

# Green Accounting for Indian States Project

Monograph 1

## The Value of Timber, Carbon, Fuelwood, and Non-Timber Forest Products in India's Forests



Deutsche Bank



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The Energy and Resources Institute

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Monograph 1 of the  
Green Accounting for Indian States Project (GAISP)

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## List of acronyms

ANSDP	adjusted net state domestic product
CDM	clean development mechanism
CSO	Central Statistical Organization
ESDP	environmental adjusted state domestic product
FSI	Forest Survey of India
GDP	gross domestic product
GSDP	gross state domestic product
ICFRE	Indian Council of Forest Research and Education
NNP	net national product
NSDP	net state domestic product
NSSO	National Sample Survey Organization
NTFP	non-timber forest product
SEEA	System of Integrated Environmental and Economic Accounting
SFD	state forest department
SNA	System of National Accounts



# The value of timber, carbon, fuelwood, and non-timber forest products in India's forests

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## Background

In common with most developing nations, India faces many trade-offs in its attempt to reduce poverty and improve the living standards of its people. There is a need for an empirical basis on which to base policy decisions on these trade-offs between the many competing priorities of a developing nation, including intergenerational claims—i.e., trade-offs between the needs of present and future generations. Available mechanisms and measures of development, including the current system of national accounts with its primary focus on GDP (gross domestic product) growth rates, do not capture many vital components of national wealth such as changes in the quality of health, changes in the extent of education, and changes in the quality and extent of India's environmental resources. All of these aspects have a significant impact on the well-being of India's citizens generally, and most of them are critical to poverty alleviation specifically because they provide income opportunity and livelihood security for the poor. GDP accounts and their state-level equivalents GSDP (gross state domestic product) accounts are therefore inadequate for properly evaluating the trade-offs encountered by India's policy-makers.

Recognizing that GDP growth is too narrow and inappropriate as a measure of economic growth and national wealth, we propose to build a framework of adjusted national accounts that represents genuine net additions to national wealth, sometimes referred to in literature as 'Green Accounts'. This system of environmentally-adjusted national income accounts will not only reflect in economic terms the depletion of natural resources and the health costs of pollution, but it will also reward additions to the stock of human capital through education.

This paper is the first in a series of monographs of the 'Green Accounting for Indian States and Union Territories Project (GAISP)', a project which aims to set up top-down economic models for state-wise annual estimates of adjusted GSDP, thus capturing and analysing true 'value addition' at both state and national levels. A top-down or macroeconomic approach is adopted to model adjustments to GDP/GSDP accounts for two reasons. Firstly, it has the advantage of providing a consistent and impartial national framework to value hitherto unaccounted aspects of national and state wealth and production.



Secondly, it optimizes existing research, which is already extensive, albeit not tied together in a manner which makes it useful for policy analysis.

The publication of the results and methodology of GAISP will provide a much improved toolkit for India's policy-makers to evaluate in economic terms the trade-offs faced by the nation. They will also enable policy-makers and the public to engage in a debate on the sustainability of economic growth, both at a national level as well as through inter-state comparisons. The first phase of GAISP consists of eight monographs, each of which will evaluate a particular area or related set of areas of adjustments to GSDP accounts. The final report of GAISP will summarize and consolidate the work done on these monographs and will include 'Adjusted GSDP' measures for the states and significant union territories comprising the Union of India, as well as commentary on the policy implications of our results.

These eight monographs are planned to be as follows.

- 1 The value of timber, carbon, fuelwood, and non-timber forest products in India's forests (the current paper)
- 2 Estimating the value of agricultural cropland and pasture land in India
- 3 The value of India's sub-soil assets
- 4 Eco-tourism and biodiversity values in India
- 5 Estimating the value of educational capital formation in India
- 6 Investments in health and pollution control and their value to India
- 7 The environmental values of forests: evaluating flood prevention and drought control benefits of India's forest cover
- 8 Estimating the value of freshwater resources in India

The final report of GAISP will tie together the adjustments described in these eight monographs, with a view to present state-wise adjusted GSDP measures and some preliminary analysis of their policy implications.

# The value of timber, carbon, fuelwood, and non-timber forest products in India's forests

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## 1 Introduction

As mentioned in the background note, GDP growth has for long been the key indicator for macro-economic policy-making. However, national income accounts suffer from the major limitation that they focus mainly on goods and services that are bought and sold in markets and ignore non-marketed services such as those provided by natural assets. As a result, there is inconsistent treatment of man-made capital and natural capital. Some depreciation is booked for produced assets, however, as environmental assets are not valued, no depreciation is accounted for. Furthermore, in assessing cost and capital, national income accounting neglects the new scarcities of natural resources, which threaten the sustained productivity of the economy, and also overlook the degradation of environmental quality and its consequential effects on human health and welfare. Adding to the above drawbacks, expenditures for restoring environmental quality are accounted as increases in national income and product. Thus, as pointed out by Repetto, Magrath, Wells, *et al.* (1989), while using the present system of national accounts it is not possible to know whether the economy is genuinely growing, or merely living off its capital.

Consider the case of forests, which is the subject of this paper. Forests have multiple competing uses, which do not satisfy the SNA's (System of National Accounts) production boundary. While forests are a source of timber with market values, they also influence local and regional climate, preserve soil cover on site, and in the case of watersheds, protect soil down stream from floods. Although forests provide multiple benefits, they cover only 20.5% of the geographical area and the sector officially contributes only about 1.5% of the total GDP in India. The economic activities considered under the forestry sector in national accounts include (a) forestry (e.g., planting and conservation of forests etc.), (b) logging (e.g., felling and rough cutting of trees, hewing or rough shaping of poles, blocks, etc.), (c) transportation of forest products to the sale depots/ assembly centres, and (d) farmyard wood (industrial wood and fuelwood collected by the primary producers from trees outside regular forests). Forest products are classified into two major groups: (1) major products comprising industrial wood (timber, roundwood, match and pulpwood) and fuelwood (firewood and charcoal wood) and (2) minor products comprising a large number of heterogeneous items such as bamboo, fodder, lac, sandalwood, honey, resin, gum, and tendu leaves. The net value added in the forestry sector does not reflect sustainability of forest resources, because it ignores the consumption of natural capital that occurs when forests are harvested or converted to other uses. The only costs of depletion considered in the 1968 SNA are the extraction costs and records the potential loss in forest wealth as other changes in assets

that have no effect on GDP. Hence, there is a need for incorporating the forest resources into the national accounts. The proper accounting of forest resources in the national accounts have several uses for policy, the most important of them being able to get a picture of real welfare losses from clearing of forests and increase the financial attractiveness of the resource.

There has been much research on identifying a suitable indicator which addresses the concerns about NNP (net national product) mentioned earlier. The idea of developing improved measures of 'welfare and sustainability' by adjusting macroeconomic aggregates like GDP for changes in the quantity and quality of environmental resources traces back to Nordhaus and Tobin (1972), who proposed adjusting GDP for the disamenities of urban life. In the eighties, several studies examined the issues related to natural resource depletion (see, for example Ward 1982; Landefeld and Hines 1985; Stauffer 1986 among others). Various theoretical links between economic sustainability and depletion-adjusted measures of investment and domestic product were also established (see, for instance Wietzman 1976; Hartwick 1977; Dasgupta and Heal 1979; Solow 1986 among others). In a study of Indonesia by the World Resources Institute, Repetto, Magrath, Wells, *et al.* (1989) has demonstrated the feasibility of adjusting national accounts to incorporate natural resources. Due to varied approaches and the absence of international consensus on how to incorporate environmental assets and costs and benefits of their use into national accounts, the United Nations Statistical Division developed a 'satellite' SEEA (System of Integrated Environmental and Economic Accounting) framework. The satellite system becomes a link between the system of national income accounts and accounts describing the natural environment. The United Nations Conference on Environment and Development in its *Agenda 21* confirmed this approach. Since then considerable efforts are being made in different countries to incorporate environmental resources into the national accounts using the SEEA framework. Looking at the published literature on forest resources in India, the studies by Haripriya (1998, 2000a and b, 2001) and Atkinson and Gundimedda (2004) have indicated the ways to incorporate forest resources into the national accounts. The studies quantified the timber, non-timber, and carbon sequestration benefits of forests.

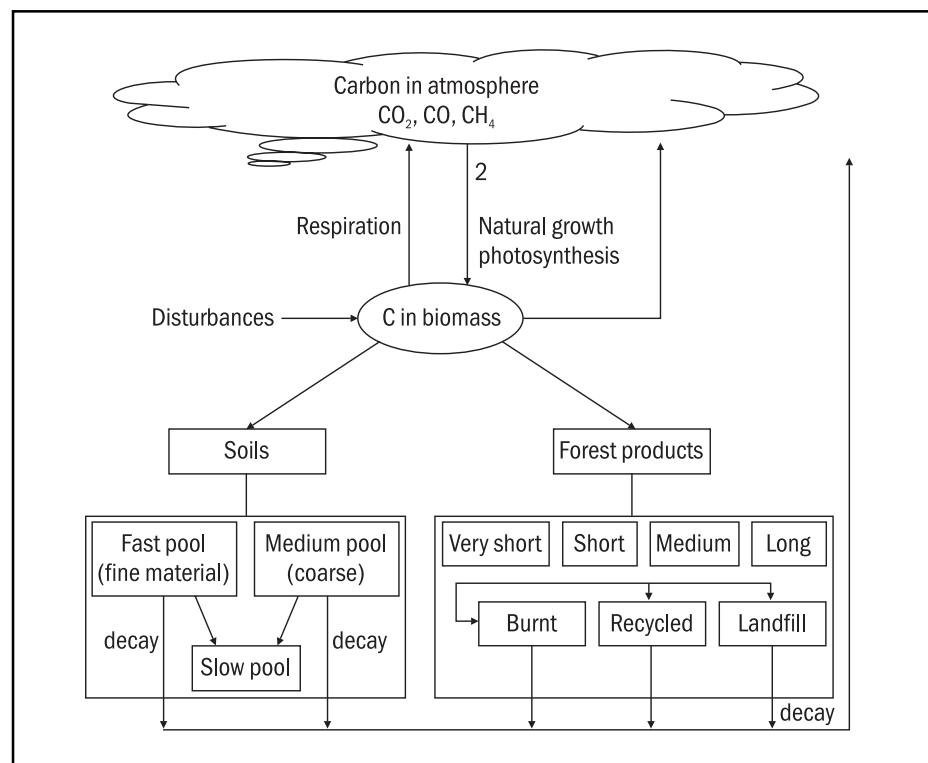
## **2** Objectives

The main objective of the present paper is to model the incorporation of forest resources into the national accounts of India's states and union territories, using the satellite SEEA framework. In this paper, forests are treated as both non-produced economic assets, which provide economic benefits, and also as non-produced environmental assets, which provide carbon sequestration services alongside. For this purpose, we have considered only the timber, fuelwood, NTFP (non-timber forest product), and carbon sequestration benefits of forests. A secondary objective

is to establish that a ‘top-down’ approach using available national databases is indeed feasible, and to set up a process for this which is replicable at an appropriate periodicity.

While accounting for timber, fuelwood, and non-timber forest products is straightforward, accounting for carbon needs careful analysis because disturbances on forests involve flux of carbon between the atmosphere, soils, and forest products. 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 CO<sub>2</sub> (carbon dioxide), CO (carbon monoxide), and CH<sub>4</sub> (methane). Some of the carbon enters the forest product sector and the carbon that has been left onsite enters the soil carbon pools. One can assess whether forests are net sources or sinks of carbon only after taking into account the net flux of carbon between the forest sector and the atmosphere (Figure 1). A study by Haripriya (2003) has developed the carbon balance accounts for India using a simulation model, which takes into account all carbon pools and fluxes. Our study uses the estimates from Gundimedda (2003) and incorporates the carbon estimates into the national accounts.

The national and state accounts are adjusted in three steps. In the first stage, physical accounts (both area and volume) were compiled for different states. In the second stage, monetary accounts for forests were developed and in the last stage, these accounts were integrated into the national accounts. The integration in the third step has enabled us to compute the depreciation of forest resources and adjust the NSDP (net



**Figure 1**

Representation of carbon flows

Source Haripriya (2003)

state domestic product) for the depletion of forest resources. The measure termed as ESDP (environmental adjusted state domestic product) can be a very useful indicator for policy-makers to evaluate the wealth impact of specific unaccounted damage (e.g., the impact of NTFP depletion on our forest-dependent poor). It will also be useful in evaluating trade-offs in land use and resource use, as further GAISP studies will estimate the economic impact of changes in other asset classes such as agricultural land, pasture, sub-soil assets, and water resources.

