Uncertainty Assessment: India's Experience

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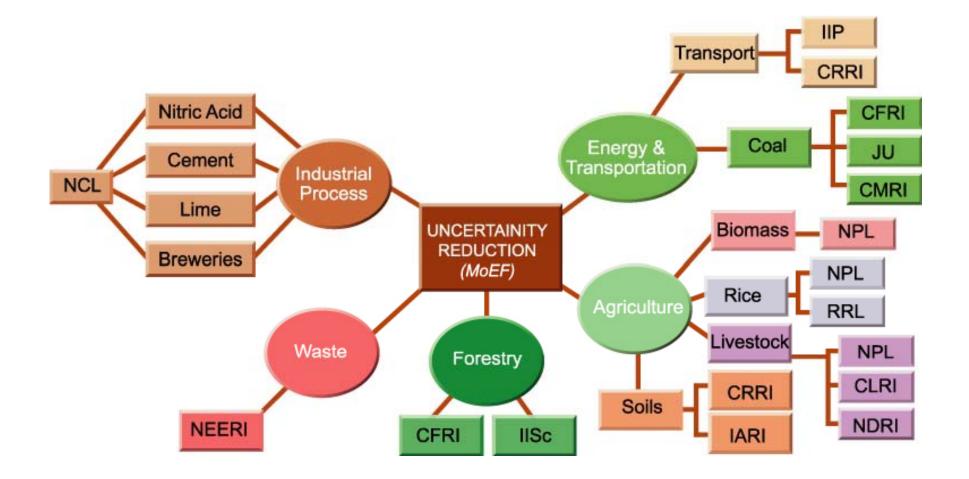
Approach towards reducing uncertainties in GHG estimates

- Development of country specific GHG emission factors
 - Updating the same with time
 - Evaluating key sources over time and developing new emission factors
- Identifying uncertainties in the steps of GHG estimates itself by using the IPCC guidelines

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Cross brief kg CH_/yt/animal 43±5 Dairy kg CH_/yt/animal 43±5 Non-dairy < 1 yr			
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Non-datry < 1 yr kg CHJytylanmal 8±3 Non Datry1-3 yrs kg CHJytylanmal 22±5 Others kg CHJytylanmal 22±5 Others kg CHJytylanmal 44±11 Developed by: NDRI, Kamal; NPL, New Deth; CLRI, Chemai 44±11 Rain fed - flood prone ton CHJkm2 19±5.0 Rainfed-drought prone ton CHJkm3 6.95±1.85 Irrigated (Continuously Flooded) ton CHJkm4 17.48±4.00 Intermittently Flooded - Single aeration ton CHJkm5 6.62±1.89 Intermittently Flooded - Multiple Aeration ton CHJkm5 2.01±1.49 Deep water ton CHJkm7 19±5.0			
Non Dairy1-3 yrs kg CHJ/yr/anmal 22±5 Others kg CHJ/yr/anmal 44±11 Developed by: NDRI, Kamal; NPL, New Dells; CLRI, Chevnai 44±11 Rain Ned - Rood prone ton CHJ/km2 19±5.0 RainNed-drought prone ton CHJ/km3 6.95±1.85 Irrigated (Continuously Flooded) ton CHJ/km4 17.48±4.00 Intermittently Flooded - Single aeration ton CHJ/km5 6.62±1.89 Intermittently Flooded - Multiple Aeration ton CHJ/km5 2.01±1.49 Deep water ton CHJ/km7 19±5.0			
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Developed by: NDRI, Kamal; NPL, New Dells; CLRI, Chemel Rice Cultivation Rainfed-flood prone Inned-drought prone ton CH,/km3 Experimentary Flooded) Intermittently Flooded - Single aeration Intermittently Flooded - Multiple Aeration Ten CH,/km5 Experimentary Flooded - Multiple Aeration Ten CH,/km7 Ten CH,/km7	and the second sec		
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Intermittently Flooded- Multiple Aeration ton CHJ/km5 2.01±1.49 Deep water ton CHJ/km7 19±5.0			
Deep water ton CHJ/km7 19+5.0			

NATCOM-I

Institutional arrangement: NATCOM I



Moving on to NATCOM - II

- Refinement of existing factors
- Development of new emission factors
- Moving towards higher tier estimates for key source categories
- Bridging data gaps identified in NATCOM I
- Launching standard QA/QC procedures for each of the categories

