# DOWNLOAD PDF CARBON INVENTORY METHODS

## Chapter 1 : Gold Circuit Carbon Sampling for Inventory and Movement

*Carbon Inventory Methods Handbook is an essential source of reference to universities and research institutions dealing with climate change, consultancy and non-governmental organizations involved in developing and monitoring land-based mitigation projects, donor agencies funding carbon mitigation projects, national greenhouse gas inventory.*

Introduction At the first Conference of Parties COP , which took place in Berlin in , the parties agreed that the specific commitments of the convention for the Annex I parties were not adequate because they were too vague and after two and a half year of intense negotiations, the Kyoto protocol was adopted at the third COP on 11 December in Japan. This protocol is the first international implementation of a cap and trade scheme. Forests play a critical role[1] in stabilizing CO2 concentration for it acts as significant source of global CO2 and also provides opportunities to act as sink through soil, vegetation and wood products. Intergovernmental Panel on Climate Change IPCC provides us the guidelines for estimation of Carbon C inventory for land use change and forest sector[2] and for agriculture, forest and other land uses[3] and good practice guidance for land use, land use change and forestry LULUCF sector[4]. Adoption of C inventory methods and guidelines should lead to accurate, reliable and cost effective estimates of C stocks and changes for a given land use system and period[5]. Implementation of sustainable C forestry and C storage led forest management in India warrants for specific research support for status monitoring and technology generation. Considerable variations in terms of assumptions and estimates on C sequestration call for standardization of estimation of C estimation emissions for forest and other resources and land-use changes[6]. Worldwide numerous ecological studies have been conducted to assess C stocks based on C density of vegetation and soils[7,8,9]. The results of these studies are not uniform and have wide variations and uncertainties probably due to aggregation of spatial and temporal heterogeneity and adaptation of different methodologies[10]. Five pools have been identified in Marrakech Accord viz. Among these only those pools need to be measured and monitored under CDM which are most likely to be impacted by the project activities. Various methods are available for estimation of carbon and flux in these pools but these methods vary on account of accuracy, precision, cost and scale of application. The broad categories of programmes requiring carbon inventory[5] are for national green house inventory, climate change mitigation projects, Clean Development Mechanism projects, projects under the global environment facility and forest grassland and agroforestry development projects. Hence, it becomes extremely important for a developing country like India where there is an excellent opportunity of having 26 million degraded land as a potential storage for carbon to evolve and refine the methodology as per the objectives. The present paper gives an insight into the varied methodologies adopted by different workers as per their objectives of study for estimations at various levels related to carbon in India. India having diverse vegetation coupled with variation in climates, the inventory experts need to explore all sources of information from all local sources and create data bases on the basis of inventory parameters pools and factors like growth rates, wood density etc. Biomass Carbon Biomass is defined as the total quantity of live and inert or dead organic matter, above and below the ground, expressed in tones of dry matter per unit area, such as hectare. Above ground biomass is the most important visible and dominant C pool in forests and plantations, although not in grasslands and croplands5. Spatial data bases of climatic, edaphic, and geomorphologic indices, and vegetation were used to estimate the potential carbon densities without human impacts in above and below ground biomass of forests in  All data were processed in GIS environment[13]. Land use data and carbon estimates for South and Southeast Asia were collected and analysed to help reduce the uncertainty associated with the release of C in the atmosphere caused by land use change. The database was developed in Lotus TM using a sequential bookkeeping model. The source data were obtained from historical and geographical documents Fig. The total amount of C sequestered in live vegetation of each ecological zone for , , , and was calculated using the equation as Where total C stock of vegetation at time i TCi is calculated based on Lji which is the total C above and below ground in vegetation type j at time i. Aji is the area in vegetation of type j at time i and n is the total number of land use categories within the zone. Flow sheet illustrating spreadsheet methodology used in analysis of changes in land use changes and C Source: Richards and Flint [14]