The paper is structured as follows. In section 3, we talk about the profile of forests in India. In section 4, we discuss the construction of physical accounts (area, volume, and carbon) and in section 5, monetary accounts are developed. Section 6 tries to integrate the measures with the national accounting statistics and obtains the state-wise environmentally adjusted domestic product for the asset classes within the scope of this paper (namely, timber, carbon, fuelwood, and NTFP). In section 7, we conclude with the policy uses of the study and also its limitations.

### **3** Profile of forests in India

India has a total land area of 328.7 Mha (million hectares) of which about 20.55% (675 538 sq. km) is classified as forestland (FSI 2001) (Tables 1–3). The total growing stock of the country as assessed by the FSI (Forest Survey of India) is 4018.2 million cubic metres and the growing stock per hectare is 74.4 cubic metres. On the basis of ecosystem, Champion and Seth (1968) have classified India's forests into four major groups, namely, tropical, sub-tropical, temperate, and alpine. These major groups are further divided into 16 type groups: Tropical (wet-evergreen, semi-evergreen, moist deciduous, littoral and swamp, dry deciduous, thorn, dry evergreen), Sub-tropical (broad leaved hill forests, pine, dry evergreen), Temperate (montane wet, Himalayan moist temperate, Himalayan dry temperate), and Alpine (sub-alpine, moist alpine, and dry alpine scrub). Of the 16 forest types, tropical dry deciduous forests form the major percentage of the forest cover in India. The tropical dry deciduous forests account for 38.2% of the total forest cover. The other predominant type is tropical moist deciduous forest, which forms 30.3% of the total forest area of the country. The forests in India are divided into 21 different strata: Fir, Spruce, Deodar, Teak, Sal, Hardwoods, etc. by the FSI in order to assess the growing stock in the country. Over 45 000 species of plants exist in India and, of these, several thousands are endemic to this country. Bamboo in India constitutes the largest bamboo resources in the world. Mangroves in India contribute 5% of the total mangrove resources of the world. In the 2001 assessment of the FSI, forest cover consists of all lands, more than one hectare in area, with a tree canopy density of more than 10%, irrespective of land use and ownership. In all the previous assessments, mangroves were treated as a

**Table 1**Forest cover in different assessments (area in km<sup>2</sup>)

State/Union Territory	Assessment						
	1987	1989	1991	1993	1995	1997	1999
Andhra Pradesh	49573	47290	47290	47256	47112	43290	44229
Arunachal Pradesh	64132	69002	68757	68661	68621	68602	68847
Assam	25160	24832	24751	24508	24061	23824	23688
<b>Bihar</b>	<b>28482</b>	<b>26668</b>	<b>26668</b>	<b>26587</b>	<b>26561</b>	<b>4832</b>	<b>4830</b>
<b>Jharkhand</b>						<b>21692</b>	<b>21644</b>
Delhi	15	22	22	22	26	26	88
Goa	1240	1255	1255	1250	1250	1252	1251
Gujarat	11991	11921	11907	12044	12320	12578	12965
Haryana	513	513	513	513	603	604	964
Himachal Pradesh	12480	12480	12480	12502	12501	12521	13082
Jammu and Kashmir	20905	20449	20449	20443	20433	20440	20441
Karnataka	32268	32104	32199	32343	32382	32403	32467
Kerala	10292	10292	10292	10336	10336	10334	10323
<b>Madhya Pradesh</b>	<b>130099</b>	<b>135541</b>	<b>135541</b>	<b>135396</b>	<b>135164</b>	<b>74760</b>	<b>75137</b>
<b>Chhattisgarh</b>						<b>56435</b>	<b>56693</b>
Maharashtra	45616	44044	44044	43859	43843	46143	46672
Manipur	17475	17685	17685	17621	17558	17418	17384
Meghalaya	16466	15645	15875	15769	15714	15657	15633
Mizoram	19084	18170	18853	18697	18576	18775	18338
Nagaland	14394	14399	14321	14348	14291	14221	14164
Orissa	53253	47227	47205	47145	47107	46941	47033
Punjab	943	1338	1343	1343	1342	1387	1412
Rajasthan	12758	12884	12889	13099	13280	13353	13871
Sikkim	2756	3041	3041	3119	3127	3129	3118
Tamil Nadu	17472	16992	16992	17005	17045	17064	17078
Tripura	5953	5535	5535	5538	5538	5546	5745
<b>Uttar Pradesh</b>	<b>31226</b>	<b>33627</b>	<b>33609</b>	<b>33961</b>	<b>33986</b>	<b>10751</b>	<b>10756</b>
<b>Uttaranchal</b>						<b>23243</b>	<b>23260</b>
West Bengal	8432	8015	8015	8186	8276	8349	8362
Andaman and Nicobar Islands	7601	7622	7622	7624	7615	7613	7606
Chandigarh	2	5	5	5	7	7	7
Dadra and Nagar Haveli	238	206	206	206	204	204	202
Daman and Diu	0	0	0	0	0	0	0
Lakshadweep	0	0	0	0	0	0	0
Pondicherry	0	0	0	0	0	0	0
<b>Grand total</b>	<b>640819</b>	<b>638804</b>	<b>639364</b>	<b>639386</b>	<b>638879</b>	<b>633397</b>	<b>637293</b>
<b>Percentage</b>	<b>19.49</b>	<b>19.43</b>	<b>19.45</b>	<b>19.45</b>	<b>19.43</b>	<b>19.27</b>	<b>19.39</b>

Source FSI (2001)

separate class; but in the 2001 assessment, mangroves are also included in forest cover. Of the total forest cover in India, 61.7% are closed forests (crown density greater than 40%), 38.29% are open forests (crown density from 10% to 40%). The states with significant forest cover are Arunachal Pradesh (81.25%), Mizoram (82.98%), Nagaland (80.49%),

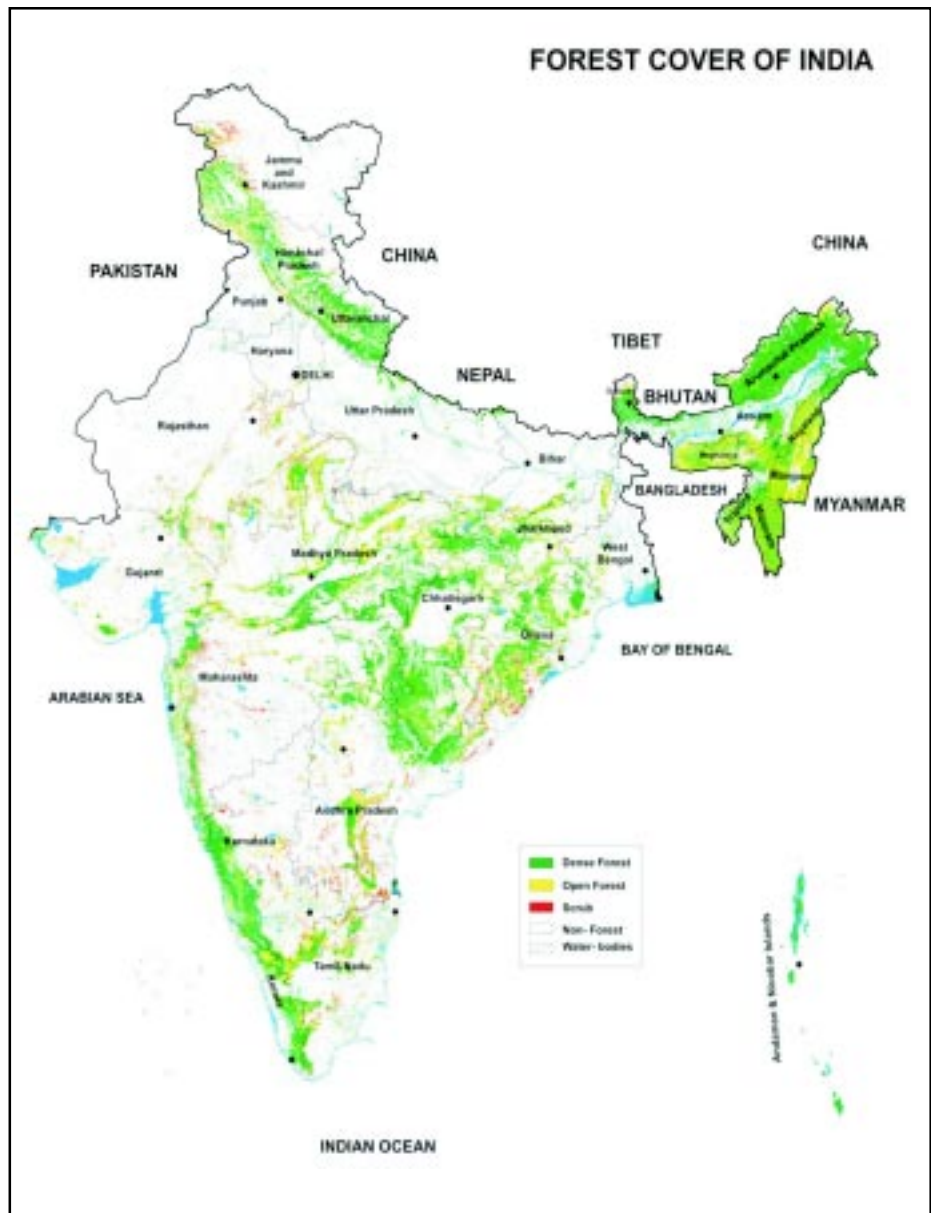
**Table 2**Forest cover in different states of India (2001) (area in km<sup>2</sup>)

State/Union Territory	Geographic area	Forest cover			Percentage	Scrub
		Dense	Open	Total		
Andhra Pradesh	275069	25827	18810	44637	16.23	9907
Arunachal Pradesh	83743	53932	14113	68045	81.25	141
Assam	78438	15830	11884	27714	35.33	224
Bihar	94163	3372	2348	5720	6.07	122
Chhattisgarh	135191	37880	18568	56448	41.75	200
Delhi	1483	38	73	111	7.51	4
Goa	3702	1785	310	2095	56.59	0
Gujarat	196022	8673	6479	15152	7.73	2408
Haryana	44212	1139	615	1754	3.97	88
Himachal Pradesh	55673	10429	3931	14360	25.79	566
Jammu and Kashmir	222236	11848	9389	21237	9.56	3087
Jharkhand	79714	11787	10850	22637	28.40	976
Karnataka	191791	26156	10835	36991	19.29	3245
Kerala	38863	11772	3788	15560	40.04	71
Madhya Pradesh	308245	44384	32881	77265	25.07	3452
Maharashtra	307713	30894	16588	47482	15.43	6137
Manipur	22327	5710	11216	16926	75.81	190
Meghalaya	22429	5681	9903	15584	69.48	259
Mizoram	21081	8936	8558	17494	82.98	467
Nagaland	16579	5393	7952	13345	80.49	47
Orissa	155707	27972	20866	48838	31.36	5782
Punjab	50362	1549	883	2432	4.83	30
Rajasthan	342239	6322	10045	16367	4.78	4925
Sikkim	7096	2391	802	3193	45.00	341
Tamil Nadu	130058	12499	8983	21482	16.52	3180
Tripura	10486	3463	3602	7065	67.38	44
Uttar Pradesh	240928	8965	4781	13746	5.71	678
Uttaranchal	53483	19023	4915	23938	44.76	598
West Bengal	88752	6346	4347	10693	12.05	149
Andaman and Nicobar	8249	6593	337	6930	84.01	0
Chandigarh	114	5	4	9	7.51	0
Dadra and Nagar Haveli	491	151	68	219	44.60	0
Daman and Diu	112	2	4	6	5.53	0
Lakshadweep	32	27	0	27	85.91	0
Pondicherry	480	35	1	36	7.45	0
<b>Total</b>	<b>3287263</b>	<b>416809</b>	<b>258729</b>	<b>675538</b>	<b>20.55</b>	<b>47318</b>

Note Geographic area includes the contested area in Kashmir

Source FSI (2001)

Manipur (75.81%), Meghalaya (69.48%), Tripura (67.38%), and Madhya Pradesh (25.07%). These states cover 32.85% of the total forest cover in India. Figure 2 gives the forest cover in India. Considering the proportion of geographic area under forest cover, the union territory of Lakshadweep, due to inclusion of forest plantations within forest cover, has the maximum percentage (85.91%).



