Accounting for carbon in the National Accounting Framework: A note on Methodology

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Forests merit attention due to their important role in the global carbon (C) flux. They store large quantities of carbon in vegetation and soil, exchange carbon with the atmosphere through photosynthesis and respiration, and act as sources of atmospheric carbon if they are disturbed by some human activities (e.g., harvesting, clear cutting for conversion to non-forest purposes, poor harvesting procedures) or natural causes (e.g., wildfires). When forests are subjected to various disturbances, some of the carbon remains in the biomass itself, some remains in situ and a part of it is transferred to the atmosphere as CO2, CO and CH4, Some of the carbon enters the wood products and forms part of the forest product sector while some that has been left on-site forms part of the soil carbon pool. A fraction of the remains as charcoal resisting decay for a long period of time. Such a detailed model has been used for instance by the Canadian Forest Sector by Kurz et al (1992). The net flux of carbon are the flows in the accounting system. A detailed modeling exercise could reveal whether there are positive flows or negative flows of carbon. However, they could be carbon sinks as well if left undisturbed due to afforestation and natural growth. The net flux of carbon between the forest sector and the atmosphere determines whether forests are net sources or sinks of carbon. The main objective of this issue paper is to demonstrate how carbon accounts can be integrated with SEEA accounts. The framework for physical and monetary accounts are discussed in the following two sections and application of framework in the Indian context is discussed in Section 3.

2. Compilation of Physical Accounts

The following format can be adopted for developing the physical accounts in line with the SEEA framework

