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# Carbon stock estimation in different forest lands: A review

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**ABSTRACT**

Terrestrial biosphere comprising of mainly forests, the major source of carbon absorption and the stock estimation methods are initiating to mitigate the threats concerned with climate change. In order to increase the global carbon stock United Nations Framework Convention on Climate Change (UNFCCC) has introduced Reducing Emission from Deforestation and Forest Degradation (REDD+) programme. Thus, several standard procedures applicable to the forestry and agroforestry land use systems have been developed. They introduced the set of methodologies for measuring, monitoring and estimating carbon stock in several forests of the world. Forest Survey of India (FSI) is the foremost contributor to measure forest biomass and carbon stock in India with the joint association of UNFCCC since 2004. This review cited the process of total carbon stock in different forests including organic carbon estimation in above ground biomass, below ground biomass, soil as well as litter biomass through remote sensing method, destructive method, non-destructive methods, ground based inventory data for consistent, precise, pertinent estimation of carbon stock. This review covers various scientific approaches for estimating carbon stock in forests.

**Key words:** Biomass, carbon estimation, forest lands, IPCC, soil organic carbon

## INTRODUCTION

The global carbon cycle has drawn increased (microorganisms) of forest land. Overall, forests concern to address issues associated with are the repository of natural source of atmospheric environmental pollution focusing on the derelict carbon stock. The biological carbon cycle is mostly ecosystem, forest degradation and global climate regulated by four reservoirs including fossil carbon, change. The estimation of carbon stock is taken oceans, atmosphere and terrestrial ecosystems, primarily by indirect methods and is concerned about forest soil and biomass. Potentially soil organic the control of terrestrial carbon exchange factors, carbon is more reliable in the short term storage of its magnitude and primary location. The reduction organic carbon rather than oceans. The amounts of fossil fuel, sovereignty and methods to measure and dynamics of carbon in the world's soils are still emission reduction and new initiatives led by forest relatively poorly known as the carbon stock changes rich developing countries has drawn global attention. dynamically over time and space. The carbon Need of the era is to control high emission and balance of terrestrial ecosystems deteriorate by storage of carbon compounds (e.g. CO, CO etc.) the impact of human activities, deforestation, 2

in the biosphere. The natural processes of trading biomass burning, land use changes, conversion and carbon are done through autotrophs and heterotrophs environmental pollution. Soil carbon pools have decreased by 40 Pg. C from the original 1471 Pg. C during 1850-1980 and carbon held in vegetation by 80 Pg C down from 672 Pg C in 1850. Global release of carbon from land use change in 1990 was between 1.1 and 3.6 Pg C $yr^{-1}$, as compared to 5.5-6.5 Pg C $yr^{-1}$ from fossil fuel combustion. The annually displaced soil due to global soil erosion is about 5.7 Pg C from the total estimated carbon i.e. approximately 1500Pg C.

Forests occupy nearly 4 billion hectares (about 30 per cent) of the earth's land area and evenly divided between tropical , subtropical, temperate and boreal forests. Two third of world's forests are found in Australia, Brazil, Canada, China, Democratic Republic of Congo, India, Indonesia, Peru, Russia, USA etc. The present review discussed several methodologies for estimating the carbon stock in forests. The forest inventory and analysis (FIA) program (2012) estimates that 14.1% of $CO_2$ emission sequestration occur in US forests and associated wood products.

## MAJOR FOREST TYPES OF WORLD

World Wide Fund for Nature (WWF) has categorised the type of forests, mainly based on location (distance from equator and altitude) and climate, as tropical forest, sub-tropical forest, mediterranean forest, temperate forest, montane forest, coniferous forest etc. which acts as carbon pool as well as carbon storage for a long period. United Nations Environment Programme- World Conservation Monitoring Centre (UNEP-WCMC) classification divides the world's forest into 26 major types, redirecting climatic zones as well as the principal types of trees. These 26 major types can be reclassified into 6 broader categories occupying about 250 Gt carbon in above and below ground biomass of forest vegetation (Global forest resources assessment, 2015). Several forest lands of world like low land evergreen broadleaf rain forest, montane forest, freshwater swamp forest, semi-evergreen moist broadleaf forest, mixed broadleaf/ needle leaf forest, mangroves, disturbed natural and deciduous/semi-deciduous broadleaf forest, sparse trees and parkland refer natural forests (10-30% canopy cover) e.g. savannah regions of world stores maximum organic carbon.