Sources of emission	CO ₂ equivalent (Gg)	Percentage of total emissions	emission	total emission	Tier used		Status of EF anvisaged in SNC
Energy and transformation							
industries	355037	28.9	355037	28.9	Tier :	CS	R
Enteric Fermentation	188412	15.3	543449	44.2	Tier 🛙	CS	R
Industry	150674	12.3	694123	56.5	Tier I	D.	D
Rice Cultivation	85890	7.0	780013	63.5	Tier II	CS	R
Transport	80280	6 .5	860299	70.0	Tier I	CS.	R
Emission from Soils	45260	3.7	905559	73.7	Tier I	D	CS
Iron and steel production	44445	3.6	950004	77.3	Tier I	D	CS
Energy use in Residential sector	43918	3.6	993922	80.9	Tier I	D	D
Biomass burnt for energy	34976	2.8	1028898	83.7	Tier :	D.	D
All other energy sectors	32087	2.6	1060985	96.4	Tier 1	D	D
Cement production	30767	2.5	1091752	88.9	Tier :	CS	R.
Energy consumed in Commercial/institutional	20571	1.7	1112323	90.5	Tie: I	D	D
Manure Management	20176	1.6	1132499	92.2	Tier :	D	D
Ammonia production	14395	1.2	1146894	93.4	Tier I	D	CS .
Land use, Land-use change and	·						
Forestry	14292	1.2	1161186	94.5	Tier I	D.	CS
Coal mining	13650	1.1	1174836	95.6	Tier III	CS.	CS
Oil and natural gas system	12621	1.0	1187457	96.7	Tier I	D	D
Municipal Solid Waste Disposal	12222	1.0	1199679	97.7	Tier :	D	CS
Domestic Waste water	7530	0.6	1207218	98.3	Tier :	D	D
Lime stone and dolomite use	5751	0.5	1212969	98.7	Tier :	D	D
Agricultural crop residue	4747	0.4	1217716	99.1	Tier I	D	D
Nitric acid production	2790	0.2	1220506	99.3	TierⅡ	CS .	CS
Human Sewage	2170	0.2	1222676	99.5	Tier I	D	D
Lime production	1901	0.2	1224577	99.7	Tier :	D	D
Industrial Waste Water	1302	0.1	1225879	99.8	Tier :	D	CS
Ferro alloys production	1295	0.1	1227174	99.9	Tier I	D	D
Aluminium production	749	0.1	1227923	99.9	Ties :	D	D
Carbide production	302	0.0	1228225	100.0	Tier 1	D	D
Soda ash use	273	0.0	1228498	100.0	Tier :	D	D
Black carbon and styrene prod.	42	0.0	1228540	100.0	Tier :	D	D

Key Sources analysis

Note: D: IPCC default emission factor, CS: Country specific emission factor, R : Revised country specific emission factor

Planning for reducing uncertainties

c e	10000 I	e	1	1	in a	i1
		Status of			Tier used	
emission		EF			in INC	
		envisage				Proposed
		d in SNC	Activities proposed in SNC	Rationale		in SNC
Energy and	CS	R	 Refinement of NCV of different types 	o Inadequate sample size taken in INC	Tier I	Tier II
transformation			of coal			
industries			o Determine technology specific point	o Thermal power plants is the key category		
			source level EFs of CO ₅ , CO and NOX			
			for thermal power plants			
Enteric	CS	R	o Sample survey of age wise domestic	 It is a key category in the agriculture sector. 	Tier II	Tier III
Fermentation			livestock population, feed type, milk	o In INC, appropriate activity data was not		
			production in various climate regions	available to make a correct assessment		
			of India	o The sample size for which measurements		
			o Develop CH, EF for enteric	were taken was small, and could not be		
			fermentation through estimation and	validated through estimates because lack of		
			measurement	activity data		
Industry (fuel	D	D	-not targeting-	-not targeting-	Tier I	Tier I
	D	P	-not targeting-	-not targeting-	Tier I	mer i
combustion)	C 0	-				
Rice Cultivation	CS					No
			hotspot areas	category amongst all the agriculture		change
				categories. As the emission from this source		
				is dominated by emissions from hotspots,		
				therefore it is proposed to investigate the EFs		
				from these regions.		
Transport	CS	R.	o Conduct survey to apportion the fossil	These two approaches will be used to	Tier I	Tier II
				reconcile the top down and bottom up		
			vehicles	emission estimates from this source		
			o Refine EFs from different kinds of			
			gasoline and diesel driven vehicles by			
			incorporating driving cycles			
Emission from Soils	D		o Development of N ₂ O EFs from	This is a major source of NO emission	Tier I	