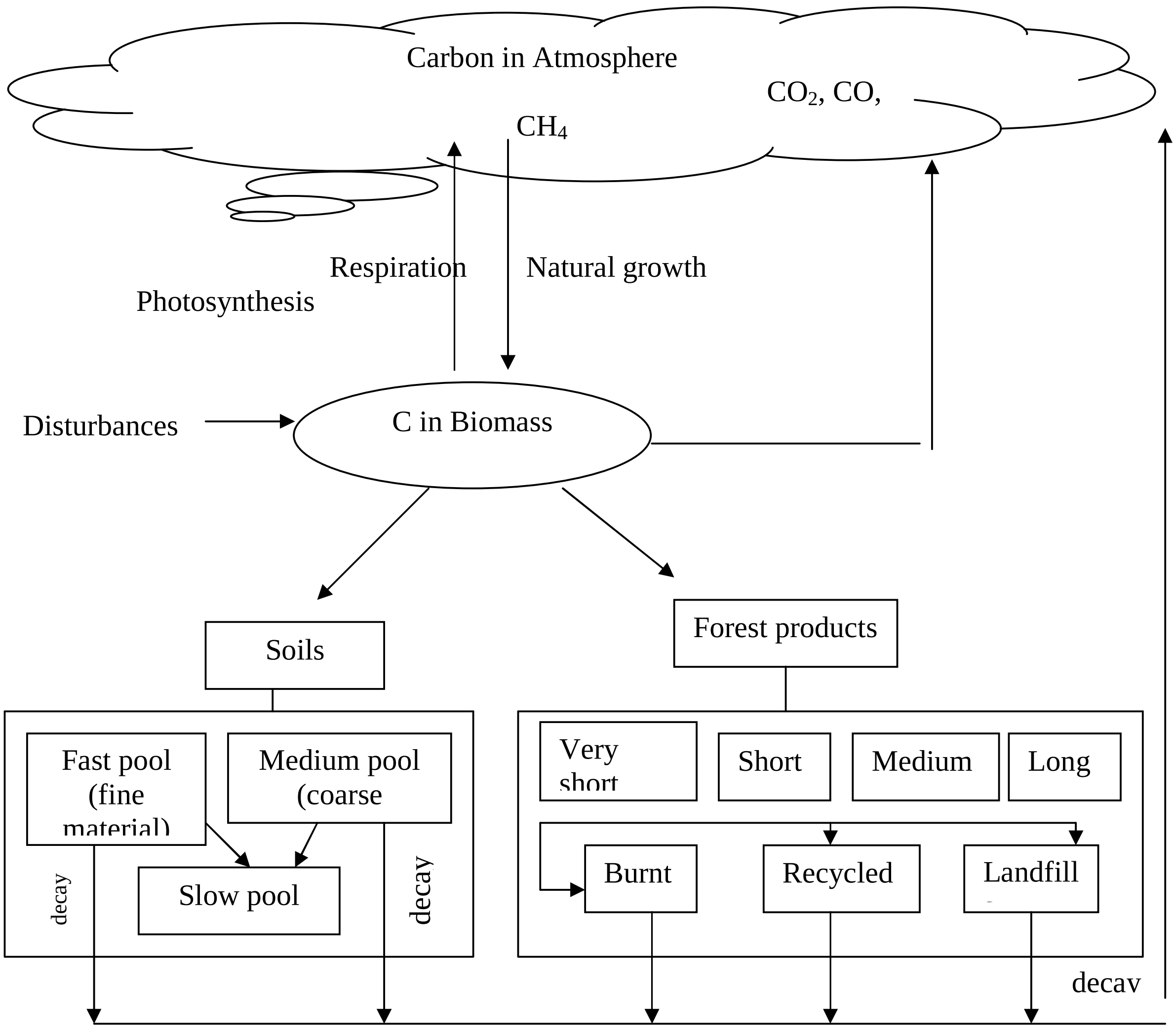
Opening Stocks

To start with entire biomass in the forests should be expressed in units of carbon and detailed accounts can be developed for forest ecosystems and forest product sector. The easiest way to get this information is to convert the growing stock estimates into biomass and then carbon. Such an approach has been adopted by Haripriya (2000a, 2001).. The biomass data is converted to carbon by assigning a carbon content of 0.5 Mg C per Mg oven dry biomass. Forest ecosystem can include three carbon pools: live biomass, dead biomass and mineral soils. The live biomass carbon represents all living tree and plant biomass. The dead biomass pool consists of carbon in detritus, forest floor, standing dead trees and coarse woody debris. The mineral soil pool consists of soil organic matter in the top 30 cms. The forest product sector contains carbon derived from tree biomass harvested in a country that may have undergone several conversion processes.

2.2.2 Changes Due to Economic Activity

Changes due to economic activity refer to the human production activities such as logging/harvest, logging damage, illegal logging and afforestation that affect (decrease/increase) the stock of forests. Any disturbance on forests (like harvest for timber, deforestation, fires, mortality etc.) involves flux of carbon between the atmosphere, live biomass, dead biomass, forest soils and forest products. The amount of carbon transferred out of the forest ecosystem depends on the extent of disturbance. Further, not all the carbon that is stored in the biomass is transferred out of the forest ecosystem. Some of the carbon is transferred into the dead biomass and soils and a part of it is transferred to wood products (in the form of timber), some remains in the biomass itself and only the rest is transferred out of the forest ecosystem into the atmosphere. The proportion of carbon transferred between different biomass and soil carbon pools, the atmosphere (CO2, CO and CH4) and the forest products sector at the time of disturbance are quantified by disturbance matrices. These matrices reallocate the carbon in different pools depending upon the specific characteristic of the disturbance. In short, while computing the total volume of carbon lost or gained due to changes in economic activity one should include a) carbon transferred to forest products (in the form of biomass); b) releases of carbon from forest biomass into the atmosphere while clear cutting or forest fires; and c) releases to soil pool etc. Another point to be noted here is that from the standpoint of national accounting, we need to define the change in carbon as the present value (future) carbon released arising from disturbances (e.g. logging) on forested land in the current accounting period.

FIGURE 1. Representation of the carbon flows



Source: Gundimeda (2003)

Other Accumulations

In the absence of disturbances, the balance between net photosynthesis and natural decomposition determines the rate of net ecosystem carbon accumulation, which is calculated as the sum of net changes in the biomass (live and dead) and soil carbon pools.

Other Volume Changes

Other volume changes comprise reductions (due to stand mortality, insect infestation, forest fires, encroachments and natural calamities) and transfer of land from economic use to forests. Fires can be of two types: ground fires (non-stand replacing) and crown fires (stand-replacing).

2.2.5 Closing Stocks

The closing stocks are computed as opening stocks less reductions plus additions.