**Table 1.** Carbon pools indicating essential of forest lands

| | | |
|---|---|---|
| Living biomass | Above ground biomass | All living vegetation above the soil including stem, stumps, branches, bark, seed and foliage. |
| | Below ground biomass | All biomass of live roots, excluding fine roots of less than 2mm diameter as these often cannot be distinguished empirically from soil organic matter or litter. |
| Non-living biomass | Dead wood | Dead wood includes wood lying on the surface, dead roots and stumps, lager than or equal to 10cm in diameter. |
| | Litter | Include all non-living biomass with a size greater than 2mm and less than 10cm, lying dead, in various states of decomposition above or within the mineral or organic soil. This include the litter layer as usually defined in soil typologies .Live fine roots above the mineral or organic soil are included in litter where they cannot be distinguished from it empirically. |
| Soils | Soil organic matter | organic carbon in mineral soils up to a depth of 1m and applied consistently through the time series. Live and dead fine roots and DOM within the soil are included in soil organic matter |

## CARBON POOLS OF FORESTS

Measuring carbon stock can be quite challenging, but a few basic assumptions can make estimating it much easier. IPCC (2003, 2006) has defined five carbon pools indicating the essential of forestlands which have been discussed in Table 1.

**Table 2.** Global carbon stock in different ecosystems

| Biome | Area (million Km $^2$) | Global carbon stock (GtC) |
|---|---|---|
| Tropical forests | 1.76 | 428 |
| Temperate forest | 1.04 | 159 |
| Boreal forest | 1.37 | 559 |
| Tropical savannas | 2.25 | 330 |
| Temperate grasslands | 1.25 | 304 |
| Deserts and semi-desert | 4.55 | 199 |
| Tundra | 0.95 | 127 |
| Wetlands | 0.35 | 240 |
| Croplands | 1.60 | 131 |