Planning for reducing uncertainties

		cs	different soils	amongst all the categories.		Tier II
Iron and steel production	D	cs	(resulting from combustion of fuel &	It is a fast growing sector of the economy in addition to being a major source of CO2 emission	Tier I	Tier II
Energy use in Residential sector	D	Þ	-not to be targeted-	-not to be targeted-		No change
Biomass burnt for energy	D	Þ	-not to be targeted-	Data available		No change
All other energy sectors	D	Þ	-not to be targeted-	Individually not in key category	Tier I	No change
Cement production	CS	R	Plant level assessment of CO ₂ EFs due to production process	It is a fast growing sector of the economy in addition to being a major source of CO2 emission	Tier I	Tier II
Energy consumed in Commercial- institutional	D	D	-not to be targeted-	 not to be targeted- As source category too diverse, and enough resources not available. 		No change
Mamure Management	D	Þ		Manure management not done in a systematic manner in India	Tier I	No change
Ammonia production	D	cs	Determine plant level CO2EF	Key category – not targeted in INC.	Tier I	Tier II
Land use, Land-use change and Forestry		CS	o Develop land use change matrix o Assess biomass stock, carbon	A key category, and targeted in SNC to bring in the GPG LULUCF (2003) guidance in the inventory estimation process.		Tier II
Coal mining	CS	CS	-not targeted-	-not targeted-	Tier III	Tier III
Oil and natural gas system	D		transport, storage, venting and flaring.	Though not a key category, but the consumption of oil and natural gas shows the highest growth rate w.r.t other fossil fuel, so efforts will be made to stream line assessment of activity data	Tier I	Tier I

Planning for reducing uncertainties

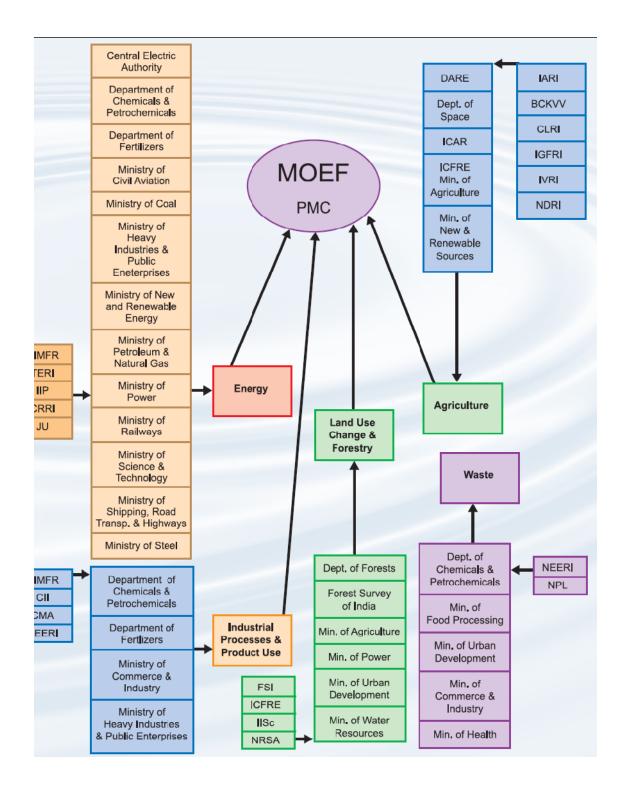
Municipal Solid Waste Disposal			 Assess per capita MSW generation, composition and handling process Generate EFs for managed and unmanaged landfill areas 	Rapid urbanization resulting in increased generation of waste and changed composition	Tier I	Tier II
Domestic Waste water	D	D	-no: targeted-	-not a key category-	Tier I	No change
Lime stone and dolomite use	D	D	-no: targeted-	nøt a key category-	Tier I	No change
Agricultural crop residue	D	D	-no: targeted-	not a key category-	Tier I	No change
Nitric acid production	CS	cs	-no: targeted-	nøt a key category-	Tier II	No change
Human Sewage	D	D	-no. targeted-	not a key category-	Tier I	No change
Lime production	D	D	-no: targeted-	nøt a key category-	Tier I	No change
Industrial Waste Water	D	cs	Chemical analysis of waste water in selected key industries	Rapid growth of certain industries like paper, pulp, beverage etc.	Tier I	Tier II
Feno alloys production	D	Р	-no: targeted-	not a key category	Tier I	No change
Aluminium production	D	D	-no: targeted-	not a key category	Tier I	No change
Carbide production	D	D	-no: targeted-	not a key category	Tier I	No change
Soda ash use	D	D	-no: targeted-	not a key category	Tier I	No change
Black carbon and styrene production	D	Þ	-not targeted-	nøt a key category	Tier I	No change