**Figure 2**

Forest cover of India

Source FSI (2001)

**4 Compilation of physical accounts**

The study constructs physical accounts (area, volume, and carbon accounts) for different states and union territories in India using the data from the 2001 assessment. The framework adopted for constructing the area and volume accounts in physical terms is explained below. The volume accounts, area accounts, and carbon accounts for different regions and the accounts for different strata are given in Tables 4, 5, and 6.



**Table 3**State-wise comparative situation of forest cover (2001 and 1999) (km<sup>2</sup>)

State/Union Territory	2001	1999
Andhra Pradesh	44637	44229
Arunachal Pradesh	68045	68847
Assam	27714	23688
Bihar	5720	4830
Chhattisgarh	56448	56693
Delhi	111	88
Goa	2095	1251
Gujarat	15152	12965
Haryana	1754	964
Himachal Pradesh	14360	13082
Jammu and Kashmir	21237	20441
Jharkhand	22637	21644
Karnataka	36991	32467
Kerala	15560	10323
Madhya Pradesh	77265	75137
Maharashtra	47482	46672
Manipur	16926	17384
Meghalaya	15584	15633
Mizoram	17494	18338
Nagaland	13345	14164
Orissa	48838	47033
Punjab	2432	1412
Rajasthan	16367	13871
Sikkim	3193	3118
Tamil Nadu	21482	17078
Tripura	7065	5745
Uttar Pradesh	13746	10756
Uttaranchal	23938	23260
West Bengal	10693	8362
Andaman and Nicobar Islands	6930	7606
Chandigarh	9	7
Dadra and Nagar Haveli	219	202
Daman and Diu	6	3
Lakshadweep	27	0
Pondicherry	36	0
<b>Total</b>	<b>675538</b>	<b>637293</b>

Source FSI (2001)

**Opening stocks**

The opening stocks represent the stock of forest resources (area under forests or the volume of growing stock) present at the beginning of the accounting period (2001 assessment). The opening stocks are taken as the total growing stock extrapolated to 2001 from an earlier assessment made by the FSI.<sup>1</sup> The total opening volume is 4018.2 million cubic metres and the total forest area is 67 553 490 ha. To convert this estimate into units of carbon, we need the estimates of biomass. In India, as

<sup>1</sup> FSI assesses the total growing stock in the country once every two years and published in the FSI (1995a). The latest assessment period at the time of carrying out the study is 1991-93. The study extrapolates the growing stock estimates for 2001 based on this value.

**Table 4**

**Area accounts of timber and fuelwood for different states in India (in ha)**

State/ Union Territory	Opening area (1)	Disturbance of tree (2) = (2.1+2.2+ 2.3)	Logging/ harvest+ illegal logging (2.1)	Logging damage (2.2)	Forest Fires (2.3)	Disturbance of forest land (3) = (3.1+ 3.2+3.3)	Shifting cultivation (3.1)	Animal grazing (3.2)	Forest encroach- ments (3.3)	Disturbance of forest area (4) = (4.1)	Transfer of land to other activities (4.1)	Addition of stumpage trees (5)	Afforest- ation (5.1)	Regene- ration (5.2)	Net disturbance (6) = (5-2-3-4)
Andhra Pradesh	4463700	139377.4	122799.4	12279.9	4298.0	685870.6	162196.0	344223.0	179451.6	16694	16694	84892.0	82310.0	2582.0	-757049.9
Bihar	2835700	230351.8	206343.0	20634.3	3374.5	166824.8	4004.0	156396.3	6424.5	3221	3221	17358.0	9296.0	8062.0	-383039.6
Goa	209500	35.5	23.2	2.3	10.0	10812.0	0	5673.0	5139.0	163	163	1922.8	1350.8	572.0	-9087.6
Gujarat	1515200	178622.6	154326.0	15432.6	8864	196403.4	0	118565.7	77837.7	21277	21277	103026.0	48820.0	54206.0	-293277.0
Haryana	175400	20237.9	18319.0	1831.9	87.0	12689.5	0	12115.5	574.0	862	862	30516.0	17009.0	13507.0	-3273.4
Himachal Pradesh	1436000	16856.9	9822.6	982.3	6052.0	90787.3	0	89430.3	1357.0	3388	3388	78138.0	33135.0	45003.0	-32894.1
Jammu and Kashmir	2123700	10241.1	8886.6	888.7	465.9	176605.6	0	163368.6	13237.0	1286	1286	26594.0	10489.0	16105.0	-161538.7
Uttar Pradesh	3768400	96574.5	82463.2	8246.3	5865.0	207910.3	0	170972.8	36937.5	24986	24986	117630.0	59442.0	58188.0	-211840.8
Karnataka	3699100	107634.3	82721.3	8272.1	16640.9	296929.0	0	190696.0	106233.0	28169	28169	117381.0	23287.0	94094.0	-315351.3
Kerala	1556000	72814.7	65217.7	6521.8	1075.2	115280.8	0	66668.8	48612.0	30263	30263	4403.1	950.2	3452.9	-213955.3
Madhya Pradesh	13371300	230732.9	208574.2	20857.4	1301.2	1725299.5	0	1723542.0	1758.0	217333	217333	132722.0	69023.0	63699.0	-2040643.3
Maharashtra	4748200	301315.4	225423.1	22542.3	53350.0	497573.3	0	428799.8	68773.5	31613	31613	78447.0	66526.0	11921.0	-752054.7
Orissa	4883800	177863.5	106393.5	10639.3	60830.7	443182.6	0	415233.4	27949.2	19007	19007	6478.0	4038.0	2440.0	-633575.1
Punjab	243200	32334.7	29142.1	2914.2	278.4	13318.3	0	8918.3	4400.0	334	334	19264.0	8825.0	10439.0	-26723.0
Rajasthan	1636700	155681.7	141439.5	14143.95	98.2	102356.3	0	94423	7933.3	8229	8229	85115.5	83577.0	1538.5	-181151.5
Sikkim	319300	626.5	519.5	52.0	55.0	5049.6	0	3849.6	1200.0	412	412	9192.3	7500.0	1692.3	3104.2
Tamil Nadu	2148200	269106.0	244465.5	24446.6	193.9	181868.9	0	164388.9	17480.0	4731	4731	104704.0	16156.0	88548.0	-351001.9
West Bengal	1069300	369382.2	335771.1	33577.1	34.0	116786.4	0	115485.3	1301.1	8929	8929	44088.0	27491.0	16597.0	-451009.6
Andaman and Nicobar Islands	693000	129.6	112.4	11.2	6.0	8079.7	0	6167.1	1912.6	2143	2143	2006.0	179.0	1827.0	-8346.3
Dadra and Nagar Haveli	21900	189.6	0	0	189.6	1327.0	33.7	680.0	613.3	141	141	615.0	300.0	315.0	-1042.6
Arunachal Pradesh	6804500	2435.7	2199.8	220.0	16.0	161998.1	23000.0	94557.1	44441.0	871	871	6613.0	4563.0	2050.0	-158691.8
Assam	2771400	60622.8	54028.3	5402.8	1191.7	347333.8	13000.0	79622.8	254711.0	1519	1519	11329.5	7117.0	4212.5	-398146.1
Manipur	1692600	18872.3	17063.5	1706.3	102.5	112731.4	36000.0	56080	20651.4	245	245	140503.6	13881	1692.6	8654.9
Meghalaya	1558400	12971.2	11211.1	1121.1	638.9	62345.4	18000.0	40602.3	3743.1	177	177	1715.9	780.8	935.0	-73777.7
Nagaland	1334500	11732.9	10181.0	1018.1	533.8	162634.2	39000.0	107352.0	16282.2	0	0	7850.5	3713.5	4137.0	-150234.4
Tripura	706500	39827.1	35821.1	3582.1	423.9	107247.0	50000.0	48627.0	8620.0	193	193	3810.0	3610.0	200.0	-88846.9
Mizoram	1749400	12320.1	10431.0	1043.1	846.0	153545.8	38000.0	115533.0	12.8	55	55	11450.0	8200.0	3250.0	-152284.9
<b>Total</b>	<b>67534900</b>	<b>2568891</b>	<b>2183699.0</b>	<b>218370.0</b>	<b>166822.0</b>	<b>6162790.5</b>	<b>383233.7</b>	<b>4821971.0</b>	<b>957586.0</b>	<b>426241</b>	<b>426241</b>	<b>1247765.0</b>	<b>736499.0</b>	<b>511266.0</b>	<b>-7837079.0</b>

**Table 5**

**Volume accounts for timber and fuel wood for different states in India ('000 cubic metres)**

State/ Union Territory	1	2= (a+b+c)		a	b	c	3 = (d+e+ f+g+h)			e	f	g	h	4 = (i+j+k)		j	k	5 = 3-(2+4)		6 = (1+5)
		Opening stock	Changes due to economic activity				logging/ illegal logging	logging damage	Affores- tation					Other volume changes	Forest fires			Stand mortality	Animal grazing	
Andhra Pradesh	252525.5	-8283.4	7595.2	7595.2	759.5	71.3	28885.6	0.0709	17.8	5.67	13702.2	15159.9	4898.7	5929	2.2	1032.5	-32270.3	220255.2		
Bihar	100959.1	-8261.3	7513.8	7513.8	751.4	3.9	543.1	0.0086	23.0	0.40	199.5	320.1	1601.1	1715	3.4	117.3	-7203.3	93755.7		
Goa	6653.6	-2.3	2.3	2.3	0.2	0.3	634.2	0.0000	2.3	0.01	0	631.9	214.7	231	0.1	16.5	-421.8	6231.8		
Gujarat	74510.6	-8771.0	8006.9	8006.9	800.7	36.6	5285.4	0.4520	12.4	6.05	0	5266.6	395.7	1459	40.7	1103.9	-13660.7	60849.9		
Haryana	2975.0	-452.2	411.9	411.9	41.2	0.9	22.4	0.0008	0.2	0.11	0	22.1	8.3	27	0.7	19.4	-466.3	2508.6		
Himachal Pradesh	159149.7	-2189.7	1999.0	1999.0	199.9	9.2	356.5	0.0917	18.8	1.36	0	336.3	926.0	1603	12.5	689.5	-1620.1	157529.6		
Jammu and Kashmir	444586.0	-2175.2	1995.9	1995.9	199.6	20.3	4001.5	0.0113	27.0	3.96	0	3970.5	6144.4	6402	31.2	288.8	-32.4	444553.6		
Uttar Pradesh	222881.5	-8998.4	8216.5	8216.5	821.6	39.8	4900.8	0.1224	57.6	3.57	0	4839.6	3367.4	5818	38.9	2489.6	-10531.8	212349.7		
Karnataka	186081.6	-7645.0	6958.8	6958.8	695.9	9.7	10718.3	0.2210	18.3	2.53	0	10697.2	3243.7	5574	39.4	2369.7	-15119.5	170962.1		
Kerala	140184.4	-6862.2	6239.1	6239.1	623.9	0.8	4743.0	0.0027	4.5	0.17	0	4738.4	-909.1	1983	3.1	2895.1	-12514.2	127670.2		
Madhya Pradesh	537800.3	-11822.6	10773.8	10773.8	1077.4	28.6	216.9	0.0053	100.7	7.08	0	109.1	2922.2	14122	26.4	11226.2	-9117.3	528683.0		
Maharashtra	200352.6	-12710.4	11596.9	11596.9	1159.7	46.1	4705.8	0.6113	47.3	4.91	0	4652.9	3389.9	5008	8.3	1626.3	-14026.3	186326.3		
Orissa	228688.3	-6113.2	5559.4	5559.4	555.9	2.2	1942.6	0.0435	50.9	0.30	0	1891.4	3440.1	4432	1.3	993.2	-4615.7	224072.6		
Punjab	1729.5	-226.0	206.3	206.3	20.6	1.0	51.1	0.0024	0.1	0.08	0	50.9	21.8	23	1.1	2.4	-255.3	1474.2		
Rajasthan	21551.9	-1497.4	1372.9	1372.9	137.3	12.8	137.3	0.0008	1.3	0.75	0	135.3	212.4	292	0.2	79.9	-1422.3	20129.6		
Sikkim	25639.3	-64.0	65.3	65.3	6.5	7.8	177.5	0.0016	1.8	0.11	0	175.5	717.0	767	1.8	51.8	475.5	26114.7		
Tamil Nadu	77420.9	-10527.6	9577.2	9577.2	957.7	7.3	921.0	0.0043	3.0	3.63	0	914.3	1248.8	1394	40.1	185.3	-10199.8	67221.1		
West Bengal	29555.0	-10200.2	9274.7	9274.7	927.5	1.9	85.1	0.0001	2.5	0.33	0	82.3	187.5	433	1.2	246.6	-10097.8	19457.2		
Andaman and Nicobar Islands	6539.1	-12.9	11.8	11.8	1.2	0	252.8	0.0000	22.0	0	0	230.8	1270.3	1494	0.4	224.1	1004.6	7543.7		
Dadra and Nagar Haveli	527.3	0.1	0	0	0	0.1	33.5	0.0011	0.2	0	1.7	31.5	16.1	22	0.1	6.0	-17.4	509.9		
Arunachal Pradesh	457797.9	-268.7	248.5	248.5	24.8	4.6	8742.6	0.0000	45.2	0.09	2966.1	5731.2	15146.7	15243	2.1	98.4	6135.3	463933.2		
Assam	294924.2	-7512.5	6835.7	6835.7	683.6	6.7	41529.7	0.0046	19.5	0.31	2015.7	39494.2	5872.8	6061	4.0	192.2	-43169.4	251754.8		
Manipur	142413.4	-931.9	927.6	927.6	92.8	88.5	6354.1	0.0054	8.1	2.97	4030.8	2312.3	1876.8	1889	1.1	13.3	-5409.2	137004.1		
Meghalaya	177203.9	-816.4	743.0	743.0	74.3	0.9	3366.3	0.0008	9.5	0.05	2778.9	577.9	2139.3	2150	1.0	11.7	-2043.4	175160.5		
Nagaland	123288.7	-738.7	676.0	676.0	67.6	4.9	6762.4	0.0041	4.3	0.83	4767.0	1990.2	1908.5	1903	5.5	0.0	-5592.6	117696.0		
Tripura	20910.5	-1097.4	999.3	999.3	99.9	1.9	2005.7	0.0012	1.4	0.14	1709.5	294.7	310.7	316	0.1	5.4	-2792.4	18118.1		
Mizoram	81371.7	-400.7	370.7	370.7	37.1	7.1	2588.9	0.0048	3.5	0.65	2583.9	0.9	1332.8	1332	2.8	2.0	-1656.7	79715.0		
<b>Total</b>	<b>4018221.3</b>	<b>-118581.0</b>	<b>108178.4</b>	<b>108178.4</b>	<b>10817.8</b>	<b>415.2</b>	<b>139964.1</b>	<b>1.7000</b>	<b>503.3</b>	<b>46.10</b>	<b>34755.3</b>	<b>104657.8</b>	<b>61904.4</b>	<b>87622.0</b>	<b>269.5</b>	<b>25987.1</b>	<b>-196641.0</b>	<b>3821581.0</b>		