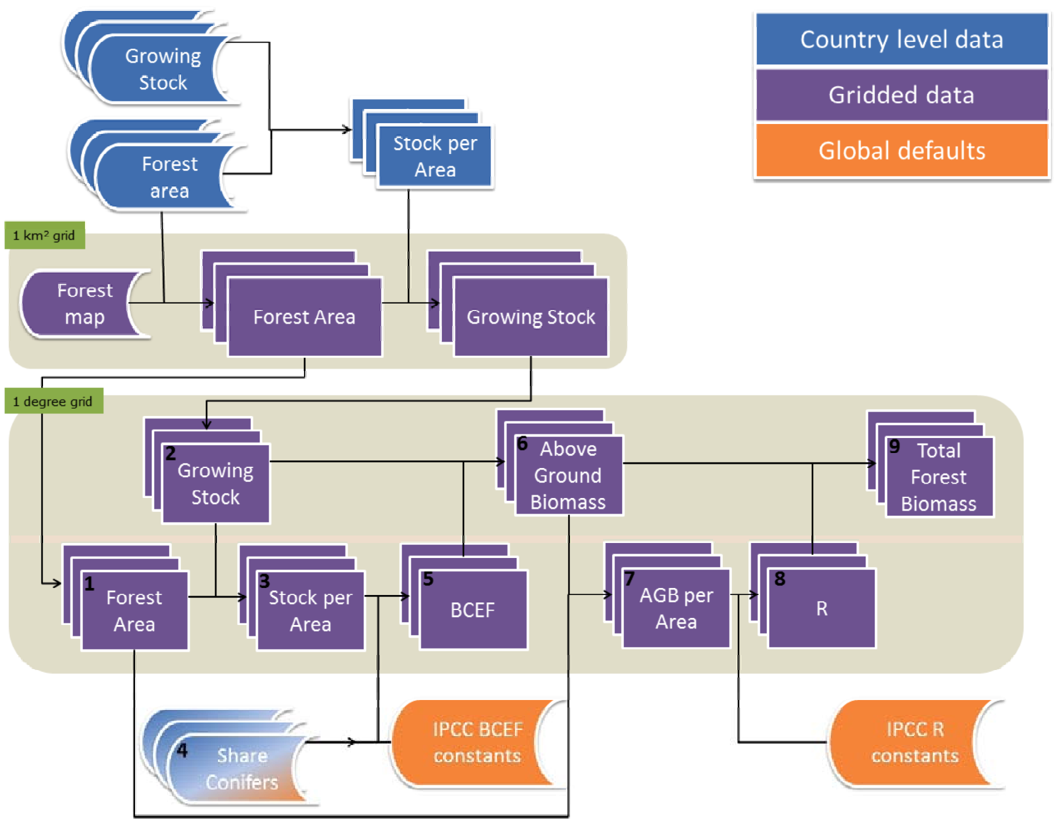


**Fig. 1.** Depiction of the data flow towards forest biomass maps, showing dependencies (Global 1-degree maps of forest area, carbon stock and biomass, 1950-2010, 2015)

### Carbon stock in Indian forests

The forest carbon stocks of different regions of India including the biomass and soil carbon are collected from several literatures. In the year of 1986 Indian forest carbon stock ranged from 8.5 to 9.5 Gt C. FAO study reported the same as 10 GtC for the year 2005. The carbon stock in biomass as well as soil has increased by 377 MtC between 1995 to 2005 (Kishwan *et al.,* 2009). Out of the total forest carbon 50 per cent accounts only the forest soil carbon. FSI reported different forest type stratification regarding carbon stock estimation in several forest lands of India. IPCC, 2014 has reported about 56% of carbon stock as soil organic carbon and 32% as above ground biomass due to the forest cover.

### Approaches of carbon stock estimation

#### *Direct measurement approach (destructive method)*

Vashum and Jayakumar (2012) had suggested method for field measurement and carbon stock estimation. They followed initially the harvested method for estimation of carbon stock by harvesting all the trees and measuring their biomass as well as carbon stock deposited in that forest ecosystem.

#### *Forest area approach*

Nasi *et al.* (2008) had focused on the carbon stock in Congo basin in accordance of Kyoto protocol. Carbon stock was accounted based on 27 sites and 2410 trees of this regional tropical forest using diameter and specific wood density. Generally, trees above 10 cm diameter were considered for biomass estimation. Both plot based and destructive data was summarised and total carbon stock of humid forests, Congo Basin was estimated.

Monte *et al.* (2000) had a survey on juniper woodland of Azzaden valley, Morocco. They collected different parts of plants and their dendrometric measurements, calculated bulk density of different plant parts and finally estimated the biomass showing the total carbon, then validation.

#### *Indirect approach (non-destructive method)*

Gao *et al.* (2015) developed a comparative estimation of carbon stock of tree components and the total by different methods like (1) Additive systems of carbon models can be directly used to compute the carbon stocks of tree components and total, given tree diameter and height (2) Additive systems of biomass models were first used to estimate the biomass of tree components and total, and then the predicted biomass was multiplied by the carbon conversion factor 0.5 (3). The biomass models can be used to estimate the biomass of tree components and total, and the predicted biomass was multiplied by the average carbon concentration of total tree.

#### *Mathematical modelling*

Bird *et al.* (2015) had followed generic framework. IPCC methodology includes carbon stock changes in different carbon pools on annual basis by applying several formulas. The survey also estimates the carbon stock changes following accounting method (loss-gain method and stock difference method) etc.

Total carbon stock present in biomass and soil could be estimated through IPCC guidelines or through the use of actual conversion and expansion factors which can be represented as:

C carbon = C biomass + C soil

Where,

C carbon = Total available carbon in the forest type, i.e., in the vegetation and in soil

C biomass = Total available carbon in the above and below ground biomass of all vegetation in the forest type

C soil = Total available soil organic carbon (SOC) up to 30cm depth in the forest type

Under REDD measurement guidelines for carbon stock leaf litter, herbs and grass of $1m^2$ plot is considered and weighted; above ground sapling biomass and regeneration of species is noted for sustainable growth and future forest enhancement; DBH of standing dead trees, logged trees and fallen branches are measured; soil collected from default depth prescribed by IPCC (2006) and organic carbon can be calculated through oxidation method. Biomass of above ground and below ground parts of trees can be estimated through regression equations referring the total biomass as well as the total carbon.