NATCOM-II

- Improving NCV of coal
- CO2 emission factors from two power plants due to combustion of coal
- CO2 emission factor from an integrated iron and steel plant due to combustion of fuel and the processes itself
- Updating CH4 from Coal mining
- CH4 from transport of oil/natural gas

NATCOM-II

- CH4 from continuously irrigated rice fields
- N2O from agricultural soils
- Improving CH4 EF from enteric fermentation in Livestock
- Soil C from Forests
- CH4 from MSW
- CH4 from Waste water from key industries



Institutional Arrangement: NATCOM II

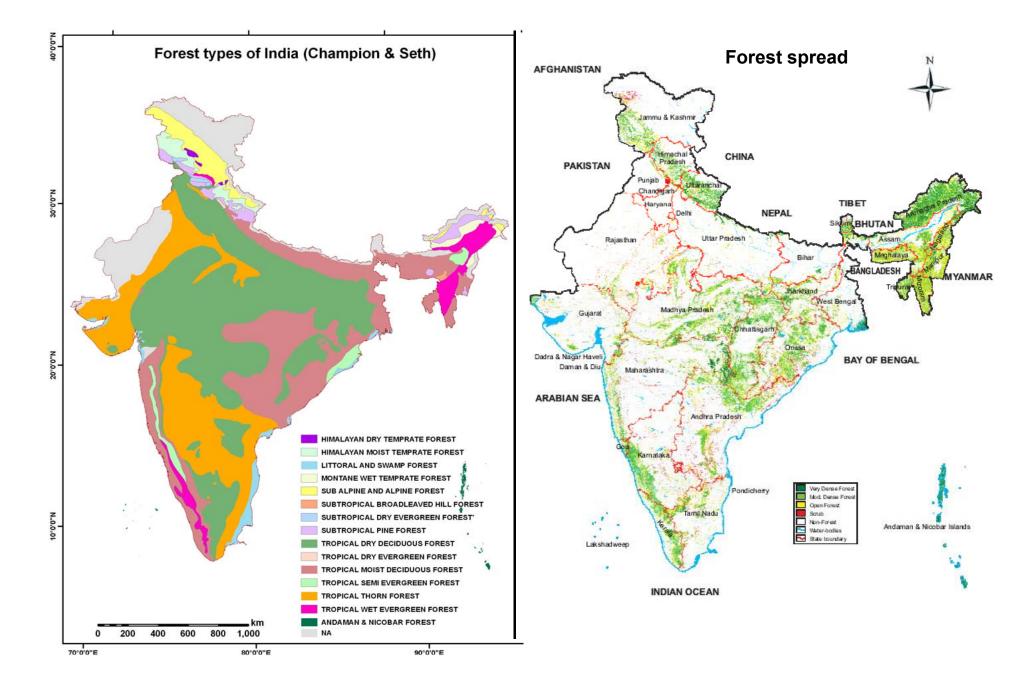
An example – LULUCF – Soil C

Problems to address..

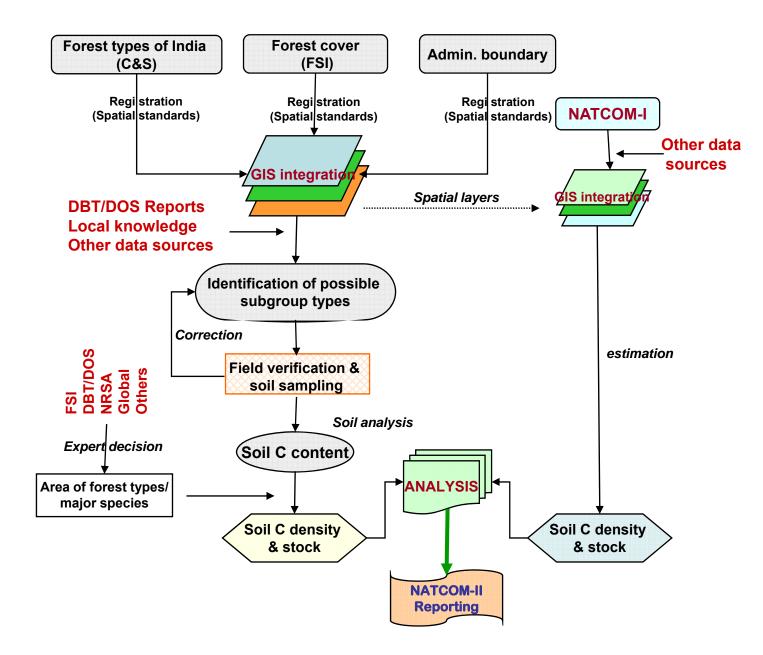
- Preparation of Forest type and sub-group type map of India (Champion & Seth, 1968)
- ✓ Harmonization of different spatial layers of India (forest types, actual forest cover, administrative boundaries and collateral data sources), and assigning them uniform spatial standards
- ✓ Non-existence or localized presence of some of the forest sub-group types and difficulty in locating them
- Even modern tools like RS and recent published estimates gives only forest types and sub-group type associations/equivalents

