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Full Length Research Paper

A study of the characteristics of tree biomass resource in tribal village ecosystem of Bolangir District, Orissa, India

Sarada P. Mohapatra[1]* and Hara P. Sahoo[2]

[1]Botany Department, Samanta Chandra Sekhar (S.C.S) College, Puri, India.
[2]Botany Department, Ravenshaw University, Cuttack, India.

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The status of tree biomass resource was investigated in 3 tribal villages (Chikalbahal, kudasingha and Bhutiyarbahal) of Bolangir District of western Orissa. There were 57 tree species with 12 tree capita^{-1} and 35 trees ha^{-1}. Multiple benefits yielding local tree species dominated the village ecosystem, while fuel only or single end use trees accounted for a small proportion of trees. The standing tree biomass was adequate to meet the requirements of the biomass fuel for cooking only for five years. Village tree biomass is presently being depleted largely for export to urban areas. So, it is high time to conserved the village tree diversity by proposing some programmes which will reduce the urban pressure and demand for tree biomass.

Key words: Village tree diversity, standing biomass, tree depletion, fuel wood, local name, India, biomass equation.

INTRODUCTION

In India, there is adequate awareness regarding the status of forest, its importance to the communities and the environment, the extent of deforestation and its impli-cation. The degree of dependence of rural communities on forest for their biomass needs varies depending on the degree and proximity of the forest. In the Bolangir District, less than 25% of the area is under forests which are basically scrub and dry deciduous which is reported botanically under explored (Panigrahi, 2002). Thus, the rural communities in such district are not likely to depend on the forest to meet their biomass needs. They depend on village trees for their various biomass needs like fuel, fodder, timber, leaf manure, oil seeds, edible fruits and the specific need of artisan.

In spite of the crucial role played by trees in village ecosystem, very few studies have been carried out on the traditional tree growing system, the status of village tree resources and the nature and dynamics of the tree depletion process which is an essential preparatory step, if effective action to counter it is to be taken. This study aimed at understanding the different aspects of tree biomass resource and its depletion in tribal village ecosystem as follows: investigate the distribution of trees according to species, location, ownership and end use, estimate the standing tree biomass of the village ecosystem and monitor the nature and extent of tree biomass resource depletion, its destination and end use.

*Corresponding author. E-mail: babuni0808@yahoo.co.in.

MATERIALS AND METHODS

Location of the study area

The district of Bolangir is flanked in the North West by Gandhamardhan hills, a name of Ramayana fame, the north east by the rock infested Mahanadi. It lies between 20°11' 40" – 21° 05' 08" Northern latitude and 82° 41' 15" – 83° 40' 22" East longitude. The district is situated in the river valley of Ang and Tel. which is on the western highlands of Orissa state with an average annual rainfall of about 1230 cm (2006-2007). The soil is red sandy to red loamy in nature. Out of 6 million tribes, about 62 notified tribes are seen in Orissa (Mohapatra, 1993). The three villages (Chikalbahal, Kudasingha and Bhutiyarbahal) were dominated by tribes like Kondha, Sangara, Gond, Mahar, etc.

Table 1. Tree population of the tribal village ecosystem.

S/N	Species	Local name	Family	Total	Percentage	Standing biomass (dry t)	Percentage	Mean dry weight for tree (kg)
1.	*Eucalyptus hybrida*	Nilgiri	Myrtaceae	2666	23.6	54.4	6.3	20.4
2.	*Shorea robusta*	Sal	Dipterocarpaceae	2265	20.1	176.1	20.3	77.7
3.	*Azadirachta indica*	Neem	Meliaceae	1043	9.2	96.6	11.1	92.6
4.	*Acacia nelotica*	Babul	Mimosaceae	835	7.4	59.3	6.8	71.0
5.	*Diospyros tomentosa*	Kendu	Ebenaceae	827	7.3	69.7	8.0	84.2
6.	*Madhuca indica*	Mahul	Sapotaceae	490	4.3	55.6	6.4	113.4
7.	*Tectona grandis*	Sabun	Verbenaceae	426	3.8	75.9	8.8	178.1
8.	*Alagngium salvifolium*	Ankel	Alangiaceae	413	3.6	-	-	-
9.	*Ficus glomerata*	Dumer	Moraceae	255	2.3	90.5	10.4	354.9
10.	*Ficus benghalensis*	Bara	Moraceae	238	2.1	74.5	8.6	313.0
11.	Others*			1829	16.3	114.6	13.3	62.6
	Total			11,287	100.0	867.2	100.0	

Eucalyptus hybrid plantation 3.50 ha; * includes 47 tree species.