Sahu *et al.* (2015) estimated carbon stock and carbon fluxes in forests of Odisha, India using recent IPCC guidelines. They included several parametric information for carbon stock estimation like Above Ground Biomass (AGB), Below Ground Biomass (BGB), Dead Wood Biomass (DWB), Litter biomass and Soil organic carbon etc. They also calculated the annual carbon flux through rate of gain and loss of carbon from the pools following the steps likewise.

**Ground-based forest inventory data from sample sites**

Sampling data for developing allometric relationships can originate from sample sites or forest inventories (Gibbs *et al.,* 2007): Sampling approaches typically consist of country or region-specific sampling designed for broad forest categories (sampling strata). Gibbs *et al.* (2007) recommend the development of a 'stratification matrix' for each country or region using broad forest types and forest conditions (e.g., drainage slope, age, and level of degradation). Such stratification can increase accuracy and precision and reduce costs (Pearson *et al.,* 2008). Focusing first on using stratification to estimate carbon stocks for forests most likely to be deforested or degraded can further reduce uncertainty and cost (Brown 2008).

Suryawanshi *et al.* (2014) elaborated another method for carbon stock estimation. Generally, for any plant species, 50 per cent of its biomass is considered as carbon (Pearson *et al.,* 2005) i.e. Carbon Storage = Biomass/2

The above ground biomass (AGB) of tree species has been calculated by multiplying volume of biomass and wood density (Pandya *et al*., 2013).

AGB (g) = volume of biomass ($cm^3$) wood density (g $cm^{-3}$)

The below ground biomass (BGB) has been calculated by multiplying above ground biomass taking 0.26 as the root shoot ratio (Chavan and Rasal, 2011; Hangarge *et al.,* 2012).

BGB (g) = 0.26 X above ground biomass (ton).

Total Biomass (TB) = Above Ground Biomass + Below Ground Biomass

Sharma and Phuong (2013) estimated a method for the mapping potential of carbon stock density in Vietnam forests. Biomass carbon stock density in both AGB and BGB pools was estimated for each forest stratum. AGB is estimated from the volume and density relationship of forest types using Eq. 1

$$AGB = VOB \times WD \times BEF$$

Where,

AGB = above-ground biomass (tdm. ha) (tdm is tonnes of dry matter),

VOB = inventoried stem volume over bark (m3 /ha),

BEF = biomass expansion factor (to convert over bark volume to total volume) and

WD = basic wood density (kg/ m¾).

A study on tropical forest shows quantitative contribution regarding global carbon stocks. Here the study was restricted in tropical growing forest climates that regenerated naturally. Further the old, and young or successional forest were taken into account. This survey appraised the biometric variables (i.e. GBH, total tree height) and wood specific gravity for each collected tree. A compared number of statistical models used to estimate the total carbon stock of tropical forest zone of earth.

Another method to estimate forest biomass carbon shows spatial area of interest. This method involved assessing of data on biomass carbon stock density, forest area, forest types, root to shoot ratio, wood density and carbon fraction etc.

Mushtaq and Malik (2014) reported on estimation of biomass from growing stock and forest biomass change regarding total carbon and carbon dioxide emission from forest zones of Western Ghats. Using the conversion factors they estimated the biomass from forest cover. Frontier forest cover change data was obtained from temporal satellite, then converted into forest biomass. They took several steps for accounting carbon stock involved in the study:

i. Estimation of growing stock from vegetation cover:-

Growing stock = vegetation cover × growing stock conversion factor × root to shoot ratio.

Growing stock = forest cover × 1.314 × 0.28

ii. Estimation of dry matter biomass from growing stock:-

Biomass = Growing stock × mean density (biomass conversion factor)

Biomass = Growing stock × 0.41

iii. Estimation of carbon from biomass:

Total carbon = Dry matter biomass × carbon fraction

Total carbon = Dry matter biomass × 0.47

Domke ***et al.*** (2012) developed Component ratio method (CRM) for live tree biomass estimation from the central stem volume in standing live and dead trees. The CRM value is determined through regional volume models and specific gravity information to estimate tree biomass (Heath *et al.,* 2009 and Woodall *et al.,* 2011).

