOPTED BY THE PEOPLE IN DUDHWA TIGER RESERVE



Electric Fencing

Colorful sarees along the fences to deter the wild animals

Scarecrows and local wind chimes to deter birds and other animals

Watch huts and colourful films

# Ecosystem Services

**Ecosystem services are the are the direct and indirect contributions of ecosystems to human well-being (TEEB)**

**Provisioning Services**

*Goods produced or provided by ecosystems*

- Food
- Fibre
- Fuel wood
- Genetic Resources
- Bio-chemicals

**Regulating services**

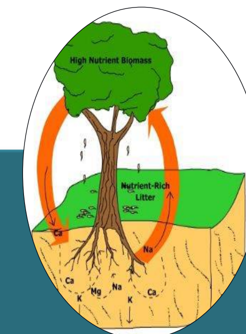
*Benefits obtained from regulation of Ecosystem processes*

- Air quality regulation
- Climate regulation
- Water purification
- Pollination
- Erosion

**Cultural services**

*Non-material benefits from ecosystems*

- Aesthetic values
- Recreation & Ecotourism
- Spiritual & Religious Values
- Knowledge systems




**Supporting services**

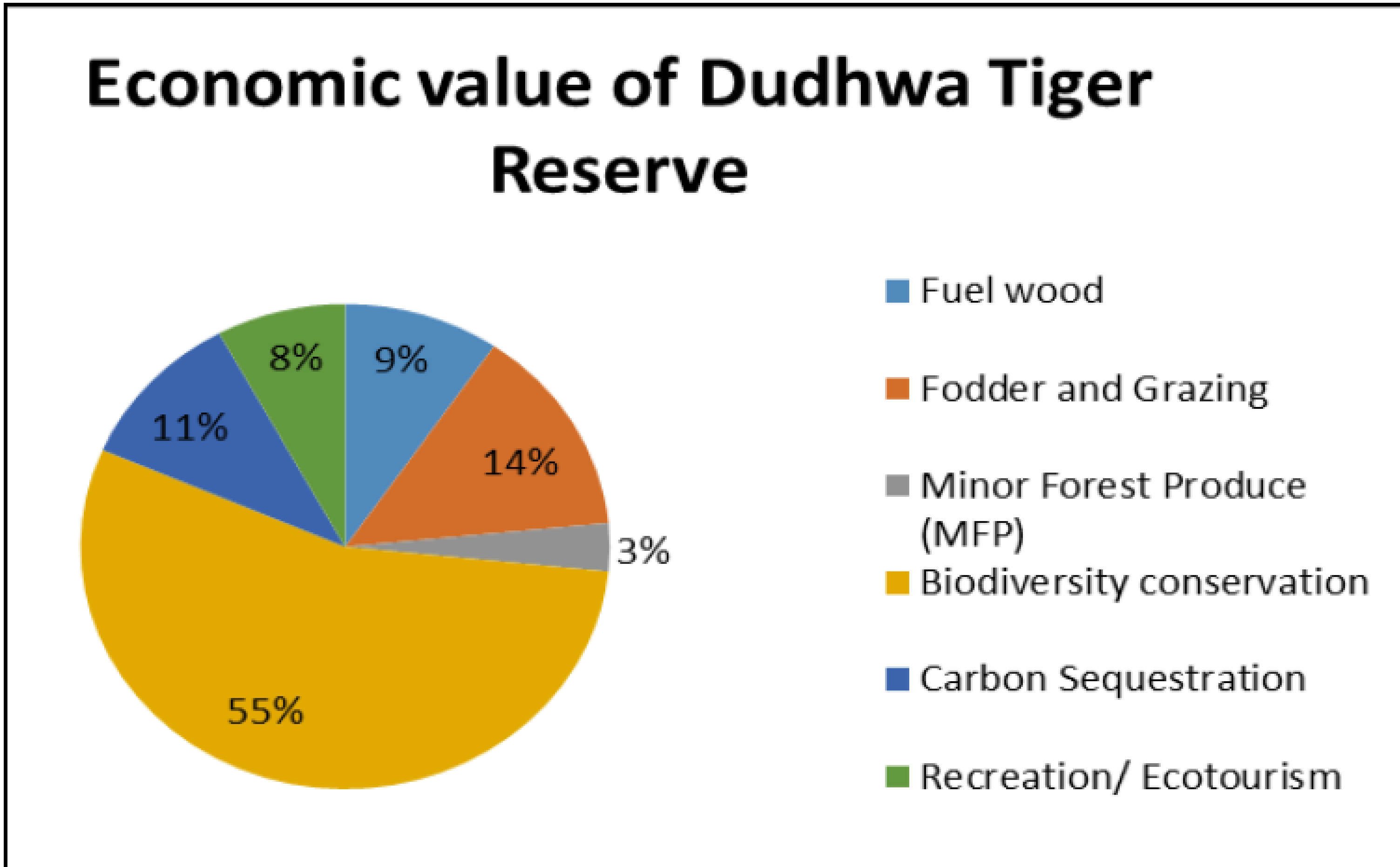
*Functions that maintain all other services*