**Table 6**

**Volume accounts of carbon for different states in India ('000 tonnes of carbon)**

State/ Union territory	Opening stock of carbon	Net release due to changes in economic activity		Release to atmos- phere due to logging	Affores- tation	Other volume changes	Releases atmosphere due to		Releases atmosphere due to stand mortality	Release of carbon due to animal grazing	Release of carbon due to shifting cultivation	Release of carbon due to forest en- croachments	Other accumu- lation	Natural growth	Regene- ration	Carbon lost due to transfer of		Closing stock of carbon
		due to forest fires	due to forest fires				land to	Net carbon change										
Andhra Pradesh	167231.7	-4932.3	4979.5	47.2	13097.4	0.0237	0.0511	0	7271.1	5826.3	3895.2	3926.4	1.5	32.7	-14134.5	153097.1		
Bihar	96999.3	-7143.2	7146.9	3.7	521.8	0.0042	0.0959	0	153.6	123.1	1648.8	1647.7	3.2	2.2	-6016.2	90983.1		
Goa	10684.7	-3.2	3.7	0.5	1018.4	0.0000	0.0159	0	0	0	370.8	371.0	0.2	0.4	-650.8	10033.9		
Gujarat	50355.6	-5332.4	5357.1	24.7	3572.0	0.1543	0.0363	0	0	0	980.9	986.0	27.5	32.6	-7923.5	42432.1		
Haryana	6693.1	-915.4	917.4	2.0	50.5	0.0009	0.0024	0	0	0	62.1	60.7	1.5	0.2	-903.8	5789.3		
Himachal Pradesh	54120.2	-669.8	673.0	3.1	121.2	0.0158	0.0276	0	0	0	503.8	545.1	4.3	45.6	-287.3	53832.9		
Jammu and Kashmir	115806.7	-509.4	514.7	5.3	1042.3	0.0015	0.0305	0	0	0	1636.0	1667.6	8.1	39.8	84.2	115890.9		
Uttar Pradesh	129830.2	-4715.1	4738.3	23.2	2854.8	0.0360	0.1453	0	0	0	3334.6	3389.0	22.7	77.1	-4235.4	125594.8		
Karnataka	141343.0	-5225.5	5232.9	7.4	8141.3	0.0848	0.0602	0	0	0	4196.9	4233.9	29.9	66.9	-9169.9	132173.1		
Kerala	59930.2	-2640.2	2640.6	0.4	2027.7	0.0006	0.0083	0	0	0	704.7	847.8	1.3	144.4	-3963.2	55967.0		
Madhya Pradesh	473314.4	-9362.0	9387.1	25.1	190.9	0.0024	0.3842	0	0	0	12198.0	12428.7	23.2	253.9	2645.1	475959.5		
Maharashtra	159626.0	-9110.4	9147.1	36.8	3749.2	0.2460	0.1635	0	0	0	3953.8	3990.0	6.6	42.8	-8905.8	150720.2		
Orissa	170190.1	-4094.3	4096.0	1.6	1445.7	0.0163	0.1641	0	0	0	3274.6	3298.3	1.0	24.7	-2265.4	167924.7		
Punjab	5158.1	-606.3	609.1	2.8	152.3	0.0036	0.0017	0	0	0	72.0	68.6	3.4	0.0	-686.6	4471.5		
Rajasthan	55933.9	-3494.2	3527.4	33.2	356.4	0.0010	0.0145	0	0	0	757.9	757.8	0.6	0.5	-3092.7	52841.2		
Sikkim	12516.5	-27.8	31.5	3.8	86.6	0.0004	0.0039	0	0	0	372.9	374.4	0.9	2.3	258.5	12775.1		
Tamil Nadu	83193.7	-10180.5	10188.4	7.9	989.7	0.0023	0.0142	0	0	0	1537.4	1497.9	43.1	3.7	-9632.8	73560.9		
West Bengal	37177.1	-11547.5	11549.9	2.4	107.1	0.0001	0.0137	0	0	0	542.4	544.7	1.5	3.7	-11112.1	26064.9		
Andaman and Nicobar Islands	40942.4	-72.6	72.8	0.2	1582.9	0.0000	0.5973	0	0	0	9354.8	9354.2	2.5	1.9	7699.2	48641.6		
Dadra and Nagar Haveli	579.5	0.1	0	0.1	36.8	0.0006	0.0010	0	1.5	1.2	24.2	24.2	0.1	0.1	-12.5	566.9		
Arunachal Pradesh	248152.1	-130.9	133.3	2.5	4739.0	0.0000	0.1062	0	1288.3	1032.3	8260.2	8262.6	1.1	3.5	3390.4	251542.4		
Assam	103681.3	-2376.7	2379.1	2.4	14599.9	0.0008	0.0297	0	567.8	455.0	2121.2	2130.8	1.4	11.0	-14855.4	88825.9		
Manipur	61033.0	-355.6	393.6	37.9	2723.1	0.0012	0.0150	0	1384.2	1109.2	809.4	809.6	0.5	0.6	-2269.3	58763.7		
Meghalaya	50381.6	-208.9	209.1	0.2	957.1	0.0001	0.0117	0	633.1	507.3	610.9	611.3	0.3	0.7	-555.1	49826.5		
Nagaland	51262.4	-276.2	278.3	2.0	2811.7	0.0009	0.0078	0	1588.2	1272.7	793.5	791.3	2.3	0	-2294.4	48968.0		
Tripura	24018.1	-1134.2	1136.4	2.2	2303.8	0.0007	0.0069	0	1573.4	1260.7	363.0	363.0	0.1	0.1	-3075.0	20943.1		
Mizoram	63191.6	-279.5	285.0	5.5	2010.5	0.0019	0.0117	0	1607.9	1288.4	1036.5	1034.4	2.2	0	-1253.4	61938.2		
<b>Grand total</b>	<b>2473346.1</b>	<b>-85344.0</b>	<b>85628.2</b>	<b>284.2</b>	<b>71290.1</b>	<b>0.6000</b>	<b>2.0000</b>	<b>0</b>	<b>16069.1</b>	<b>12876.2</b>	<b>63416.3</b>	<b>64016.8</b>	<b>190.8</b>	<b>23222.9</b>	<b>-93217.8</b>	<b>2380128.4</b>		

estimates of biomass using direct measurement (destructive sampling) are not available for all forest types in the country, a study by Haripriya (2000a, 2002a) used the volume inventory data to estimate the carbon content of the biomass in different states and different types of forests (Haripriya 2000a). Carbon content is assumed to be approximately 0.5 times the respective biomass estimate. According to the study, the carbon density per hectare varies in different states from 21.2 tC/ha to 59.1 tC/ha with an average carbon density per hectare of 37 t. Using this estimate, the opening stock of carbon in Indian forests is 24 73 346 100 tC. We have included only the aggregate carbon content of forest biomass and did not include the stock of carbon in soils. The rationale for this is that we are interested in the change in carbon as a result of 'disturbance' on forested land in the current accounting period.

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***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. To compute the changes in carbon stock due to economic activity, information on the total volume of timber harvested, area subject to logging, illegal logging, and area afforested is required. The volume of timber harvested/logged is derived from the production statistics of timber and fuelwood obtained from the CSO (Central Statistical Organization) for the year 2001/02.<sup>2</sup> The area subjected to logging is derived from the volume accounts by dividing the total volume harvested by the growing stock per square kilometre.<sup>3</sup> The estimates indicate that around 2 183 699 ha (3.2% of the forest area) is subject to logging (for timber and fuelwood) during the study period. Damage due to logging is assumed to be 10% of the volume of timber logged from both recorded and unrecorded production.<sup>4</sup> As logging involves logging damage, the study takes the latter into consideration (we assumed that 10% of the total volume harvested either remains on the stump or is damaged). However, the volume of timber harvested for timber and fuelwood is highly debated as the estimated consumption exceeds the recorded production. The recorded production of timber and fuelwood is far below the actual consumption and hence, a considerable amount of timber and fuelwood goes unnoticed due to illegal felling of trees. The statistics on the number of trees cut illicitly and the loss in revenue due to illicit logging is available with various SFDs (state forest departments) and the revenue generated from the seizure of illegal material is recorded in the production statistics. However, a considerable amount of timber and fuelwood still goes unnoticed. In order to account for the unrecorded production, the CSO uses a norm of 10% of the total

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<sup>2</sup> The estimates are based on the projections from 1994 production estimates.

<sup>3</sup> 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.

<sup>4</sup> The figure is based on the information provided by the state forest department of Maharashtra (visited on 28 May 1997).

recorded production of industrial round wood as the value of unrecorded production of industrial round wood.<sup>5</sup> For fuelwood, while previous estimates used a norm of 10 times the recorded production, current estimates have been prepared by superimposing the trend of fuelwood consumption observed from the NSSO (National Sample Survey Organization) consumption surveys for the year 1983/84 on the estimates for 1980/81 prepared on the basis of recorded production (CSO 1989).<sup>6</sup> The study also considers the amount of logging done illegally in Indian forests (estimated in Haripriya 2002b).

While computing the total volume of carbon 'lost' (or harvested) 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. As the timber can be logged either by clear felling or partial cutting, one has to consider the respective carbon balances by different methods. The study by Haripriya (2003) assumed that when the logging is done by clear-cutting only, 80% of the stem biomass is transferred to the wood products, whereas 2% remains on the stem, 8% is transferred to soils and 11% is released to the atmosphere. When the forest is subject to partial cutting, 85% of the stem biomass is transferred to wood products, 10% remains on the stump, and 5% is transferred to the soils. The amount of carbon remaining on the stem or transferred to soils gives the amount of logging damage. Another point to be noted here is that from the standpoint of national accounting, we have defined the change in carbon as the present value of (future) carbon released arising from disturbances (e.g. logging) on forested land in the current accounting period. In other words, it does not matter that the carbon in forest products is not released in 2001/02. The key thing is that the logging activity occurred in this period. Based on this, the total carbon leaving the biomass is estimated at 85 628(000) tC. This includes the transfer of carbon to the atmosphere as well as to the soil.