During 1998, German Advisory Council on Global Change, assessed areas and carbon storage capacity of various zones. Tropical forest occupies second highest amount of carbon (212 Gt.), where as boreal forests store the highest (559 Gt.). With largest area desert or semi desert zones store relatively small amount of carbon whereas wetlands cover a small area but store relatively high carbon in it (240 Gt.). Rather grass lands also signify an increased amount of carbon density growing on alluvial clay soils.

**Carbon stock in mangroves**

Kauffman and Donato (2014) have experimented on the ecosystem components of mangroves for the quantification of forest biomass and ecosystem carbon stock as mangroves possess specific physical, climatic, hydrologic features of the environment and can fix much carbon in comparison to tropical forests. The main diversity centre of mangroves is found in indo-pacific regions. They developed a measurement plan following project boundaries, stratify project area, measurement of carbon pools, determine measurement frequency and finally estimate the total carbon stock in the area of Sundarbans of Bangladesh, Kalimantan, Indonesia Riverine. They considered parameters like diameter at breast height for species-specific equations and for general equation wood density.

**GIS and remote sensing methods**

The indicative estimation of carbon stock in Victoria's publicly managed land used data was developed via a database, into full CAM (i.e. Plot files, Carbon models). The biophysical data like GIS (Tree cover, harvesting etc.) described the features influencing carbon stock on site and included harvesting extent, fire history, vegetation type and geographic region.

## SOIL ORGANIC CARBON

Reporting rates for soil carbon were the lowest of all carbon pools, perhaps indicating scarcity of country data or problems in applying the IPCC (2003) default values. The IPCC 2006 Guidelines provides a range from 20 to 300 t C per hectare. The global average soil carbon content to a depth of 30 cm estimated from the FRA 2005 data set was 73 t C per $ha^{-1}$. The carbon balance of terrestrial ecosystems deteriorates by the impact of human activities, deforestation, biomass burning, land use changes, conversion and environmental pollution. Again the soil carbon pools have decreased by 40 Pg. C from the original 1471 Pg. C during 1850-1980 and carbon held in vegetation by 80 Pg C down from 672 Pg C in 1850. Global release of carbon from land use change in 1990 was between 1.1 and 3.6 Pg C $yr^{-1}$, as compared to 5.5-6.5 Pg C $yr^{-1}$ from fossil fuel combustion. The annually displaced soil due to global soil erosion is about 5.7 Pg C from the total estimated carbon i.e. approximately 1500Pg C. Estimation of SOC stock generally refer to given depth of soil (i.e. 0 - 15 cm, 15 - 30 cm, 30 - 50 cm, 50 - 100 cm, > 100 cm ). The compactness of soil is measured through the calculation of bulk density (BD) of soil.

Soil with high clay content therefore tends to have higher SOC than soil with low clay content (under similar land use and climate conditions.) which offers a range of 20 to 300t C. per hectare. The FRA, 2005 data set had estimated the organic carbon content was 73 t C per hectare and the range varies from 20 to 300 t C per hectare (IPCC, 2006). In most soil types the majority of C is held as soil organic carbon (SOC) were be determined by a partial oxidation method (Walkley and Black 1934).

The estimates presented by IPCC guidelines designate the global forest vegetation stores 283 Gt C in its biomass, and an additional 39 Gt C as deadwood, for a total of 359 Gt C. Soils to a depth of 30 cm and litter contain 312 Gt C. Thus, even to a depth of only 30 cm, they store about the same amount of carbon as the forest vegetation. Expanding carbon content in soils to a depth of 1m by applying the correction factor, litter and soil together contain 448 Gt C.

The SOC stock of a given area of soil with the same soil type can then be expressed as below-SOC stock = (SOC content of the soil × BD × area × depth)/10,where SOC stock is given in Pg. (1015g), SOC content is in g C g-1, BD is in Mg m-3, area is in Mha and depth is in m.