- Nutrient cycling
- Soil formation
- Primary production

# Economic value of ecosystem services provided by DTR

| Sr. No | Ecosystem Service | Type of Service | Annual Value (Rs. In million) | % Contribution |
|---|---|---|---|---|
| 1 | Biodiversity Conservation | Supporting Service | 5810.81 | 55 |
| 2 | Fuel wood | Provisioning Service | 1007.17 | 10 |
| 3 | Minor Forest Produce | Provisioning Service | 388.40 | 3 |
| 4 | Carbon Sequestration (Using market price) | Regulating Service | 1116.47 | 11 |
| 5 | Fodder and Grazing | Provisioning Service | 1473.20 | 14 |
| 6 | Ecotourism | Cultural Service | 836.27 | 8 |
| | Total Economic Value | | **10,582. 34** | 100.00 |

# An index to standardize the contribution of co-benefits- CCBA Index

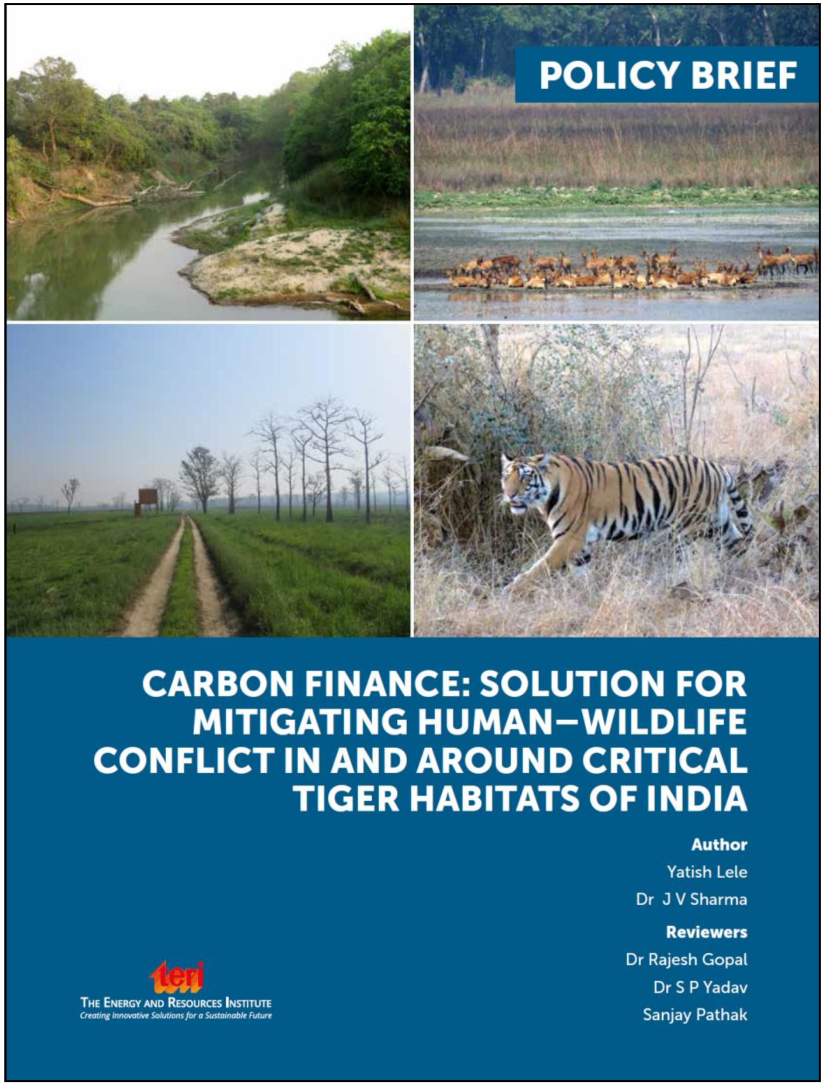