Opportunities..

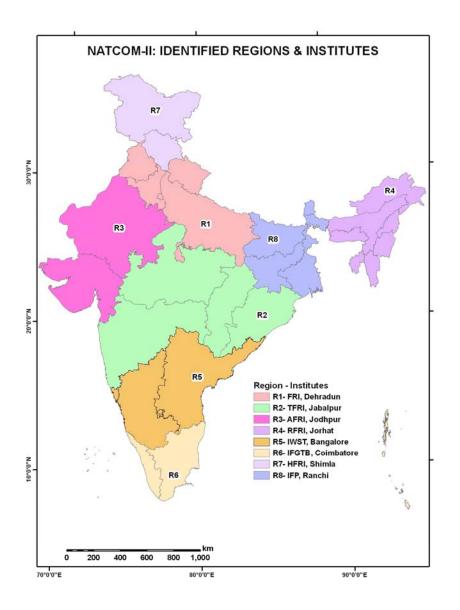
- Preparation of Forest type map and sub-group type details of India in tabular format (Champion & Seth, 1968)
- Harmonization of different spatial layers of India (forest types, actual forest cover, administrative boundaries and collateral data sources) in GIS and assigning them uniform spatial standards
- ✓ Use of FSI and DBT-DOS reports



Flow diagram showing overview of methodology



ICFRE participating Institutes and their area of jurisdiction



Nodal ICFRE Institutes and number of sample locations

	Total No. of samples		171	513+78=591
R8	IFP, RANCHI	BH, JH, WB, Sikkim	13	39+10=49
R 7	HFRI, SHIMLA	HP, J&K,	16	48+08=58
R6	IFGTB, COIMBATORE	TN, KE, A&N Is. Pondy,	32	96+10=106
R5	IWST, BANGALORE	KA, AP, GOA	15	45+08=53
R4	RFRI, JORHAT	North East	29	87+12=97
R3	AFRI, JODHPUR	RA,GU, D&N Haveli, D&Diu	18	54+10=64
R2	TFRI, JABALPUR	MP, MS, OR,CH	17	51+10=61
R1	FRI, DEHRADUN	UA, UP, PUN,HA, ND, Chandigarh	31	33+10=43
Region	Name of the Institute	Area coverage	No. of subgroup types	Number of samples (@ 3 per type + from non- forest area)

What is given...

- Forest types, sub-groups, sub-group types, C & S code, distribution and dominant species along with the identified institute is supplied to every participating institutes.
- This will be supplemented with any other map available for now or as soon is become available.

Detailed methodology Prepared for :

Sample collection Storage Analysis and calculation

Inception meeting with Nodal officers from different ICFRE Institutes conducted 9-10 May

Sampling procedure to be uniformally adopted by all teams demonstrated in the field

QA/QC plan developed

Compartment/Vi	llage		_Block/Te	ehsel		
Division/Distt		State				
Altitude	Aspect	Latitude		Longituc	le9t	
orest type :		Dominant spe	cies			
Slope (%) :		Rock out crop (%	%):			
Coarse Fragmer	ıts (%)					
<u>Fick on appropri</u>	iate feature	<u>):</u>				
a) Erosion class	: Slight	Moderate	Severe		Gullied	
		Hill slope Plateau				Valley
) Moisture	: Wet	Moist Light (25 % surfac		Dry		
I) Plant litter	:	Light (25 % surfac	e area co	verage)		
	Moderat	te (25-50 % surface	area cove	rage)		
		>50 % surface area	· · · ·			
Soil depth:	Shallow	/ (<25 cm.) ,	Moderat	ely deep (25-50)	
		ite (50-100)	Deep (>	100 cm)		
Sample Collecte						
Division:						
nstitute:						
Date_						
Soil Sample No.	:	(Region No./ For	est types /	/ Sample N	lo Replica	ation No
		Foe ex.	(R6/ TEG	/ 1-2)		

Soil Sample Collection Protocol

Most carbon accounting purposes require a volumetric estimate of soil carbon. This requires measures of bulk density and the volumetric proportion of coarse fragments (e.g. gravels).