The area afforested in India is 736 499 ha (1.1% of the forest area) during 1996/97 (information provided in ICFRE 2000).<sup>7</sup> However, 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 hectare in these afforested areas. Such an effort is being made by the FSI for some agro-forestry

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<sup>5</sup> Due to ban on clear felling this assumption may need to be revised. It is recorded that in some states like Rajasthan the logging figure is as high as 2.5 times of the recorded production. But till some consensus is reached about the figure we decided to stick to this norm.

<sup>6</sup> From the total estimate of fuelwood consumption the amount of biomass obtained from agriculture is deducted by CSO in order to avoid double counting.

<sup>7</sup> A three-year average is used so as to avoid any lags in data reporting.

areas but is not yet complete. 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 square kilometre and assumes that the same conditions prevail at the existing sites. The volume additions due to afforestation are derived by multiplying the area afforested with the mean annual increment per square kilometre of different strata.<sup>8</sup> Based on this, the mean annual addition to timber is 415 000 cubic metres and the amount of carbon sequestered is 284 000 tC.

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### ***Other accumulations***

Other accumulations consist of the accumulation of timber due to natural growth (mean annual increment), natural regeneration, and the transfer of forestland for non-forest uses (for example, for agriculture, residential or industrial purposes). The mean annual increment of different species is taken from the statistics published by the FSI (1995). The total annual increment in India according to 2001 assessment is 87 622 000 cubic metres.<sup>9</sup> This volume estimate is converted to units of carbon using the same method as discussed earlier. Based on this the mean annual accumulation of carbon in biomass is 64 017 000 tC.

In addition, there is also some amount of regeneration in forests. The area regenerated (naturally and artificially) is obtained from ICFRE (2000). The data indicates that around 511 266 ha (0.75% of forest area) is regenerated every year. Only the information on area regenerated in various states is available and the volume added due to regeneration is computed by multiplying the area regenerated with the mean annual increment per hectare of different species.<sup>10</sup> 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 total area transferred in India was 426 241 ha (0.63%) during the year 1996/97. The volume reduction due to transfer of land for non-forest purposes is derived by multiplying the area transferred with the growing stock per hectare. Around 25 987 000 cubic metres of timber is lost due to this transfer of forestland. The timber available from this land is included in the logging statistics and hence not considered here again.

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### ***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: surface fires (non-stand replacing) and crown fires

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<sup>8</sup> The assumption was made as the information on volume of stock growing in afforested area is not available.

<sup>9</sup> Actually the FSI publishes figures based on 1993 assessment only. The FSI (2001) publishes the same figure as the mean annual increment for the year 2001 also. Hence we used the same estimate.

<sup>10</sup> As a result of frequent fires and heavy grazing, only 18.3% of the total forest area has regeneration potential of important species (FSI 1995).

(stand-replacing). As surface-fires are non-stand replacing fires they are not considered under other volume changes and only the stand-replacing fires are considered. The area subject to forest fire is given by ICFRE (2000). In India, about 166 822 ha (0.25%) of forest was affected by fire in 1996/97. The volume of forest stock affected by forest fire is derived by multiplying the naturally regenerated volume and the afforested volume with the percentage area affected by the forest fire.<sup>11</sup> Further, we have 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 as well as releases that eventually occur in future as a result of fires today) and 30% is released into the atmosphere. The total amount of carbon lost (or released to the atmosphere) is estimated at 600 tC. Here the change in carbon is defined as the present value of (future) carbon released arising from disturbances on forested land in the current accounting period.

As the forests are infected by pests, only insect infestations resulting in loss of biomass are explicitly considered in the study. Recent insect-induced mortality data are not available in India and the most latest statistics available at the time of this analysis are the estimates of loss in timber volume due to insects, pests, and diseases from Indian Forest Statistics (various years between 1947 and 1972) for various states. Past statistics reveal that the average volume rendered unusable annually due to attack of insects/pests is about 0.031% for broad-leaved species and 0.005% for coniferous species (Indian forest statistics, various issues for the years 1947–70). This study also assumes the same proportion of insect-related volume loss for 2001. The area disturbed due to mortality of trees is derived from the volume accounts by dividing the volume lost due to mortality of trees with the growing stock per hectare. The volume estimates are converted to carbon estimates as discussed before. The total carbon released out of the woody biomass is about 0.46 million tonnes of carbon.

The percentage area subject to grazing is available from FSI (1995). This is the only publication, which gave the percentage of area subject to light, moderate, and heavy grazing. We have considered only the area subject to heavy grazing. About 6% of the forest area is subject to heavy grazing in India. The volume lost due to grazing is derived by multiplying naturally regenerated volume and the afforested volume with the percentage of area subject to heavy grazing.<sup>12</sup> However, no carbon loss is assumed from grazing because the carbon increases due to natural regeneration is assumed to be offset by loss in carbon due to surface fires and grazing.

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<sup>11</sup> Only the forest area that is prone to frequent fires is considered as affected by fire annually in this study.

<sup>12</sup> In the construction of physical resource accounts, only the forest area subjected to heavy grazing is considered as it leads to the destruction of stumpage trees. It is assumed that moderate and light grazing does not cause much damage to the forests.



There are varying estimates on actual area subject to shifting cultivation in different states. The net area subject to shifting cultivation (after excluding the regenerated areas) is about 383 233 ha (0.56% of the total forest area). The estimates for shifting cultivation in Andhra Pradesh, Bihar, and Tripura are taken from ICFRE (2000). For other north-eastern states, only the cumulative area subject to shifting cultivation for a period of 10 years is available from FSI (1999). For these states we took an average value. The volume lost due to shifting cultivation is obtained by multiplying the area subject to shifting cultivation with the growing stock per hectare, which is 34 755 (000) cubic metres. The total carbon released as a result of shifting cultivation includes releases for forest biomass into the atmosphere and transfer to the soils. Here we have assumed that 80% of the carbon is transferred to the wood products and only the rest is released to the atmosphere (16 069 100 tC) (*see Table 6 column 10*).

The forests in India are affected due to encroachments. The data on forest encroachments is taken from ICFRE (2000). However, for the two north-eastern states, there is no data on forest encroachments. For these two states, we assumed the same percentage area under encroachment in the neighbouring state as an approximate estimate. The total area under encroachments in India is 957 586 ha (about 1.4% of the total forest area).

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### **Closing stocks**

The closing stocks are computed as opening stocks less reductions plus additions. The closing stock of timber is 3 821 581 (000) cubic metres while that of carbon is 2 380 128 (000) tC.

## **5 Construction of monetary accounts**

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### **Valuation of timber and fuelwood**

Timber and fuelwood are valued using producer's prices as provided by the CSO. We have the values for the years 1993/94 and 1994/95. We have extrapolated these values based on the wholesale price index for timber (Table 7). The value of the NTFPs like rattan, gum, lac, and bamboo per hectare is also taken from the statistics provided by the CSO. The value recorded represents only some of the non-nationalized items of NTFPs. Further, in India, the residents of forest villages have the privilege to collect all NTFPs for their bonafide personal use or for earning their livelihood. This makes the task of finding the exact value of NTFPs very difficult. In order to take into account this unrecorded production, the value of the NTFPs is taken to be 10 times the value recorded by the SFD. The value of the NTFPs recorded in the national accounts is Rs 20 350 million (in the year 2000/01) and the value of NTFPs per hectare is estimated at Rs 301 per hectare. The present value of NTFPs is about 7525 and is obtained by dividing the value of NTFPs generated in the first year by the social discount rate of 4%. The value varies between different states (Table 8). This value is very low given the fact that only 10 times the royalty value is considered (which as such is very low). It is clear from Table 9 that on an average out of every 1000 population, about

**Table 7**

Unit (net) price of timber and fuelwood as recorded in the national accounts

State/Union Territory	Timber (1993/94) unit price	Fuelwood (1993/94) unit price	Timber (1994/95) unit price	Fuelwood (1994/95) unit price	1993/94 weighted price of logging and illegal logging	1994/95 weighted price of logging and illegal logging	Average
Andhra Pradesh	12736.1	447.0	13363.1	480.6	508.4	557.5	532.9
Arunachal Pradesh	2210.9	429.0	2211.0	486.7	1664.0	1799.5	1731.8
Assam	2102.4	480.0	2222.7	490.0	495.9	501.5	498.7
Bihar	7161.8	456.7	6905.7	494.6	597.5	637.8	617.6
Goa	2871.9	380.1	3801.2	427.2	494.3	772.5	633.4
Gujarat	6076.7	875.5	6203.4	1080.9	898.2	1102.6	1000.4
Haryana	8020.6	265.7	8377.1	259.4	878.0	334.5	606.3
Himachal Pradesh	4252.4	576.0	4108.7	576.0	1008.1	1059.0	1033.5
Jammu and Kashmir	5828.2	1036.0	6482.4	1036.0	1306.9	1130.1	1218.5
Karnataka	5138.8	766.0	5546.8	792.0	876.0	962.1	919.1
Kerala	5658.6	765.0	6347.7	872.0	1077.5	1393.7	1235.6
Madhya Pradesh	4461.6	461.9	5529.2	564.5	637.6	796.7	717.1
Maharashtra	4519.8	824.1	6173.5	880.9	858.4	927.3	892.8
Manipur	2615.0	480.0	2888.0	530.0	527.2	578.9	553.0
Meghalaya	1149.9	150.1	1162.1	160.1	335.2	454.2	394.7
Mizoram	2817.3	500.0	2789.1	550.1	991.1	643.8	817.4
Nagaland	7711.6	673.2	7687.3	674.4	1151.1	1139.3	1145.2
Orissa	3731.8	621.5	4550.8	657.0	653.9	673.5	663.7
Punjab	1221.4	220.1	936.4	346.4	947.4	742.8	845.1
Rajasthan	4825.7	600.1	5142.9	615.1	600.5	615.4	608.0
Sikkim	1875.4	400.4	—	400.3	405.3	—	202.7
Tamil Nadu	1980.4	412.0	2366.0	441.0	449.3	486.5	467.9
Tripura	1924.4	370.7	2193.0	429.2	395.8	443.1	419.5
Uttar Pradesh	2238.2	680.0	2384.9	747.0	744.8	811.7	778.2
West Bengal	4250.5	641.2	5061.7	685.7	689.6	740.3	715.0
Andaman and Nicobar Islands	3112.2	621.5	3238.4	576.0	3112.2	3238.4	3175.3

Source Computed

192 people are dependent on common property resources (of which forests are part) for timber, 656 for fuelwood, 342 for fodder, 372 for thatching materials, 246 for fruits, 203 for bamboo/canes/reeds, 167 for honey, etc. Given the dependence of population on different open access lands, the value recorded at present is very low. However, due to lack of estimates of exact contribution of NTFPs in different states, we took this estimate as a lower bound. Further, from CSO we could not get the state-wise contribution of NTFPs. Hence, we used the proportion of value contributed to the value added by forestry and logging sector at the all-India level and derived the respective contribution in different states. For most of the north-eastern states the value recorded is very low and for these states we used an all-India average. We will revise these estimates when we get the state-wise estimates. Further, it is assumed that the production of NTFPs is sustainable and prices and costs are also stable.