Accordingly[14], the actual C stock of a given vegetation class is calculated as the product of its potential maximum C stock M and two fractional multipliers which quantify the estimated reduction of M by environmental limitations E and degradation D. Similarly[15,16] a book keeping model was developed that tracks the C content of each hectare disturbed by human activity. In another study[17] estimated forest cover, growing stock and biomass for the year This was done at state level for the entire country using information available from the vegetation maps, thematic maps and ground forest inventory collected by Forest Survey of India FSI. For this purpose all the states and union territories were divided into grids of 2. Data was collected for parameters related to growing stock from grids. The growing stock of each state was estimated by calculating the number of grids for each combination of density and forest composition. The volume per ha termed as wood volume factor for a particular combination of density and forest composition was generated using data of forest inventory surveys. Three wood volume factors were calculated for each stratum and density class for each map sheet for each state. The estimated volume or growing stock was converted into biomass by using specific gravity[18,19] of dominant tree species in each grid and C stock was computer employing the formulae,. A study was conducted[20] to estimate C flux through litter fall in forest plantations in India. Data on 24 species from 82 stands was tabulated so as to cover the entire country. Mean litter fall total and alone from the plantation was computed. A C fraction of 0. Above ground biomass was recorded at the site for shrubs and grasses whereas standard relationship was used to record tree biomass at the site in arid and semi arid areas of Rajasthan and 0. Allometric equations[23] models have been suggested for national level studies in estimating Above ground tree biomass AGTB developed[24] on the basis of climate and forest stand types. Biomass stock densities are converted to carbon stock densities using the default carbon fraction[2] of 0. Furthermore root-to-shoot ratio value[25] of 1: Carbon in standing biomass is determined by multiplying the area of each land use category by its average biomass and then multiplying the sum by the carbon content of biomass, which is assumed to be 0. If there is an insufficient amount of fuel wood in the project region, the model automatically begins to burn fossil fuel which results in increasing carbon emissions[26]. The model estimates the amount of carbon sequestered by approximating land use and relative biomass changes in the landscape over time. The model uses data on selected carbon pools as collected from the field, viz. Above ground biomass was calculated by laying quadrates and Mean Annual Increment MAI was calculated using volume equations as given in Forest Survey of India publication[28]. Below ground biomass was has been calculated using IPCC default value which is above ground biomass x 0. A similar study[29] was carried out to estimate eligible carbon pools under CDM for medicinal trees of Haryana in which observations on growth height, girth and crown cover of selected plantation interventions was taken as per the structured data sheets. For calculation of Mean Annual Increment MAI of plantation intervention on private lands restricting to bund plantations, it was assumed that the farm size will be 0. Biomass expansion factor and wood density have been used as per good practice guidelines by IPCC. Default value of 0. Local Level Estimates A study[30] was conducted to evaluate C sequestration through community based forest management in Sambalpur Forest Division Orissa. Two villages with total area of ha were selected on the basis of number of years for which the allotted peripheral reserved forests have been protected. Quadrates were laid and observations were recorded for girth and height for each species of trees, shrubs and herbs. The data collected during was used for the estimation of growing stock and other indices. Sequestration potential of natural forests in seven village forests of Chindwara Forest Division of Madhya Pradesh was estimated for different density classes using harvested method of stratified tree technique. Quadrates were laid and sample trees were felled and roots excavated for determination of above and below ground biomass. The whole tree biomass without foliage was recorded for different components viz. In a study carried out to find[33] C content of some forest tree species the plant samples of various parts were subjected to oven drying. Ash content method was also used to estimate C. Below ground biomass was calculated as AGB 0. Sequestered carbon was calculated in the model by multiplying the dry biomass with a default value of 0. In a