3. Monetary Accounts

For valuing the carbon sink services, we can adopt different approaches to get the price of carbon, The first approach uses the market values. The market values for carbon can be determined by the price on Emissions Trading scheme or voluntary or other compliance carbon markets. The second approach values a ton of carbon in accordance to the impact that this emission will have on future generation's well-being. This approach has been referred to as the social cost of carbon approach. The third approach uses abatement costs i.e. the costs of maintaining/reducing carbon emissions. They are extremely variable depending on the abatement measure being considered. For example, for forestry projects under the CDM, the abatement costs are the production costs of growing/conserving the forests to capture or avoid CO_2 emissions.

World Bank in its estimates of genuine savings have used the Frankhauser (1994) estimates. That study estimates dollar (present) value of the damage caused by a tonne of carbon emitted in the mid-1990s is $20 (in the range of $6–45) (Gundimeda, Atkinson, 2006). A meta analysis by Tol (2009) shows that the uncertainty about the social cost of carbon is very large depending on the model and the assumptions used. Stern Review quotes a figure of $85/tCO2 equals $314/tC. We need to build a range of estimates based on the existing studies.

4. Empirical Experience on Carbon Accounts from India

In this section a summary of the empirical estimates for India are presented (largely drawn from the paper Gundimeda et al. 2007). The accounts were derived for the period 2001 – 2003. The opening stocks are taken as the total growing stock present at the end of the 2001 assessment made by the FSI. In India, as estimates of biomass using direct measurement (destructive sampling) are not available for all forest types in the country, a study by Haripriya (2000b, 2002a) used the volume inventory data to estimate the carbon content of the biomass in different states and different types of forests (see Haripriya, 2000b). The biomass data are converted to carbon values by assigning a carbon content of 0.5 Mg C per Mg oven dry biomass. According to the study, the carbon density/ha varies in different states from 3.4 to 171.8 t C/ha with an average carbon density/ha of 42 tC/ha. Only the aggregate carbon content for forest biomass has been included in the study but not the stock of carbon in soils.

The volume of timber harvested/logged is derived from the production statistics of timber and fuel wood obtained from the CSO for the year 2002-2003. The area subjected to logging is derived from the volume accounts by dividing the total volume harvested by the growing stock per sq. km.[1] Damage due to logging is assumed to be 10% of the volume of timber logged from both recorded and unrecorded production[2]. The area afforested in India is available from various forest statistical reports but it is not clear if the total area afforested also includes the area under compensatory afforestation. The study assumes that the recorded figure includes compensatory afforestation carried out in different states. Further, the statistics reported at the national level do not indicate various species planted, the survival rate of these plantations, how much area actually ends up forested and the growing stock per ha in these afforested areas. This makes the task difficult and so the study estimates the volume additions due to afforestation by multiplying the area afforested with the mean annual increment per sq. km and assume that the same conditions at the existing sites prevail. The volume additions due to afforestation are derived by multiplying the area afforested with the mean annual increment per sq. km of different strata.[3] All these volume estimates were converted to carbon using the simulation model used in Haripriya (2003). The net accumulation estimates are also converted to units of carbon using the biomass conversion factors.[4] The carbon increases due to natural regeneration is assumed to be offset by loss in carbon due to surface fires and grazing. Some of the forest area is transferred for non-forest purposes. The study had assumed that only regenerated and afforested volume of young trees is assumed to be affected by stand replacing forest fire. Haripriya (2003) estimated that when the forest is affected by fires, only 20% of the stem biomass remains, 50% is burnt and the carbon is transferred to the soils (immediate and releases that eventually occur in future as a result of fires today) and 30% is released into the atmosphere. Here the change in carbon is defined as the present value of (future) carbon released arising from disturbance on forested land in the current accounting period). In case of shifting cultivation, the study had assumed that 80% of the carbon is transferred to the wood products and only the rest is released into the atmosphere. The closing stocks are computed as opening stocks less reductions plus additions. Any difference with the exact closing stocks as per the 2003 assessment is recorded under errors and omissions. For developing the monetary estimates, the study used $20/tC for valuing carbon releases.

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[1] Due to the ban on clear felling in India, the statistics on area logged are not available. However, the volume of timber logged is available. In the absence of data on area logged, the volume of timber logged is used to obtain the information on the area logged.

