Journal of Research in Biology

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Original Research paper

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A Comparison of Fuel wood consumption and Woody biomass accumulation in the tribal village ecosystem of Bolangir (Orissa)

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ABSTRACT:

A thorough study of fuel wood consumption and woody biomass accumulation in the tribal dominated village ecosystem of Bolangir district of Orissa was made to find out a relation between the two. The three village complex such as Chikalbahal, Kudasingha and Bhutyarbahal were taken in the study area where people of Gond, Kondha and Sabar tribe inhabit and their main source of fuel wood consumption is agricultural wastes, village trees and to some extent the near by forest as it is easily approachable. This project set out to add data to the debate by comparing fuel wood consumption to woody biomass accumulation in the village ecosystem. High, mean and low fuel wood consumption rates were found to be 552, 380 and 292 kg per person per year respectively. Woody biomass accumulation was calculated at 1659.6 kg/ha/year. Under the highest consumption rate 0.33 ha of wooded land is needed to meet the fuel wood demand of one person. These figures and evidences from observing fuel wood collection undermine the notion that at least in this region fuel wood consumption is a driver of deforestation. The paper concludes by discussing forest management issues in the region and suggests areas for future research.

Keywords:
Fuel Wood, Village complex, Woody biomass, Bolangir, Deforestation.

Article Citation:
Sarada Prasad Mohapatra.
A Comparison of Fuel wood consumption and Woody biomass accumulation in the tribal village ecosystem of Bolangir (Orissa).
Journal of research in Biology (2011) 2: 62-67.

Dates:
Received: 08 May 2011 /**Accepted:** 11May 2011 /**Published:** 28 May 2011

Journal of Research in Biology

INTRODUCTION

In the later half of 20th century the narrative of dry forest to woodland conversion consistently included fuel wood collection and consumption as a root cause. The idea that local people were deforesting their lands in order to supply themselves with fuel wood gained a following over time (Mohapatra and Sahoo, 2009). Governmental and nongovernmental organizations alike have reported concerns over fuel wood-caused desertification and impending fuel wood crises. In light of the lack of consensus this study sought to elucidate the relationship between fuel wood consumption and deforestation. Specifically fuel wood consumption and forest regeneration rates were estimated with the goal of comparing the two to develop an idea of how much land would be necessary to meet fuel wood demands of inhabitants of the tribal village of Bolangir.

Study area

The district of Bolangir (Orissa) is flanked in the North West by Gandhamardhan hills, a name of Ramayan fame, the north east by the rock infested Mahanadi. It lies between $20^0$11' 40" – 21^0 05' 08" northern latitude and 82^0 41' 15" – 83^0 40' 22" east longitude. The district is situated in the valley of rivers like Ang and Tel. It is in the western highlands of Orissa state with an average rain fall of about 1230 cm. and red sandy to red loamy soil nature. Out of 6 million tribal people about 62 notified tribes are seen in Orissa (Mohapatra, 1993). The three villages i.e. Chikalbahal, Kudasingha and Bhutiyarbahal are dominated by tribals like Kondha, Sabar, Gond, Mahar etc. Bolangir is one of the drought affected district of Orissa due to less rainfall. The three study villages are about 30 Km. away from the Bolangir town. The villagers mainly depend on the forest available nearer to village Chikalbahal for their livelihood. The total number of tribal people in these three villages are 687. The villagers depend on the trees available in the nearby forest for their food to healthcare (Mohapatra and Sahoo 2008).

METHODOLOGY

Fuel wood Consumption

Fuel wood consumption was estimated by recording the fuel wood use of three different households of three villages over the course of a week and this weekly measurement was made twice. A household is here defined by the collection of women who share cooking responsibilities and the men and the children they feed. A typical household would consists of a husband and wife (or wives, as polygyny is practiced in the tribal areas), one or more grown sons and their families and any younger unmarried children. The households sampled were not selected randomly. Because the process of monitoring fuel wood consumption was some what intrusive, It is chosen to monitor the consumption rates of families which were more willing to be cooperative.

The women were asked to show all of the places where they stored wood they used for fuel. All of the wood was then weighed to the nearest 0.01 kg using a hanging scale. Women were then asked to agree to set any wood collected from the fields during the week that I was monitoring their fuel wood use and to not add it to the pile of weighed wood or use it until I had weighed it.