Method for collection of data on tree resource

A survey was conducted in 2006-2007 of all trees greater than 1.5 m in height in the ecosystem and the following information were collected; (i) species name (ii) diameter at breast height (DBH) and height (iii) end use of the tree and (iv) owner's name.

Methods for monitoring tree resource depletion

All the trees felled during the years (2006-2007) in the study area were monitored and the following information was recorded; (i) DBH and height (ii) ownership (iii) destination and end use of felled tree.

Methods for estimating the standing tree biomass and felled tree biomass

For a sample of felled trees of each species, the above ground weight of the tree (excluding leaves) was measured along with DBH and height. The stem diameter and tree height account for the greatest proportion of the variability in woody biomass volume of trees and are thus considered for developing biomass estimation equation. The equation used is as follows:

$$B = b + a D^2H$$

Where, B is the weight (in oven dry kg); D is DBH in meters; b is the biomass; H is height of the tree in meters and a is area of cultivation.

The numbers of observation varied for each species depending on the willingness of the farmers to allow the investigator to weigh the trees.

For tree species with a poor fit (coefficient of determination: $R^2 < 0.5$), trees were grouped into 5 cm DBH class intervals. The mean oven dry weight of the sample trees of each DBH class interval was used for estimating the biomass of all trees in that class in the ecosystem.

RESULTS

Tree biomass resource

Tree population and species distribution

Tree population and species distribution is given in Table 1. There were 11287 trees with 35 trees/ha and 12 trees/capita in the ecosystem which were identified by following flora of Orissa and Bihar (Haines, 1921: 25). In addition, 3.5 ha of *Eucalyptus* plants were planted by 9 farmers. Out of 57 tree species present in the ecosystem, the predominant 10 accounted for 83.7% of the total tree population. Among the 10 species, 8 were local and 2 exotic.

Distribution of trees according to DBH

This gives an idea of the size and age of the trees. It can be observed from Table 2 that a large proportion of *Eucalyptus* and *Tectona* were small (< 10 cm DBH) relative to the older local tree species (> 10 cm DBH).

The 3.5 ha of *Eucalyptus* plantation was not considered as they were young plantation with a height of less than 1.5 m height.

Table 2. Distribution of trees according to DBH (percentage of total number).

S/N	Species	DBH (in cm)				Total number of trees
		<5	5-10	10-20	>20	
1	*Eucalyptus hybrida**	24.0	48.9	25.1	2.0	2666
2	*Tectona grandis*	9.6	46.9	33.4	10.1	426
Total number of trees		(680)	(1505)	(813)	(94)	(3092)**
1	*Shorea robusta*	14.2	37.4	35.2	13.1	2265
2	*Azadirachta indica*	21.8	34.7	29.5	14.0	1043
3	*Acacia nelotica*	10.8	30.9	42.9	15.4	835
4	*Diospyros tomentosa*	7.6	21.6	38.7	32.1	827
5	*Madhuca indica*	12.0	49.8	32.7	5.5	490
6	*Alagngium salvifolium*	9.7	34.6	42.4	13.3	413
7	*Ficus glomerata*	8.6	16.1	38.4	36.9	255
8	*Ficus benghalensis*	1.6	15.3	32.3	50.8	238
9	*Pterocarpus marsupium*	15.4	29.7	39.6	15.3	202
10	*Albizzia lebbeck*	7.8	17.7	17.0	57.5	141
11	*Tamarindus indica*	7.7	21.0	24.3	47.0	119
Total no. of trees		(879)	(2222)	(2430)	(1297)	(6828)*

* Trees in plantation not included; ** figures in parenthesis are total number of trees.

Distribution of trees according to land holding group

There was a positive correlation coefficient of 0.57 between the sizes of the land owned with number of trees owned. Similarly, the correlation coefficient between land owned and number of tree species owned was 0.59.