A study report by Ajonina *et. al* (2014) provided a method for soil measurement of carbon in mangrove ecosystem for carbon content of soil. Dried soil sample of 5-10 gm were weighed through the process of Loss- On- Ignition, the sample set in a muffle furnace for combustion at 550° C for 8 hours. The prepared set of sample cooled in a decicator and reweighed. Then the SOC can be calculated as :

SOC (t $ha^{-1}$) = Bulk density x g $cm^{-3}$ x organic carbon %

A forest inventory study by FSI (2002-2008) established a comparative measures of 15 forest type cover in India. Carbon stock was estimated following the various result of carbon pools listed in Table 3.

The total scenario of carbon stock in several regions of India explicitly indicate the states rich in forestlands like Andaman and Nicobar, Puducherry, Chandigarh, Sikkim etc. contributed more organic carbon stock.

Ramachandran *et al.* (2007) extrapolated different methods for carbon content of soil i.e. the data were statistically analysed for the computation of standard deviation, frequency distribution and analysis of variance (ANOVA) for each forest type using Microsoft® Excel® worksheet. The total SOC estimated as follow

SOC density (mg $ha^{-1}$) = SOC (%)/100 × corrected BD (mg $m^{-1}$) × Soil layer depth (m) × $10^{-4}$ ($m^2$ $ha^{-1}$ ),

Where BD = bulk density.

Corrected bulk density (mg $m^{-3}$) = BD (Mg $m^{-3}$) × (100- per cent coarse fraction)/100,

Data on SOC content (%) and SOC density (mg $ha^{-1}$) of surface, middle and bottom were mapped using the ArcGIS software.

Total SOC storage = SOC density (mg $ha^{-1}$) × forest area (ha)

The least significant difference (LSD) was worked out using MstatC software (a one-way analysis of variance (Russel *et al.*, 1991), to compare the SOC mean values of different forest types at different depths (0-30,30-60 and 60-90).

The forest inventory and analysis (FIA) program initiates a new approach towards carbon stock accounting and estimation in 2016. They are developing a framework for quick addressing of new questions that enables carbon analytics by using all the inventory information like disturbances and land use changes. The annual inventory system and total carbon stocks on all forests will serve as the foundation of this type of accounting system.

**Table 3.** State/UT wise per hectare carbon stock of India in different carbon pools (Fifth Assessment Report of the IPCC 2014)