[2] The figure is based on the information provided by the state forest department of Maharashtra (visited on May 28th 1997)

[3] The assumption was made as the information on volume of stock growing in afforested area is not available.

[4] As a result of frequent fires and heavy grazing only 18.3% of the total forest area has regeneration potential of important species (FSI, 1995a).

In the final step the estimates were integrated with the national accounts. Table 1 gives the summary of our results in terms of area, volume and carbon accounts for the year 2001-03 for all India and also their monetary value. The physical volume of carbon released (now and in the future) as a result of these activities is illustrated in column 4. This refers to carbon embodied in tree biomass: e.g. stem, foliage and root biomass etc. Opening stocks of carbon are 3558 million tC while closing stocks are 3429 million tC. That is, there is a net loss of carbon in timber biomass of roughly 95.3 on tC. However not all this carbon is released in the current period. Column 4 describes all (undiscounted future) gains or losses in carbon arising from disturbance in the current accounting period. For example, in the case of carbon released as a result of logging, the total volume of carbon 'lost' includes (a) biomass transferred to (forest) products; (b) releases to fast/ medium soil pools etc. and (c) current releases of carbon from forest biomass into the atmosphere. In essence, it is only the latter that contributes for climate change now. That is, this carbon is instead transferred to forest products or soils respectively and released in future periods.

The empirical estimates show that the annual losses due to release of carbon due to forest fires and loss in timber is 0.04% and 0.08% of *GDP* in India. Though the area subject to logging is less it translates into higher timber and carbon values. The contribution of forests due to harvesting timber contributes to 35% of *GDP* (if it is correctly valued and all the uncrecorded removals are properly accounted for). However, the corresponding carbon loss due to usage of forests for timber and fuel wood is 1.1% of *GDP*. Net accumulation of (forest) carbon is equivalent to **-**0.6% of *GDP* where its largest negative and positive components being logging (1.1%) and natural growth (0.72%) respectively. On balance, net timber and carbon accumulation in India's forests is about –9.6% and **-** 0.6% of GDP**.**

Table 1 India's Forest Wealth: Summary Physical and Value Account

	VOLUME ACCOUNT			VALUE ACCOUNT			
	Land[(a)]	Timber[(a)]	Carbon	Timber[(a)]	Carbon	Timber	Carbon
	Sq. km	000. cum	000 tonnes	Million. Rupees	Million. Rupees	% of GDP	% of GDP
Opening Stocks	675130	*5068313*	*3558126.01*	*90667058.45*	*3202313*	489.04	17.27
Changes due to econ. activity	-29032.9	-336116	-219761.53	-6434664.47	-197785	-34.71	-1.07
Logging	38837.74	315318.9	227168.48	5965309.13	202407.1	32.17	1.09
Logging damage	3883.77	31531.89	22716.85	596530.91	0.1	3.22	0.000001
Afforestation	13688.61	10734.59	5135.26	127175.57	4621.73	0.686	0.025
Other volume changes	111284.29	56957	30313.08	627201.08	11478.95	3.38	0.062
Forest fires	3332.65	15.33385	4.34	203.87	3.91	0.0011	2.108E-05
Stand mortality	109.89	684.9598	3.21	10667.92	2.89	0.057	0.00002
Grazing	96425.82	967.2345	0	17781.88	0	0.096	0
Shifting cultivation	3832	14584.48	7076.46	171482.62	6368.82	0.92	0.034
forest encroachments	7583.92	41672.2	5670.37	427064.78	5103.33	2.30	0.027
Other accum	41169.48	230961	154776.58	5285276.81	139298.9	28.51	0.75
Natural growth	28656.04	209999.6	148830.28	5677338.82	133947.2	30.62	0.72
Regeneration	10486.77	4298.283	4530.80	53142.00	4077.72	0.29	0.022
Transfer of land	-2026.68	16663.31	1415.50	-445204.02	1273.95	-2.40	0.007
Net Changes	2722.00	-163073	-95298.03	-1776588.75	-115968	-9.58	-0.62
Closing Stocks	*677852.00*	*4905240*	*3429273.07*	*88910549.61*	*3086346*	479.56	16.65

Source:Computed

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