The forests also provide fodder for the livestock. The value of fodder obtained from forests is valued using the cost of alternate acreage. In the

**Table 8**

Estimates of carbon in biomass, value of NTFPs (non-timber forest products) and fodder (per ha)

States/Union Territory	Carbon in biomass (tC/ha)	Value of NTFPs	Net present value of NTFP	Value of fodder per ha	Net present value of fodder
Andhra Pradesh	37.5	334.6	8366.2	253.7	6341.9
Bihar	34.2	607.5	15188.5	18.5	462.4
Goa	51.0	57.6	1441.2	129.9	3248.5
Gujarat	33.2	172.1	4302.1	167.6	4189.5
Haryana	38.2	771.0	19275.0	201.1	5027.9
Himachal Pradesh	37.7	416.5	10412.3	288.6	7215.8
Jammu and Kashmir	54.5	233.9	5846.7	363.0	9074.6
Uttar Pradesh	34.5	812.5	20311.3	111.5	2786.3
Karnataka	38.2	456.6	11415.4	171.6	4289.8
Kerala	38.5	1228.6	30713.9	287.7	7193.5
Madhya Pradesh	35.4	199.0	4973.8	184.8	4620.0
Maharashtra	33.6	626.9	15672.3	244.7	6117.3
Orissa	34.8	271.2	6779.8	185.2	4629.2
Punjab	21.2	940.1	23503.0	114.6	2864.0
Rajasthan	34.2	639.0	15975.8	88.8	2220.7
Sikkim	39.2	271.2	6779.8	29.6	741.0
Tamil Nadu	38.7	238.0	5950.7	283.2	7079.3
West Bengal	34.8	907.4	22684.6	571.3	14281.6
Andaman and Nicobar Islands	59.1	271.2	6779.8	71.4	1785.7
Dadra and Nagar Haveli	26.5	271.2	6779.8	0	0
Arunachal Pradesh	36.5	271.2	6779.8	44.6	1114.1
Assam	37.4	271.2	6779.8	117.2	2929.1
Manipur	36.1	271.2	6779.8	126.8	3170.5
Meghalaya	32.3	271.2	6779.8	123.2	3080.3
Nagaland	38.4	271.2	6779.8	315.6	7890.6
Tripura	34.0	271.2	6779.8	311.8	7795.5
Mizoram	36.1	271.2	6779.8	309.2	7730.2
<b>Average</b>	<b>36.6</b>	<b>430.5</b>	<b>10763.3</b>	<b>189.5</b>	<b>4736.3</b>

absence of well-developed cultivated market, the value is determined as the opportunity cost of allotting alternate acreage to it (Munshi and Parikh 1990). This is equivalent to loss in revenue from agriculture due to cultivating equivalent amount of fodder obtained from forests on agricultural land. To estimate the value of fodder, it has been assumed that the total leaf fodder production in the country is 4.9 tonnes of dry matter and the grass production is 3 tonnes per hectare (Tewari 1994). Further, the study makes the assumptions that only 2% of the leafy biomass is utilized as fodder (NCA 1976). Under these assumptions, the total fodder produced in the forests of India is 23.6 million tonnes. The amount of land required to grow fodder grazed in forests is computed as the ratio of total fodder grazed in forests and the average yield of fodder on agricultural lands. The report on the Committee on Livestock Feeds and Fodder, NCA (1976) estimated fodder yields as 50 tonnes/ha of irrigated land and 25 tonnes/ha of unirrigated land. The ratio of irrigated to unirrigated area in different states is used to obtain the average yield of fodder on agricultural lands. The opportunity cost of land in different states is derived as the ratio of the agricultural GDP to the gross sown area ratio in

**Table 9**

Forest dependent population in different states (proportion out of 1000)

Zone	Timber	Fuel-wood	Fodder	Other leaves	Thatching materials	Fruits	Bamboo/cane/reeds	Tendu leaves	Medicinal plants	Edible oil seeds	Honey	Other edible products	Lac	Non-edible oil seeds	Gums and resins	Fibres and flosses	Tans and dyes	Bee-wax	Animals and birds	Katha
Western Himalayas	338	880	741	704	191	45	32	14	42	2	40	31	8	2	18	0	2	4	20	2
Eastern Himalayas and Brahmaputra Valley	294	704	346	360	391	323	483	70	233	35	295	85	47	2	54	41	22	163	298	18
Lower Gangetic Plains	157	571	163	371	97	32	64	102	87	14	145	40	0	2	21	0	0	51	78	0
Middle Gangetic Plains	114	524	374	397	349	149	217	107	63	44	116	55	44	11	47	32	52	68	127	46
Trans Gangetic Plains	21	305	131	71	124	55	40	14	30	0	39	14	0	2	2	0	0	16	39	0
Upper Gangetic Plains	0	402	221	146	135	103	23	0	44	0	34	63	0	2	2	0	0	34	34	0
Central Plateau and Hills	366	879	312	598	376	501	332	408	221	275	178	246	88	93	86	101	34	66	256	6
Eastern Plateau and Hills	156	756	342	349	402	293	163	392	99	77	202	69	43	23	62	32	45	111	103	33
Western Plateau and Hills	100	492	346	189	207	155	116	132	18	20	118	36	17	10	59	10	0	6	61	6
Southern Plateau and Hills	151	643	322	315	302	202	166	98	90	25	225	40	31	17	76	65	25	104	173	16
East Coast Plains and Hills	174	573	283	314	225	222	292	68	85	30	202	38	7	9	63	22	0	112	222	0
Western Coast Plains and Hills	201	687	461	350	266	332	267	115	252	24	247	95	21	15	82	30	0	173	167	0
Gujarat Coast Plains and Hills	75	503	356	313	169	201	96	97	66	41	127	56	46	2	89	0	28	34	46	0
Western Dry Region	0	140	47	0	85	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0
All Islands	595	936	234	757	861	351	842	88	407	0	440	185	158	2	92	0	0	230	401	0
All India	192	656	342	372	286	246	203	179	112	73	167	83	36	25	60	38	21	77	146	12

Source NSSO (1999)

each. The value of the fodder obtained from the forests varies from Rs 18.5/ha to Rs 571.3/ha with an all-India average of Rs 183.5/ha. The present value of fodder derived from forest land is Rs 4588.2/ha (discount rate of 4%).

### **Valuing net timber accumulation**

The net timber accumulation can be obtained from the present value method or the net price method or the user cost method. A brief description of different methods is given below.

#### **Present value method**

The present value  $V_0$  of natural resources is the sum of the expected net revenue flows  $N_t Q_t$ , discounted at nominal or real interest rates  $r$  for the life  $T$  of the asset:

$$V_0 = \sum_{t=0}^T N_t Q_t / (1 + r)^t$$

where  $N_t$  is defined as the total unit value of the resource less the costs of extraction, development, exploration and  $Q_t$  is the quantity exploited during the period  $t$ .

#### **Net price method**

The value of the resource at the beginning of the period  $t$ ,  $V_t$  is the volume of the resource  $R_t$  multiplied with the difference between the average market value per unit of the resource  $P_t$  and the per-unit (marginal cost of extraction, development and exploration, including a normal return to the capital  $C_t$ ).

$$V_t = (P_t - C_t) R_t$$

#### **User cost method**

The user cost, i.e. the discounted net revenue from the sale of the resource, is:

$$R - X = R / (1 + r)^{n+1}$$

where  $R$  is the annual net revenue from the sale of the resource, assumed to be constant over its lifetime (of  $n$  years),  $X$  'true income' element calculated so that  $R - X$  represents a capital element whose accumulated investment at an interest rate  $r$  during the  $n$  years would create a permanent stream of income of  $X$ .

In this paper, we obtained the value accounts for timber, fuelwood, and carbon using the net price method. Various volume entries in the physical accounts are multiplied with the net price of (timber and fuelwood) to obtain the value accounts for timber and fuelwood. As forests yield NTFPs (in addition to timber), value accounts of NTFPs are derived by multiplying the area accounts with the discounted value per hectare of

the products (Haripriya 2001). Once the value of the opening stocks and closing stocks are determined by net price method, net accumulation can be calculated by subtracting the value of the opening stock from the value of closing stock.

If timber and fuelwood are the only products obtained from forests then the asset value of timber production forest equals the discounted sum of total net rent of timber and fuelwood. As the forests are also a source of NTFPs, the asset value should also include the discounted value per hectare of these products. This implies that the asset value depends on the discount rate, age of the forest, etc. The economic accounts of NTFPs (Table 12) are derived by multiplying the area accounts with the present value per hectare of the products. The opening value of the asset is computed by multiplying the opening area with the present value per hectare of NTFPs, as the values are generated throughout the life of the asset. When forests are logged for timber and fuelwood, the NTFPs generated from the forests are lost forever. Hence, the area subjected to logging is multiplied by the value of the NTFPs lost. The area gained due to afforestation and regeneration is multiplied with the total revenue generated per hectare by NTFPs in that particular year (as timber and fuelwood are already accounted for in the economic accounts of timber).<sup>13</sup> As the fires considered in the study affect only the young plants, shrubs, and herbs (which do not have much NTFP value but have option value), the loss in NTFP value due to forest fires is taken as zero.<sup>14</sup> The area subjected to grazing is valued at the market price of allotting alternate acreage to it and there will be no change in the value of forest assets. From Table 12, it can be seen that due to logging of forests for timber and fuelwood and transfer to non-forest purposes there is a loss in value of the NTFPs obtained from forests.

Unlike timber, NTFPs continue to give the benefits throughout the life of the forest and hence, the loss in revenue due to conversion of forest land is equal to the discounted future marginal rent that is foregone due to transfer for non-forest purposes. This is also true for fodder. Assuming that the above products are provided at a constant annual value per hectare, regardless of the forest's age, then the loss in value of NTFPs due to deforestation is given by the annuity value. In other words,

Loss in value due to transfer to non-forest purposes = Area deforested × annual per-hectare value of NTFPs/ $r$ , where  $r$  is the social discount rate.

The closing value of the asset is the opening value + revaluation + net gain or loss in value of assets due to various changes.

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<sup>13</sup> In this study, no distinction has been made between young regenerating forests and the mature forests and the study assumes that the young species also contribute the same annual value as that of the mature forest due to lack of information on the relation between the value of the NTFPs and the age of the forest.

<sup>14</sup> In fact, there is a loss of potential pharmaceutical benefits from the forests, which need to be valued, using the option value approach. However, this value is out of scope of this monograph.

**Table 10**

**Monetary accounts for timber and fuelwood for different states (million rupees)**

State/ Union Territory	Opening stock	Changes due to		Logging/ harvest plus illegal logging	Logging damage	Afforesta- tion 1996/97	Other volume changes	Forest fires 1996/97	Stand mortality	Animal grazing	Shifting cultiva- tion (1997)	Other accumu- lations	Natural growth	Regene- ration	Transfer of land to other activities	Net volume change	Closing stock
		economic activity	plus illegal logging														
Andhra Pradesh	588368.2	-19299.7	4047.8	404.8	166.2	31980.0	0.2	41.5	13.2	31925.1	11413.7	13814.2	5.2	2405.7	-8052.3	580315.9	
Bihar	586751.5	-48013	4640.9	464.1	22.6	1294.7	0	133.9	1.3	1159.5	9286.4	9967.2	0.8	681.7	-38749.2	548002.2	
Goa	15875.7	-5.4	1.5	0.1	0.8	5.5	0	5.5	0	0	512.1	551.2	0.3	39.3	506.0	16381.6	
Gujarat	168536.8	-19839.3	8010.1	801.0	82.8	35.0	0.5	28.0	6.5	0	803.3	3300.1	0.2	2497.0	-19118.7	149418.1	
Haryana	18903.3	-2873.4	249.7	25.0	5.5	2.0	0	1.6	0.4	0	48.8	171.6	0.4	123.2	-2830.1	16073.2	
Himachal Pradesh	520980.7	-7168.0	2066.1	206.6	30.2	63.5	0.1	61.4	2.0	0	2992.3	5247.5	2.0	2257.1	-4205.9	516774.8	
Jammu and Kashmir	2688821.2	-3476.8	2432.0	243.2	122.9	173.0	0	163.4	9.5	0	36973.0	38718.8	1.1	1746.9	33373.3	2722194.5	
Uttar Pradesh	421472.1	-4154.26	6394.3	639.4	75.2	114.5	0.2	108.9	5.4	0	6338.3	11001.9	44.2	4707.8	2108.8	423580.9	
Karnataka	704453.0	-0.55811	6395.8	639.6	36.9	73.6	0.3	69.3	4.0	0	12171.0	21101.6	40.3	8971.0	12133.5	716586.5	
Kerala	569137.8	-7126.3	7709.1	770.9	3.4	18.8	0	18.1	0.7	0	-3690.7	8050.8	12.5	11754.0	-10820.4	558317.4	
Madhya Pradesh	1495736.7	-219.239	7726.1	772.6	79.4	298.8	0	280.2	18.6	0	8118.9	39276.3	65.0	31222.4	7820.2	1503556.9	
Maharashtra	397020.7	-1829.23	10354.3	1035.4	91.4	104.3	1.2	93.8	9.3	0	6712.5	9923.9	11.4	3222.7	4791.9	401812.6	
Orissa	389100.3	-2065.9	3689.9	369.0	3.7	88.4	0.2	86.6	1.6	0	5866.2	7540.8	15.2	1689.8	3796.5	392896.8	
Punjab	2256.5	-5679.7	174.3	17.4	1.2	0.3	0	0.2	0.1	0	28.4	300.0	1.5	3.1	-5652.6	-3396.1	
Rajasthan	19050.8	-5719.3	834.7	83.5	11.3	1.8	0	1.1	0.7	0	187.7	258.1	0.2	70.6	-5542.9	13507.9	
Sikkim	17625.0	-6934.8	13.2	1.3	5.3	1.3	0	1.3	0.1	0	492.9	527.3	1.2	35.6	-6447.2	11177.8	
Tamil Nadu	69414.6	-6874.0	4481.2	448.1	6.6	6.0	0	2.7	3.3	0	1119.6	1249.8	36.0	166.2	-5761.0	63653.6	
West Bengal	55620.4	-9227.4	6631.0	663.1	3.6	5.4	0	4.7	0.6	0	352.9	814.9	2.2	464.2	-8878.1	46742.2	
Andaman and Nicobar Islands	19309.3	-3317.2	37.3	3.7	0.1	65.0	0	65.0	0	0	3751.1	4411.6	1.3	661.8	433.8	19743.1	
Dadra and Nagar Haveli	1556.9	-155.7	0	0	0.2	5.8	0	0.6	0	5.1	47.2	65.0	0	17.8	-108.6	1448.3	
Arunachal Pradesh	1413063.6	-739.9	430.3	43.0	14.2	9295.2	0	139.6	0.3	9155.4	46752.5	47049.9	6.4	303.7	45998.5	1459062.1	
Assam	385037.7	-6.56788	3408.9	340.9	8.8	2657.4	0	25.4	0.4	2631.6	7667.2	7912.9	5.2	250.9	7651.9	392689.6	
Manipur	210902.5	-4026.5	513.0	51.3	131.1	5985.7	0	11.9	4.4	5969.3	2779.3	2797.5	1.6	19.7	-1378.3	209524.3	
Meghalaya	225988.5	-5964.2	293.3	29.3	1.1	3556.1	0	12.1	0.1	3544.0	2728.3	2741.9	1.3	15.0	-3237.1	222751.4	
Nagaland	698283.8	-33.5	552.6	55.3	27.7	27028.7	0	24.5	4.7	26999.5	10809.1	10778.2	30.9	0	10747.9	709031.8	
Tripura	24582.8	0.2	1144.5	114.4	2.2	2011.6	0	1.6	0.2	2009.7	366.5	371.5	1.3	6.3	364.5	24947.2	
Mizoram	262212.7	-373.1	155.5	15.5	22.8	8340.0	0	11.2	2.5	8326.3	4301.0	4292.2	15.1	6.3	3905.1	266117.8	
<b>Total</b>	<b>11970063.0</b>	<b>-165122.9</b>	<b>82387.4</b>	<b>8238.7</b>	<b>957.3</b>	<b>93212.4</b>	<b>2.7</b>	<b>1394.0</b>	<b>89.9</b>	<b>91725.5</b>	<b>178929.5</b>	<b>251966.6</b>	<b>302.8</b>	<b>73339.6</b>	<b>12849.5</b>	<b>11982912.0</b>	