Distribution of trees according to end uses

Table 3 shows that tree species providing fuel alone accounted for only 3.7% of total trees, the rest of the tree species were multiple benefit yielding. Twigs of all the tree species are used as fuel, fodder, timber, green manure, poles, oil seeds, edible fruit and medicine and these were some of the benefits derived by the community from the various trees. In addition to the direct benefits to the community, trees also play important ecological roles such as recycling of nutrients through leaf litter of trees on the bunds of crop land, reduction of soil erosion and provision of shelters for birds, insects, etc. (Ambasta, 1986).

Above ground standing tree biomass

For estimation of the above ground standing tree biomass, 85% of trees were considered; as for some species, the harvest data was not available. The 3.5 ha of *Eucalyptus* plantation were not considered as they were very young plantation. Biomass estimation equations are given in Table 4. Standing tree biomass estimates are given in Table 1. The standing biomass was as low as 0.91 t capita^{-1} and 2.4 t ha^{-1} of ecosystem land. Local tree species namely *Madhuca*, *Diospyros* and *Ficus* dominated the standing biomass.

The mean above ground dry weight of trees (excluding leaves) of each species was considered and it ranged from 20.4 kg tree^{-1} for *Eucalyptus* to 354.9 kg tree^{-1} for *Ficus glomerata* (Table 1). Some species like *Eucalyptus*, *Madhuca* and *Diospyros* had a lower mean percentage tree weight vise: 72.9, 51.6 and 56.5%.They were smaller trees in the DBH range of up to 5 and 10 cm (Table 2). Regular harvest of twigs and branches of tree species like *Pterocarpus*, *Acacia* and *Azadirachta* for fuel, fodder and manure purpose also led to lower weight of the standing trees.

Monitoring tree source depletion

Rate of tree resource depletion

Data on felling of trees during 2006-2007 given in Table 5 showed that about 6% of the tree populations were felled in each year. Multiple benefits yielding local species like *Madhuca*, *Ficus*, *Diospyros* and *Acacia* were felled in large numbers. The correlation coefficient between the number of trees cut and size of the land holding was 0.33 during the period of 2 years.

Destination of the trees felled and their end use

Evidently, 76.1% of the total biomass felled was exported to near by towns (Table 6). The farmers sold the trees to

Table 3. Distribution of tree population according to end uses.

S/N	End uses	Examples	Tree population (existing)	Percentage of the total
1	Fuel	*Cassia fistula*	423	3.7
2	Fodder + Fuel	*Terminalia alata* *Zizyphus mauritiana*	159	1.4
3	Fodder + Timber + Fuel	*Ficus* sp. *Albizzia lebbeck*	913	8.1
4	Fodder + Timber + Oil seeds + Fuel	*Azadirachta indica* *Madhuca indica*	878	7.8
5	Timber + Fuel	*Alangium salvifolium* *Terminalia* sp.	444	3.9
6	Pole + Timber	*Eucalyptus hybrida* *Tectona grandis*	3092	27.4
7	Green manure + Oil seeds + Fuel	*Pongamia pinnata* *Shorea robusta*	2265	20.1
8	Fruits + Timber + Fuel	*Syzygium cuminii* *Artocarpus heterophyllus*	1154	10.2
9	Implements + Fuel	*Acacia nelotica* *Diospyros tomentosa*	1317	11.7
10	Fruits + Fuel	*Moringa olifera* *Tamarindus indica*	250	2.2
11	Others		392	3.5
Total			11,287	100.0

Table 4. Biomass estimation equations ($B = b + aD^2H$) (see text for explanation).