Existing guidelines (IPPC, 1997) for carbon accounting refer only to the upper 0.30 m. This zone is intended to cover the actively changing soil carbon pool.

SOC Density (t/ha) =	Organic Carbon Content (%) * Bulk density *
	Soil Layer depth * (1- volume fraction
of	coarse fragments)

While sampling certain points should be kept in mind.

- Locate sample site away from roads, houses and construction sites, etc.,
- In a forested area sample should be drawn away from the trunk of the tree or between trees.
- Avoid eroded and locations where large plant material is under decay.
- Always dig **a fresh rectangular pit** and in grass land first clear the top layer and dig the profile.

1. Estimating Rock Outcrop

It is desirable to have a more accurate estimate of the volume of rock within the soil individual. Measure rock outcrop along a series of linear transects. At each transect intercept, record the length of rock surface (>50 mm). The area of rock outcrop is estimated using:

Aro = 100 (∑r / L)

where Aro is the areal percentage of of rock outcrop, L is the total transect length and r is the length of rock intercepted (m).

Rock outcrop can also be measured using the 10 m grid (100 m² area) assuming that the observer is at the middle of the grid. Make schematic sketch of the rock out crop on the grid and estimate the percentage.

2. Estimating Percent Coarse Fragment in the Soil

Percent coarse fragment (>2mm size) in soils will be estimated by morphological examination of soil.

Coarse fragments by volume in layer of 0-30 cm. using the visual estimation of coarse fragments key should be observed.

An area of 10 cm. by 10 cm. (100 cm2) can be visualized in layer covering of coarse fragments.

It is also useful to indicate the size of coarse fragments (CF) by type, as given in table 4b:

Type of coarse fragments and its size

Gravels (G) <u>2 -75 mm;</u> Cobbles (C) <u>75-250 mm;</u> Stones (S) <u>> 250 mm</u> (25 cm).

3. Collection of Samples

In each sampling units, three sampling points will be selected as replicates.

At each point soil sample of 0-30 cm. depth will be collected.

One sample will also be collected in **non-forested area (agricultural area)** close to the major forest types.

Detailed number of samples, forest sub types and nodal institutes are given in sampling plan with participating institute.

3.1 Soil sample for carbon estimation:

- Forest floor litter of an area of 0.5m x 0.5 m, at sampling point will be removed and a pit of 30 cm wide, 30 cm deep and 50 cm in length will be dug out.
- Soil from three sides of the pit, will be scraped with the help of Kurpee from 0 to 30 cm depth and bulked. Scrap uniform thickness of soil layer from top to bottom (0-30m cm)
- This soil will be mixed thoroughly and removed gravels. Quarter the bulked soil sample and select opposite quarter approximately of 500 gm. Here, coarse fragments can also be approximated.
- Keep in a polythene bag and tightly closed with thread.
- A label showing the sampling details should be put in side of polythene bag before closing the bag.
- Proper entry to be made in field note book

3.2 For bulk density estimation by Core sampler

3.3 Storage of the samples

• If numbers of samples are large and not possible to analyze / process immediately after collection from field, then samples collected for soil organic carbon, should be placed in refrigerator or deep freezer.

• Taken out desired numbers of sample and prepare them for estimation.

4. Preparation of sample

4.1 Carbon estimation in the laboratory

- Open the polythene bag and spread the samples on a brown paper sheet in the laboratory. Let the sample dry at room temperature in the laboratory.
- Avoid direct sun drying or oven drying.
- Marking of the sample (which was given on the label at the time of the collection of sample) should be written on the brown paper sheet to avoid the mixing of the samples.
- After drying the samples, grind it and sieve it through 100 mesh sieve (2 mm sieve). This sieved sample will be used for soil organic carbon estimation.

4.2 Analysis

Soil organic carbon will be estimated by standard Walkley & Black method and

Vegetation characteristics of the sample site

Measure 22x22m either side of sample location (Quadrat of 31x31 m=0.1 ha)

Enumerate all tree species > 10 cm dia within the quadrat

For shrubs 5x5 m qudart

For herbs and grasses 1x1 m quadrat

Thank You