**Table 11**

**Monetary accounts of carbon for different states in India (million rupees)**

State/ Union Territory	Opening stock	Changes due to		Logging harvest plus illegal logging	Afforestation	other		Forest fires	Stand mortality	Animal grazing	Shifting cultivation	Other accumula- tions	Natural growth	Re- generation	Transfer of land to other activities	Net volume change	Closing stock
		economic activity	economic activity			volume changes	volume changes										
Andhra Pradesh	150508.5	-4439.1	4481.6	42.5	6554.6	0.0213	10.6	0	6543.9	3505.6	3533.8	1.3	29.5	-7488.0	137787.4		
Bihar	87299.4	-6428.9	6432.2	3.4	158.2	0.0038	19.9	0	138.2	1483.9	1483.0	2.9	2.0	-5103.1	81884.8		
Goa	9616.2	-2.9	3.4	0.5	3.3	0.0000	3.3	0	0	333.7	333.9	0.2	0.3	327.5	9030.5		
Gujarat	45320.0	-4799.1	4821.4	22.3	7.7	0.1388	7.5	0	0	882.8	887.4	24.7	29.3	-3924.0	38188.9		
Haryana	6023.8	-823.9	825.7	1.8	0.5	0.0008	0.5	0	0	55.9	54.7	1.4	0.2	-768.5	5210.3		
Himachal Pradesh	48708.2	-602.9	605.7	2.8	5.8	0.0142	5.7	0	0	453.4	490.6	3.8	41.0	-155.2	48449.6		
Jammu and Kashmir	104226.0	-458.5	463.2	4.8	6.3	0.0013	6.3	0	0	1472.4	1500.8	7.3	35.8	1007.6	104301.8		
Uttar Pradesh	116847.2	-4243.6	4264.5	20.8	30.2	0.0324	30.2	0	0	3001.1	3050.1	20.4	69.4	-1272.7	113035.4		
Karnataka	127208.7	-4703.0	4709.6	6.7	12.6	0.0763	12.5	0	0	3777.2	3810.5	26.9	60.2	-938.3	118955.8		
Kerala	53937.1	-2376.2	2376.5	0.3	1.7	0.0005	1.7	0	0	634.2	763.0	1.2	129.9	-1743.7	50370.3		
Madhya Pradesh	425982.9	-8425.8	8448.4	22.6	79.8	0.0021	79.8	0	0	10978.2	11185.8	20.9	228.5	2472.6	428363.5		
Maharashtra	143663.4	-8199.3	8232.4	33.1	34.2	0.2214	33.9	0	0	3558.4	3591.0	5.9	38.5	-4675.1	135648.1		
Orissa	153171.1	-3684.9	3686.4	1.5	34.1	0.0147	34.1	0	0	2947.2	2968.5	0.9	22.2	-771.8	151132.2		
Punjab	4642.3	-545.6	548.2	2.6	0.3	0.0032	0.3	0	0	64.8	61.7	3.0	0	-481.2	4024.3		
Rajasthan	50340.5	-3144.8	3174.6	29.9	3.0	0.0009	3.0	0	0	682.1	682.0	0.5	0.5	-2465.7	47557.0		
Sikkim	11264.9	-25.0	28.4	3.4	0.8	0.0004	0.8	0	0	335.7	337.0	0.8	2.1	309.9	11497.6		
Tamil Nadu	74874.3	-9162.5	9169.5	7.1	2.9	0.0021	2.9	0	0	1383.6	1348.1	38.8	3.3	-7781.8	66204.8		
West Bengal	33459.3	-10392.7	10394.9	2.2	2.9	0.0001	2.9	0	0	488.2	490.2	1.3	3.4	-9907.4	23458.4		
Andaman and Nicobar Islands	36848.1	-65.3	65.6	0.2	124.0	0.0000	124.0	0	0	8419.3	8418.8	2.3	1.7	8229.9	43777.5		
Dadra and Nagar Haveli	521.5	0.1	0	0.1	1.6	0.0005	0.2	0	1.4	21.7	21.8	0.1	0.1	20.2	510.3		
Arunachal Pradesh	223336.9	-117.8	120.0	2.2	1181.6	0.0000	22.1	0	1159.5	7434.2	7436.3	1.0	3.1	6134.8	226388.2		
Assam	93313.1	-2139.0	2141.2	2.1	517.2	0.0007	6.2	0	511.0	1909.1	1917.7	1.3	9.9	-747.2	79943.3		
Manipur	54929.7	-320.1	354.2	34.1	1248.9	0.0011	3.1	0	1245.8	728.5	728.6	0.4	0.5	-840.5	52887.3		
Meghalaya	45343.4	-188.0	188.2	0.2	572.2	0.0001	2.4	0	569.8	549.8	550.1	0.3	0.6	-210.4	44843.8		
Nagaland	46136.2	-248.6	250.4	1.8	1431.0	0.0008	1.6	0	1429.4	714.2	712.1	2.0	0	-965.5	44071.2		
Tripura	21616.3	-1020.8	1022.7	2.0	1417.5	0.0006	1.4	0	1416.0	326.7	326.7	0.1	0.1	-2111.5	18848.8		
Mizoram	56872.4	-251.5	256.5	4.9	1449.5	0.0017	2.4	0	1447.1	932.9	931.0	2.0	0	-768.2	55744.4		
<b>Total</b>	<b>2226012.0</b>	<b>-76809.6</b>	<b>77065.4</b>	<b>255.8</b>	<b>14882.4</b>	<b>0.53988</b>	<b>419.6</b>	<b>0</b>	<b>14462.2</b>	<b>57074.7</b>	<b>57615.1</b>	<b>171.8</b>	<b>712.1699</b>	<b>-34617.26</b>	<b>2142115.5</b>		



**Table 12**

Monetary account of NTFPs (non-timber forest products) for different states in India (million rupees)

State	Value of opening stock	Net loss of NTFPs due to logging and timber and fuelwood	Value of non-marketed benefits gained due to afforestation and regeneration	Value of NTFPs lost due to shifting cultivation	Loss of NTFPs due to transfer of forests for non-forest purposes	Net loss
Andhra Pradesh	21607.3	1130.1	1248.6	2385.6	245.5	-2512.6
Bihar	23024.3	3447.4	271.7	62.7	50.4	-3288.9
Goa	257.2	0	9.0	0	0.8	8.2
Gujarat	3731.2	730.3	874.9	0	180.7	-36.1
Haryana	2195.4	388.4	741.6	0	20.9	332.3
Himachal Pradesh	10859.0	112.5	1377.4	0	59.7	1205.2
Jammu and Kashmir	6927.1	57.2	396.8	0	19.2	320.5
Uttar Pradesh	56847.2	1842.4	2717.0	0	577.1	297.4
Karnataka	29858.2	1038.7	1843.5	0	442.4	362.4
Kerala	36156.4	2203.4	166.9	0	1147.2	-3183.7
Madhya Pradesh	40916.1	1141.1	1273.3	0	2085.0	-1952.9
Maharashtra	48418.1	3886.2	1709.3	0	688.8	-2865.7
Orissa	18964.3	793.5	73.9	0	216.9	-936.4
Punjab	3640.6	753.4	507.9	0	8.8	-254.3
Rajasthan	10099.9	2485.6	1548.8	0	149.7	-1086.5
Sikkim	1621.0	3.9	69.1	0	3.1	62.2
Tamil Nadu	7437.7	1600.2	1364.3	0	61.6	-297.6
West Bengal	14395.6	8378.5	1629.8	0	330.1	-7078.8
Andaman and Nicobar Islands	4469.9	0.8	17.2	0	18.4	-2.0
Dadra and Nagar Haveli	102.4	0	4.2	0.2	1.0	3.0
Arunachal Pradesh	36564.5	16.4	52.2	181.6	6.9	-152.6
Assam	10732.3	402.9	110.0	126.2	14.7	-433.9
Manipur	3871.2	127.3	1398.1	358.2	2.4	910.1
Meghalaya	3851.6	83.6	16.9	177.5	1.7	-245.9
Nagaland	3656.3	75.9	115.2	572.1	0	-532.9
Tripura	2347.8	267.1	55.5	728.8	2.8	-943.2
Mizoram	6058.4	77.8	166.1	551.4	0.8	-463.8
<b>Total</b>	<b>408611.3</b>	<b>31044.8</b>	<b>19759.2</b>	<b>5144.2</b>	<b>6336.8</b>	<b>-22766.6</b>

To build value accounts for carbon, valuation of carbon sink services is required. The value of carbon depends on the time frame and the kind of project. Three kinds of carbon projects are considered in the literature: carbon storage, carbon parking, and carbon sequestration. Carbon storage and carbon parking relate to the forest capacity to maintain a certain amount of biomass per hectare, which means that carbon in it is not released into the atmosphere. They only differ in the length of the commitment period. In the case of carbon storage, pricing refers to a one-time payment for forest conservation. The value of the carbon service lies in avoiding potential future CO<sub>2</sub> emissions forever. In the case of carbon parking, pricing refers to avoiding the emissions for a particular time frame in return for an economic compensation. Carbon sequestration refers to the removal of CO<sub>2</sub> currently in the atmosphere, i.e. the mitigation of past emissions. There are two approaches, marginal social damage

or abatement costs, which can be used to value the carbon sink services. Marginal social damage costs refer to the economic value of the damage caused by the emission of an additional metric tonne of carbon to the atmosphere. Abatement costs refer to 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 (clean development mechanism), the abatement costs are the production costs of growing/conserving the forests to capture or avoid CO<sub>2</sub> emissions.

In this paper, as we have considered the carbon sequestration services of forests, we have valued carbon using marginal social damage approach. Frankhauser (1994) and Tol (1999) discuss the wide range of marginal social damage costs estimated by various authors, which average approximately US \$20/tC. Given that the Frankhauser (1994) give a range of carbon values between \$6/tC and \$45/tC with a best guess of \$20/tC; while developing the monetary accounts, we used an estimate of \$20/tC for valuing carbon releases (Atkinson and Gundimeda 2004).