S/N	Species	b	a	R^2	"t" value of a
1	*Eucalyptus hybrida*	9.109	162.6706	0.90	24.08
2	*Shorea robusta*	74.7128	100.3786	0.71	6.1514
3	*Acacia nelotica*	13.098	228.0895	0.72	87.4576
4	*Pterocarpus marsupium*	119.1276	101.0613	0.65	6.046
5	*Diospyros tomentosa*	44.9932	200.0566	0.88	9.86
6	*Albizzia lebbeck*	73.8972	163.7661	0.49	9.3249
7	*Azadirachta indica*	19.2224	238.5245	0.65	6.0871
8	*Tectona grandis*	152.1094	109.9462	0.72	10.00
9	*Ficus* species (4 species together)	279.8166	89.1477	0.51	4.7866
10	*Ficus benghalensis*	-2.8555	200.8617	0.52	3.75

the traders from urban centers. Inquiry from the traders revealed that the main trunk of some species would be sold as timber or poles and the rest would be sold as cooking fuel. The local use of tree biomass was primarily

Table 5. Tree felling in tribal village ecosystem.

S/N	Species	Number of trees felled			Total number of trees	Percentage of trees felled
		2006	2007	Total		
1	*Eucalyptus hybrida*	189	282	471	2666	17.7
2	*Shorea robusta*	167	135	302	2265	13.3
3	*Diospyros tomentosa*	89	75	164	827	19.8
4	*Madhuca indica*	81	33	114	490	23.2
5	*Tectona grandis*	80	42	122	426	28.6
6	*Azadirachta indica*	63	13	76	1043	7.3
7	*Ficus* species	51	22	73	657	11.1
8	*Acacia nelotica*	18	25	43	835	5.1
9	*Albizzia lebbeck*	16	27	43	141	30.5
10	*Pterocarpus marsupium*	15	12	27	202	13.4
11	Others*	62	56	118	-	-
Total		831	722	1553	-	-

Table 6. Biomass of felled trees and their end uses* (in tonnes).

S/N	Species	Locally used			Exported	Total
		Fuel	Timber	Bricks		
1	*Eucalyptus hybrida*	-	11.99	-	15.70	27.69
2	*Tectona grandis*	5.14	4.82	0.22	16.76	26.94
3	*Shorea robusta*	6.94	-	5.30	34.50	46.74
4	*Acacia nelotica*	4.87	1.58	1.59	29.66	37.70
5	*Terminalia alata*	0.50	-	-	14.23	14.73
6	*Ficus* sp.	9.88	-	5.23	59.66	74.77
7	*Diospyros tomentosa*	2.65	-	-	9.03	11.68
8	*Albizzia lebbeck*	-	1.66	-	18.71	20.37
Total		29.98	20.05	12.34	198.25	260.62
% of total		11.5	7.7	4.7	76.1	100.0

Out of 1553 trees felled, 88% were considered here.

as fuel for firing bricks in a small quantity. Felled tree biomass was used as fuel mainly for special functions like marriages and death ceremonies, while mass cooking takes place in daily usage as rare utilization of felled trees.

DISCUSSION

Large diversity of trees

There were 57 tree species along the stream banks, dominated by multiple use species like *Madhuca*, *Ficus* and *Azadirachta* which indicated that the farmers in the past had either planted these species or had resorted to selective retention. *Ficus*, *Cassia*, *Azadirachta*, *Tamarindus* and *Syzygium* species could be termed as key stone species whose role is critical to the ecosystem, since they supply crucial biomass requirements such as fuel, fodder, leaf manure, timber, oil seeds and edible fruits. Pure fuel yielding trees were not traditionally retained in the village. The dominance of multiple benefit yielding local trees contrasts the usual programmes of the state forest departments where fast growing exotic species like *Ecucalyptus* (mainly as poles) and *Acacia auriculiformis* (only as fuel) dominate. According to study in 10 states in India with social forestry programmes, 70 to 100% of the selected beneficiaries planted *Eucalyptus* (Saxsena and Brahmam, 1994, 1996).

Who is responsible for depletion of village tree resources?

This study has clearly proved that trees are not felled in rural areas for the local biomass needs. Urban pressure and demand is responsible for depletion of valuable

village tree biomass resources. The urban institution and industry had greater negative environmental impact (like deforestation) than rural dependence on fire wood as a domestic fuel. When a tree is felled for the urban market, the village community will lose a sustainable source of supply of twigs, branches and leaves which can be used as fuel, fodder and manure. So, to conserve the village tree diversity and resources, there is a need to have programmes exclusively for producing the urban needs of fuel and timber and to reduce the local demand for fuel wood by using fuel efficient stoves in urban as well as rural areas.

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