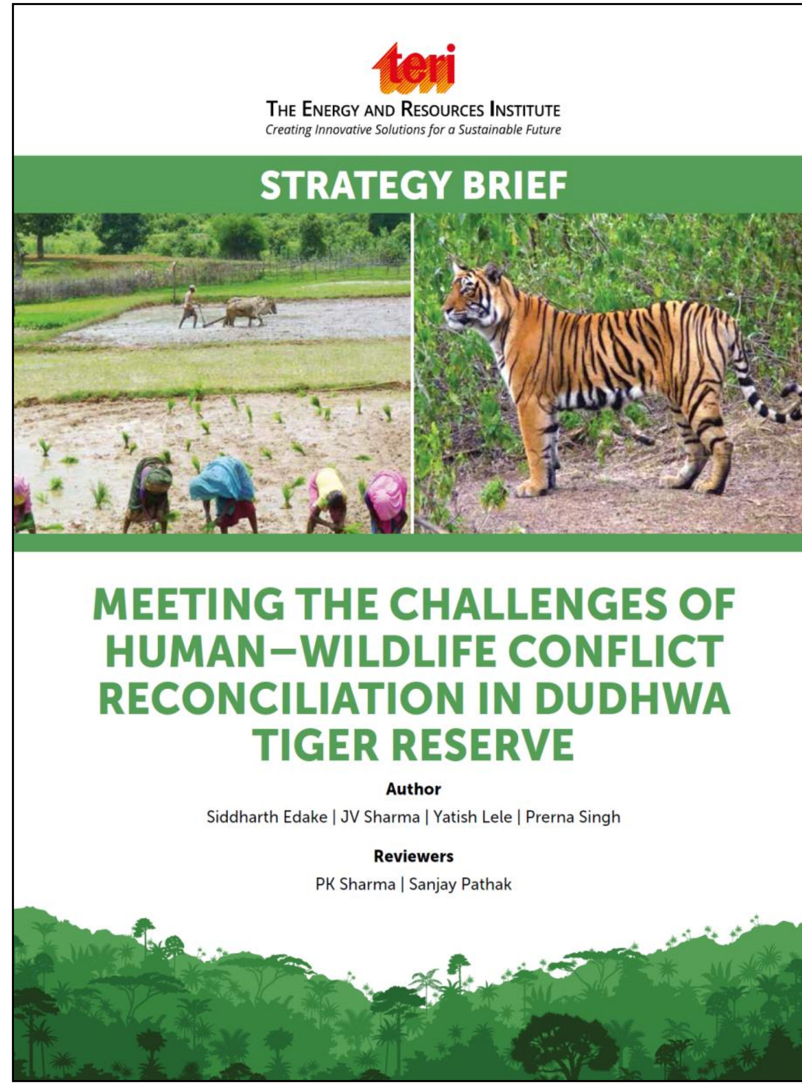

CCBA Index- 1:8

# Way Forward

- Ujjwala scheme (Distribution of LPG cylinders) implemented by UPFD in almost more than 200 villages.
- The average annual carbon sequestered by DTR is around 1 million CERs.
- Implementation of this scheme and strategy prepared for HWC has led to improvement in the carbon sequestration potential with an additional 0.3 million tCo2e.(use of LPG save 90% fuel wood Emissions and saved wood further sequester Co2)
- Awareness and capacity building of forest staff and local communities is required to support them in further development of PDD and monitoring report for voluntary carbon market.

# Publication



# Thank you