Tables 10, 11, and 12 give the monetary accounts for timber and fuelwood, carbon, and NTFPs respectively, for the year 2000. From the tables, it can be seen that the overall decrease in the value of total stock of timber, carbon, and NTFPs at the end of the accounting period are significant.

## **6** Integration with the SNA

In the final step, we integrated the estimates with the national accounts. In the conventional national accounts only the depletion of the man-made assets is considered to get the NSDP. As we discussed earlier, when forests are subject to some disturbance in the form of logging or conversion to non-forest purposes, potential values of the forests are lost and need to be accounted for (rather than merely accounting for the exploitation costs and recording the changes in forest area and other changes in volume which do not have any effect on GDP). Instead of considering only the NSDP (obtained after considering the depreciation of man-made assets), the ESDP needs to be considered for policy which takes care of the depletion of forests due to various economic activities. This is done in two stages. At first, the state domestic product is adjusted by netting out the value recorded in the CSO accounts and adding the value added estimates obtained in our study (to account for differences in values and also to avoid double counting). This gives the ANSDP (adjusted net state domestic products). In the second stage, we adjusted the revised NSDP by netting out the depletion of forests due to various disturbances. Depletions of carbon are applied to protected areas only, whereas depletions of timber are applied to the remaining forested areas, so that there is no double-counting of timber and carbon depletion. Table 13 gives the estimates of GSDP, NSDP, and ESDP.

**Table 13**

**GSDP, NSDP, and ESDP for different states in India (million rupees) for 2002/03**

State/Union Territory	GSDP	NSDP	Forestry and Logging	Adjusted NSDP	Depletion of timber and fuelwood	Depletion of carbon	Depletion of NTFPs	Total depletion	ESDP	ESDP/NSDP	Depletion of timber as % of NDP	Depletion of carbon as % of NDP	Depletion of NTFPs as % of NDP	Total depletion as % of NDP
Andhra Pradesh	1607683.90	1439753.90	16992.80	1453730.86	-8052.30	-7487.98	-2512.63	-8094.07	1445636.80	0.99	0.55	0.52	0.17	0.56
Bihar	897150.20	787033.60	23133.80	803573.95	-38730.49	-5103.13	-3288.86	-37809.55	765764.40	0.95	4.82	0.64	0.41	4.71
Goa <sup>1</sup>	7711.20	67356.90	136.80	70863.76	506.03	327.53	8.22	327.53	71191.30	1.00	-0.71	-0.46	-0.01	-0.46
Gujarat	1382850.30	1144047.60	5307.50	1271916.72	-19026.96	-3924.00	-36.14	-4343.23	1267573.48	1.00	1.50	0.31	0.00	0.34
Haryana	658372.20	579374.90	1386.60	599546.21	-2826.12	-768.50	332.27	-2187.86	597358.35	1.00	0.47	0.13	-0.06	0.36
Himachal Pradesh	159460.00	142024.30	7198.80	141338.51	-4166.81	-155.19	1205.20	-2809.31	138529.19	0.98	2.95	0.11	-0.85	1.99
Jammu and Kashmir <sup>2</sup>	147495.90	128052.00	4653.90	133391.52	33560.89	1007.57	320.47	1007.57	134399.09	1.01	-25.16	-0.76	-0.24	-0.76
Uttar Pradesh	1796014.70	1568624.70	21802.20	1628485.29	2138.29	-1272.74	297.42	-606.74	1627878.56	1.00	-0.13	0.08	-0.02	0.04
Karnataka	1139292.20	1004063.10	19120.90	1029435.50	12242.27	-938.32	362.36	698.00	1030133.50	1.00	-1.19	0.09	-0.04	-0.07
Kerala <sup>1</sup>	761819.80	696021.20	13849.40	689093.27	-10820.43	-1743.70	-3183.68	-1943.65	687149.62	1.00	1.57	0.25	0.46	0.28
Madhya Pradesh	1132756.60	974607.60	28846.70	1019420.99	7828.52	2472.62	-1952.87	3756.57	1023177.57	1.00	-0.77	-0.24	0.19	-0.37
Maharashtra	2951911.80	2632252.50	32471.10	2672291.73	4796.88	-4675.11	-2865.70	-3732.03	2668559.71	1.00	-0.18	0.17	0.11	0.14
Orissa	446844.50	387373.00	11326.90	402749.10	3783.55	-771.84	-936.40	570.51	403319.61	1.00	-0.94	0.19	0.23	-0.14
Punjab <sup>1</sup>	707508.70	629677.50	2183.70	642935.52	-5652.58	-481.23	-254.29	-5700.36	637235.17	0.99	0.88	0.07	0.04	0.89
Rajasthan <sup>1</sup>	873717.50	768878.00	11560.00	788085.83	-5542.89	-2465.67	-1086.50	-4956.45	783129.38	0.99	0.70	0.31	0.14	0.63
Sikkim	11527.30	10386.50	190.40	10407.54	-6447.23	309.86	62.16	-27.19	10380.35	1.00	61.95	-2.98	-0.60	0.26
Tamil Nadu	1537287.10	1367808.70	7177.20	1398966.56	-5760.97	-7781.77	-297.56	-7602.77	1391363.79	0.99	0.41	0.56	0.02	0.54
West Bengal	1671370.80	1537807.20	10498.20	1515621.63	-8878.11	-9907.43	-7078.81	-12015.19	1503606.44	0.99	0.59	0.65	0.47	0.79
Andaman and Nicobar Islands	11563.90	10407.51	64.60	10673.13	433.68	8229.93	-2.01	3616.88	14290.01	1.34	-4.06	-77.11	0.02	-33.89
Arunachal Pradesh <sup>1</sup>	19450.50	17395.10	806.00	19092.20	45998.50	6134.84	-152.64	6134.84	25227.04	1.32	-240.93	-32.13	0.80	-32.13
Assam	354314.20	317208.00	5476.60	321714.02	7651.87	-747.18	-433.89	-747.18	320966.84	1.00	-2.38	0.23	0.13	0.23
Manipur	35312.60	32047.80	628.30	32473.47	-1378.26	-840.49	910.15	-565.00	31908.47	0.98	4.24	2.59	-2.80	1.74
Meghalaya	43429.20	38422.70	376.50	39927.60	-3237.09	-210.39	-245.92	-245.32	39682.28	0.99	8.11	0.53	0.62	0.61
Nagaland <sup>2</sup>	36793.60	34272.00	1067.50	33308.47	10747.93	-965.48	-532.90	5994.94	39303.41	1.18	-32.27	2.90	1.60	-18.00
Tripura <sup>1</sup>	60616.90	56603.40	762.10	55594.42	363.24	-2111.55	-943.19	-1921.26	53673.16	0.97	-0.65	3.80	1.70	3.46
Mizoram <sup>3</sup>	17687.20	16346.10	167.20	16519.06	3899.09	-768.17	-463.83	634.15	17153.21	1.04	-23.60	4.65	2.81	-3.84
<b>Total</b>	<b>18539942.80</b>	<b>16387845.81</b>	<b>227195.70</b>	<b>16801156.88</b>	<b>13322.05</b>	<b>-34617.26</b>	<b>-22766.57</b>	<b>-72549.05</b>	<b>16728607.83</b>	<b>1.00</b>	<b>-0.08</b>	<b>0.21</b>	<b>0.14</b>	<b>0.43</b>

Note <sup>1</sup> indicates data on 2001/02; <sup>2</sup> indicates data on 2000/01; <sup>3</sup> indicates data on 1999/2000. (Negative depletion means appreciation in value).

GSDP - gross state domestic product; NSDP - net state domestic product; ESDP - environmental adjusted state domestic product; NTFPs - non-timber forest products; NDP - net domestic product

It is seen from the table that, even with adjustments only addressing the limited set of assets, which are within the scope of this monograph, for some states ESDP is higher than NSDP while for the other states it is lower. The gap between NSDP and ESDP indicates the extent of environmental degradation caused due to economic activity. If the ratio of ESDP to NSDP is  $\geq 1$ , the economy is doing well in terms of environment but if it is lower, the growth has come at the expense of environmental degradation for these states. For some states, although logging and other disturbances which damage the growing stock of forests are significant, the reason why their ratio of ESDP/NSDP is still above 1 is that in these states the regeneration of forests or mean annual increment in forests is very high whereas in other states it is low. The existing system of national accounts does not take into account the changes in value due to additions and reductions in forest stock, which our study does.

## **7** Conclusions

Accounting for forest wealth is an important ingredient in creating a framework for analysing policy trade-offs. The accounts that we have presented for India's forests have described forestry-related stocks and flows in terms of land area (under forest), physical volume (of timber and carbon) and, finally, monetary values. In this way, we have tried to estimate the 'true' value of economic activity in individual states.

We recognize that the results should be viewed with caution due to limitations placed by available data. For instance, we have pointed out how the data on forest fires, grazing, disease, and other causes indicate only the area in hectares affected by these losses. As a result, the volume lost is derived by using suitable conversion factors. Similarly, the available estimates for different states are not always for the same time period, indeed in some cases we do not have any information. In all such cases, we have had to make do with approximations and assumptions. Therefore, the conclusions are tentative and any policy implications based on this study must be drawn carefully. The data used here will be revised as and when we get more up-to-date information, such as is expected with the publication of FSI's 2003 report on the state of India's forests, and when we obtain further state-level analysis of official statistics.

Nevertheless, the study has demonstrated that forest resource accounting is feasible in India at a disaggregate level using a 'top-down' approach. Furthermore, the study provides an interesting view of how different regions are doing when their performance is measured on a sustainability yardstick. For instance, the study clearly shows that the country's North-East is a far more important part of the national economy than is apparent from conventional accounting. Our study also identifies certain large states that perform very poorly when confronted by a sustainability framework. Note that we were able to derive these distinctions even though our estimates only give a lower bound (due to undervaluation of NTFPs, timber, and fuelwood). In fact, forests have several other

externalities (such as biodiversity values, opportunities for eco-tourism, impact on water resources, flood prevention, and drought control services) that we have ignored as they are outside the scope of this monograph. In our view, the differences across states could become even sharper when we are able to add estimates of these other facets, which are the subject of subsequent monographs of the GAISP project. Our study has also confirmed the conclusions of other earlier works that the economic value added by forestry is in fact much higher than is reflected in official GDP and SDP accounts.

In order for policy-makers to make good judgments regarding various trade-offs, it is essential that we recognize and bridge the gap between ESDP and NSDP. We are attempting here to build an empirical basis on which to base policy decisions on the trade-offs between the many competing priorities of a developing nation. A proper accounting framework should better reflect the state of the country's natural and human wealth. This monograph is intended as a step towards creating such a framework.

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## Green Accounting for India's States and Union Territories Project

In common with most developing nations, India faces many trade-offs in its attempt to improve the living standards of its people. The trade-offs emerge in various arenas, and several mechanisms for decision-making (including political institutions) have been developed to help choose between competing alternatives. Unfortunately, most of these decision mechanisms do not take into account intergenerational choices, i.e. trade-offs between the needs of the present and the future generations. In our view, it is urgently necessary to develop a mechanism to do this because many of the choices we make today could severely affect the welfare of our children tomorrow.

Therefore, we propose to build a framework of national accounts that presents genuine net additions to national wealth. This system of environmentally-adjusted national income accounts will not only account for the depletion of natural resources and the costs of pollution but also reward additions to the stock of human capital.

The Green Accounting for Indian States and Union Territories Project (GAISP) aims to set up economic models for preparing annual estimates of 'genuine savings', i.e. true 'value addition', at both state and national levels. The publication of the results will enable policy-makers and the public to engage in a debate on the sustainability of growth as well as make cross-state comparisons. It is hoped that a policy consequence of the project is gradual increases in budgetary allocations for improvements in education, public health, and environmental conservation, all of which are key elements needed to secure India's long-term future.

### Monograph 1

This study is a part of an effort to build an empirically based framework that would allow policy judgements regarding the accumulation or depletion of natural and human capital. In this monograph, we have demonstrated that forest resource accounting is feasible in India at a disaggregate level using a 'top-down' approach. The results give an interesting view of how different regions are doing when their performance is measured by the sustainability yardstick. For instance, the study clearly shows that the country's north-eastern region is a far more important part of the national economy than is apparent from conventional national accounting. We recognize that the results should be treated with caution at this stage because of problems with available data. Nonetheless, we believe that the study is a definite step forward and we hope to be able to refine and widen the scope of this approach during the course of this project.

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