study[36] to assess comparison between different methods for estimation of biomass in a forest ecosystem it was concluded that stratified tree technique is the best but urged to develop estimating equations of wide applicability to obtain reliable estimates of stand biomass without destructive sampling. Carbon allocation in different parts of three year old agroforestry species was studied[37] adopting destructive method of sampling. Field measurements taken were fitted into regression equation with a general form factor of 0. The carbon and nitrogen content percent in each plant component was estimated on CHNS analyser. Similarly destructive sampling[39] was adopted to assess carbon sequestration potential of selected bamboo species of Northeast India. Total dry biomass of sample component was calculated by multiplying weight of oven dry sample with total fresh weight of plant component and divided it by fresh weight of plant sample component taken. The total oven dry weight of each component was then multiplied by the total number of plants in that category. Carbon content was estimated by indirect method[40] using a factor of 0. Sampling of vegetation in the two forests was carried out by belt transect method. Because of high species richness in tropical forests, it is difficult to use species-specific regression models, as used in the temperate zone[41,42,43]. Therefore, mixed species tree biomass regression models Table: Geospatial technology[50] was used to estimate C stock in natural forests of Eastern Ghats Tamil Nadu. Volume was multiplied with wood density to obtain biomass. C was obtained following standard methodology[51] by with  On the basis of thematic maps prepared by FSI and survey done by FSI for forest inventory, growing stock, ground biomass and C stock was determined[52] for the assessment years and for a particular combination of density and forest composition in Ranchi district. Estimated volume of growing stock was converted to biomass based on specific gravity[18,19] of dominant tree species in each grid and dry biomass was multiplied by the factor 0. Similarly satellite data was used in a study[53] to estimate carbon pool in Govind Wildlife Sanctuary and National Park to generate forest type and density maps by visual and digital interpretation methods. Field measurements of height and girth were taken to calculate volume of sample plots of 0. Volume was multiplied with specific gravity to obtain biomass and later the results of biomass were extrapolated in the stratified forest type map. The classified forest types were sub-classified into crown cover levels of 20 percent interval and calibrated through field checks. The crown cover for various forest types was related with the stand biomass above ground and the relationship was used mean biomass was computed for each class which when multiplied with the respective aerial extent gave total biomass of the content. In a review work[57] biomass distribution in a forest ecosystem was described as the function of vegetation type, its structure and site conditions. Phenology plays an important role in using satellite data for estimating qualitative and quantitative characters especially in deciduous vegetation as similarly reported[58] that SAR Synthetic Aperture Radar being sensitive to moisture, temperature, branch architecture, biomass, age classes, girth, canopy density etc. Spectral response modelling[59] was applied to estimate per unit biomass values of sample plots in homogenous vegetation strata. The results when extrapolated to the entire area generated biomass map of the Madhav National Park. It was further reported that a combination of various forest parameters like trunk, branches, basal area, soil etc. Soil Organic Carbon After careful comparison of the different international standards to be followed for forest carbon estimation, the carbon fraction CF 0. Data on the extent of forest cover, forest stratum, density and volume per ha for each grid were collected. The major forest stratum in grid was marked using thematic maps prepared by FSI forests of India have been stratified into 24 species strata. Grid volume for a grid was calculated stratum wise. Soil Organic Carbon SOC values under different forest species in various locations in India were collected from published literature in different journals, reports, books etc. Six different eco zones were selected in arid and semi arid areas of Gujarat and Rajasthan and data presented for only common access resources. Soil samples were collected in triplicate from each type of land upto 75 cm depth divided into , and cm soil layers and analysed for SOC[21]. Different although not too different methodologies have been adopted in various studies[61] and methods vary in the choice of stratification, measuring carbon pools and values or factors of estimation Table:

## Chapter 2 : Carbon Inventory Methods - Carbon Stocks - Climate Policy Watcher

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Received Mar 31; Accepted Jun 7. Abstract Background The German greenhouse gas inventory in the land use change sector strongly depends on national forest inventory data. This does not reflect inter-annual variability in the time series, which would be assumed as the drivers for the carbon stock changes fluctuate between the years. Therefore additional data, which is available on annual basis, should be introduced into the calculations of the emissions inventories in order to get more plausible time series. Results This article explores the possibility of introducing an annual rather than periodical approach to calculating emission factors with the given data and thus smoothing the trajectory of time series for emissions from forest biomass. Two approaches are introduced to estimate annual changes derived from periodic data: The logging factor method incorporates annual logging data to project annual values from periodic values. This is less complex to implement than the growth factor method, which additionally adds growth data into the calculations. Conclusion Calculation of the input variables is based on sound statistical methodologies and periodically collected data that cannot be altered. Thus a discontinuous trajectory of the emissions over time remains, even after the adjustments. It is intended to adopt this approach in the German greenhouse gas reporting in order to meet the request for annually adjusted values. Estimation of GHG emission and removal patterns and their changes over time enables decision makers in government and private industry to develop future action plans and policies towards mitigation of emissions. Therefore as well as for various other reasons GHG inventories are implemented to estimate emissions and removals [ 3 â€” 6 ]. Information on trends of emissions and removals are used e. The reporting according to this is following an specific reporting guideline framework elaborated by the Intergovernmental Panel on Climate Change IPCC [ 5 , 9 , 10 ] based on literature and good practices developed by technical experts [ 11 â€” 13 ]. Since plant growth reflects the possibility of removing CO2 from the atmosphere especially the plant growth rate, or increment, influences the performance of forest wooded ecosystems to uptake CO2. On the other hand, emissions are caused by biomass losses harvest, disturbance and mortality. The combination of these two opposite effects results in net emissions or removals of CO2 which are also expressed as carbon stock changes. Calculations on this within the preparation of the German inventory on CO2 balances of forests are based on available data from National forest inventories which are carried out periodically and therefore do until now only deliver average values for time periods. As the times series of the inventories are also used to assess impacts of policies and management changes over time the following research focuses on methods for improvement of the GHG inventory and thus prepare a more thorough basis for decision making. This article attempts to introduce an approach for an annual estimation of carbon stock change which extends the actually used calculation method on stock changes by additionally incorporating harvest statistics and information on increment available for Germany. With the use of the methods presented, instead of periodic values annual ones can be estimated in order to reflect inter-annual variation of wood harvest and increment in German forests and their influences on the emission factors. Methods Determination of biomass carbon stocks using forest inventory data Forest inventory data National forest inventories NFI are the primary source of forest information and are recognized as an important data source for estimating forest carbon stocks [ 14 ]. Detailed information about the sampling strategy of the German NFI can be found, for example, in [ 15 ] or [ 16 ]. The required forest conditions in the new federal states were evaluated based on forest planning data Datenspeicher Waldfonds, DSWF [ 16 ] representing management activities, which were practiced in their original form, until the beginning of  In addition, an intermediate survey IS on a sub-sample of the NFI plots was also carried out in Inventurstudie und Treibhausgasinventar Wald in order to get values for biomass carbon stocks at an additional point in time between the NFI and and with a view to open the balance for the first commitment period of the Kyoto Protocol [ 15 , 17 ]. Biomass Two methods are generally used to convert field measurements of trees to above ground biomass AB [ 3 ]. If, however, the forest inventory data report individual tree parameters like diameter at breast height DBH , height, age and so on then these data can be converted to biomass directly by using biomass regression equations [ 3 ]. The core function of this integrated biomass function based on a modified Marklund model. Also empirical data were available to fit a function for the subpopulation of trees smaller than 1. In the gap between both models a synthetic model acts as an interpolation function. The next section describes the integrated model, for more details see [ 20 ] and [ 21 ]. Caused by the non-linear nature of the model, the risk exists to over-estimate the single tree AB in the upper extrapolation zone. To avoid or at least to reduce such effects, the last slope of the Marklund function was linearized above this tree species-specific DBH threshold using a Taylor linearization with an abortion after the first order term [ 20 ] as shown in Eq.

## Chapter 3 : Greenhouse gas inventory - Wikipedia

*Carbon Inventory Methods Handbook fills the need for a handbook that provides guidelines and methods required for carbon inventory. It provides detailed step-by-step information on sampling procedures, field and laboratory measurements, application of remote sensing and GIS techniques, modeling, and calculation procedures along with sources of data for carbon inventory.*

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*The broad categories of programmes requiring carbon inventory[5] are for national green house inventory, climate change mitigation projects, Clean Development Mechanism projects, projects under the global environment facility and forest grassland and agroforestry development projects.*

## Chapter 6 : ARB's Emission Inventory

*Carbon inventory requiring estimation of carbon dioxide emissions and removals in land-use categories for national greenhouse gas inventory and changes in stocks of carbon in projects aimed at climate change mitigation has become increasingly important in global efforts to address climate change.*

## Chapter 7 : Carbon Inventory Methods and Guidelines - Carbon Stocks

*Forest inventory represents the default method currently used for forest carbon sink evaluation within the GHG reporting for the UNFCCC (Houghton et al. ) and is an example of the stock change approach.*

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*Tropical Forest Carbon Inventory R. Condit p. 7 Chapter II. Summary of methods As a prelude to detailed descriptions of methods for estimating aboveÂ-ground forest biomass, I first.*

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*The Carbon Calculation Tool , CCTvexe, is a computer application that reads publicly available forest inventory data collected by the U.S. Forest Service's Forest Inventory and Analysis Program (FIA) and generates state-level annualized estimates of carbon stocks on forest land based on FORCARB2 estimators.*