| Sl. No. | State | Area Km² | AGB | BGB | Dead wood | Litter | SOM (t ha$^{-1}$) | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | Andhra Pradesh | 44372.00 | 35.42 | 13.74 | 0.16 | 1.09 | 39.28 | 89.69 |
| 2 | Arunachal Pradesh | 67777.00 | 34.54 | 7.74 | 0.55 | 2.37 | 96.85 | 142.05 |
| 3 | Assam | 27645.00 | 16.11 | 3.70 | 0.38 | 1.96 | 38.95 | 61.10 |
| 4 | Bihar | 5579.00 | 29.45 | 11.06 | 0.19 | 0.75 | 42.77 | 84.22 |
| 5 | Chhatisgarh | 55863.00 | 36.46 | 12.11 | 0.43 | 1.15 | 48.70 | 98.85 |
| 6 | Delhi | 176.00 | 11.29 | 2.54 | 0.10 | 0.53 | 32.03 | 46.49 |
| 7 | Goa | 2164.00 | 19.03 | 5.07 | 0.42 | 1.44 | 51.57 | 77.53 |
| 8 | Gujarat | 14715.00 | 23.68 | 8.56 | 0.21 | 0.67 | 44.02 | 77.14 |
| 9 | Haryana | 1587.00 | 24.86 | 8.54 | 0.13 | 0.46 | 45.91 | 79.90 |
| 10 | Himachal Pradesh | 14369.00 | 44.15 | 11.63 | 0.37 | 1.65 | 54.41 | 112.21 |
| 11 | Jammu & Kashmir | 21273.00 | 45.17 | 12.34 | 0.35 | 1.46 | 54.30 | 113.62 |
| 12 | Jharkhand | 22591.00 | 36.48 | 14.11 | 0.19 | 0.54 | 43.37 | 94.69 |
| 13 | Karnataka | 35251.00 | 33.07 | 9.58 | 0.40 | 4.84 | 76.77 | 124.66 |
| 14 | Kerala | 15595.00 | 38.25 | 9.75 | 0.55 | 3.86 | 75.53 | 127.94 |
| 15 | Madhya Pradesh | 76013.00 | 34.25 | 13.08 | 0.20 | 0.92 | 41.34 | 89.79 |
| 16 | Maharashtra | 47476.00 | 29.73 | 10.28 | 0.40 | 1.83 | 58.56 | 100.80 |
| 17 | Manipur | 17086.00 | 15.29 | 5.00 | 0.29 | 2.24 | 58.03 | 80.85 |
| 18 | Meghalaya | 16988.00 | 13.65 | 3.73 | 0.46 | 2.90 | 67.02 | 87.76 |
| 19 | Mizoram | 18684.00 | 8.48 | 1.75 | 0.35 | 1.47 | 40.36 | 52.41 |
| 20 | Nagaland | 13719.00 | 12.08 | 3.11 | 0.43 | 1.86 | 77.19 | 94.67 |
| 21 | Orissa | 48374.00 | 30.41 | 10.08 | 0.38 | 1.56 | 45.04 | 87.47 |
| 22 | Punjab | 1558.00 | 28.02 | 10.35 | 0.16 | 0.37 | 49.95 | 88.85 |
| 23 | Rajasthan | 15850.00 | 20.64 | 8.08 | 0.13 | 0.40 | 26.97 | 56.22 |
| 24 | Sikkim | 3262.00 | 32.22 | 9.24 | 0.48 | 1.40 | 78.46 | 121.80 |
| 25 | Tamilnadu | 23044.00 | 31.72 | 10.63 | 0.34 | 2.04 | 47.04 | 91.77 |
| 26 | Tripura | 8155.00 | 17.34 | 3.57 | 0.63 | 1.96 | 48.75 | 72.25 |
| 27 | Uttar Pradesh | 14127.00 | 29.50 | 8.93 | 0.27 | 1.11 | 40.60 | 80.41 |
| 28 | Uttarakhand | 24442.00 | 43.51 | 11.25 | 0.51 | 2.31 | 59.29 | 116.87 |
| 29 | West Bengal | 12413.00 | 29.45 | 9.33 | 0.23 | 1.42 | 56.04 | 96.47 |
| 30 | Andman & Nicobar | 6629.00 | 49.83 | 15.12 | 1.99 | 4.59 | 79.72 | 151.25 |
| 31 | Chandigarh | 15.00 | 29.50 | 10.13 | 0.18 | 0.69 | 52.20 | 92.70 |
| 32 | Dadra & Nagar Haveli | 221.00 | 23.67 | 5.63 | 0.59 | 1.99 | 41.54 | 73.42 |
| 33 | Daman & Diu | 9.00 | 3.96 | 0.97 | 0.09 | 0.79 | 32.72 | 38.53 |
| 35 | Puducherry | 41.00 | 21.57 | 4.61 | 0.14 | 1.66 | 58.64 | 86.62 |
| Total | | 677088.00 | 31.03 | 9.79 | 0.37 | 1.79 | 55.43 | 98.41 |

## CONCLUSION

The amount of forest biomass is very crucial for monitoring the carbon stocks as well as carbon loss due to deforestation. This review correlates the several carbon measurement methods to mitigate global climate change. Although direct approach method provides accurate measures, it is time and resource consuming and destructive as well as expensive. However comparative estimation of carbon stock through non-destructive method or indirect approaches are more reliable and saving of the degraded forest vegetation. The soil organic carbon rather measured through estimation of bulk density. Soil depth up to 0-30 cm is suitable by means of deposition of fresh carbon due to active participation soil microbes. Rather a new approaching method by FIA programs establishes a knowledge of carbon estimation through annual inventory system of past decades upto 1990 as well as a decade forward. This study also comprehends forest types of world and their vegetation pattern which acts like a major carbon pool of terrestrial ecosystem. The growing or regenerated forest lands store and sequester more carbon through rapid growth of canopy cover and above ground biomasses.

Thus it is necessary to conserve forest through mass plantation and creating a grading status for public awareness. Thus constant efforts should be taken to conserve natural forest ecosystem and for implementation of reducing emissions from deforestation and forest degradation (REDD) programmes. Implication in sustaining soil productivity, several biological activities and complimentary effect of organic carbon in soil and their storage enhance total carbon stock.

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