I then visited the households' everyday during the week and weighed all fuel wood brought from the field by any of the women of the household. Finally, all wood for all women of the household was then reweighed at the end of the week. Fuel wood consumed by the household for the week was then calculated by the following formula:

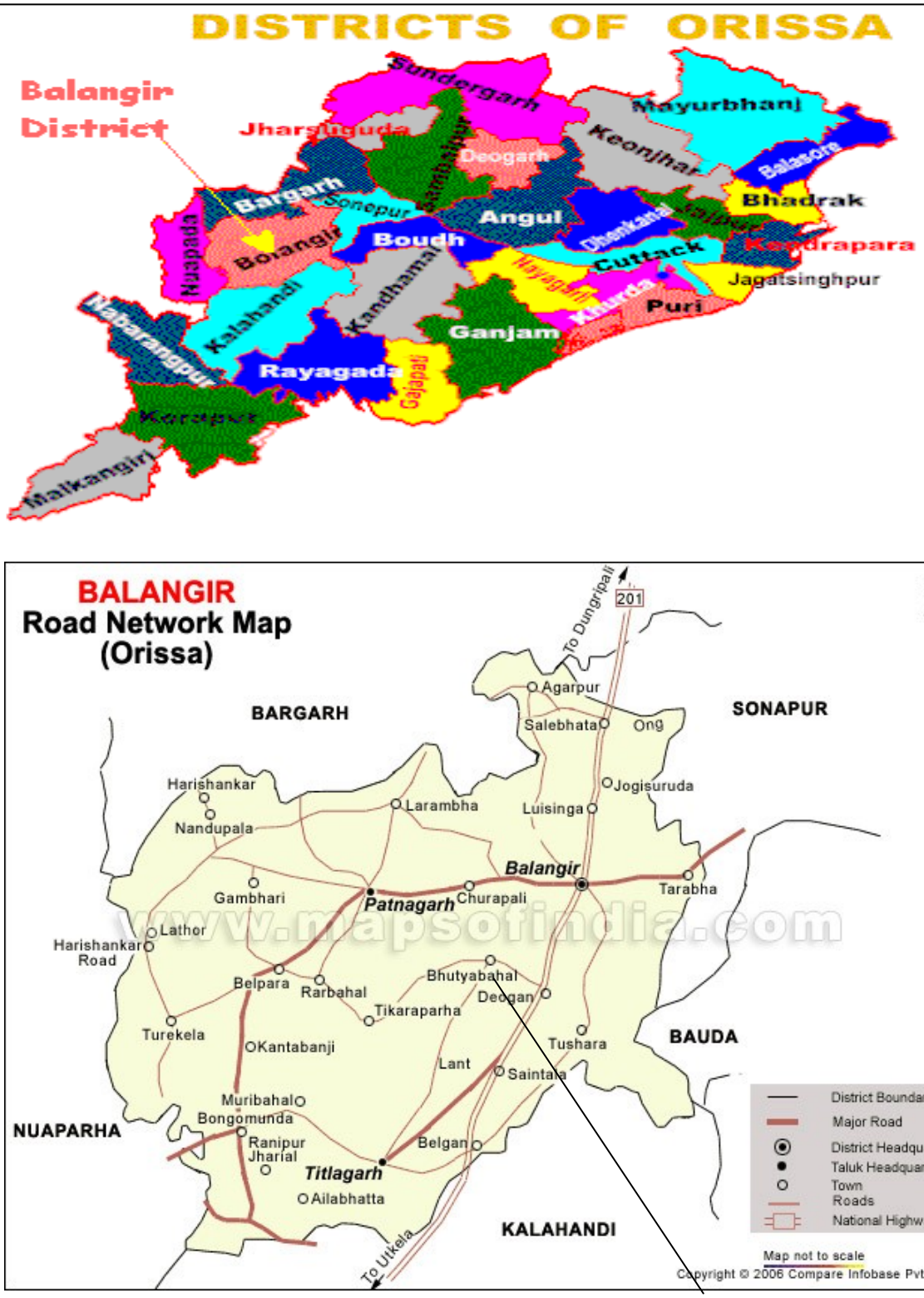
Weight of wood Beginning of Week + Weight of wood collected during week = Weight of wood present at the end of week

This value for fuel wood consumed was then used to estimate fuel wood consumption per person by dividing the total household's weekly consumption rate and dividing by the number of non-infants within the household.

Fuel wood supply

Fuel wood supply was calculated by estimating biomass accumulation for the area. This was done by establishing an inventory plot within two hectares of former agricultural land that had been left fallow for two years. A systematic grid design (Avery & Burkhart 1994) was established within the fallow. Twenty $100m^2$ circular subplots (radius= 5.64 m) were situated within the 2 ha inventory plot resulting in a total inventoried area of $2000m^2$ or 5% of the 2 ha fallow. The foci of the subplots were spaced at intervals of 33.33m from north to south and 40m from east to west. A full inventory of all trees with stems greater than 10 cm diameter at breast height (dbh) within the inventory subplots were conducted. Species, dbh, total tree height, tree species and stem taper were recorded.

After completion of the inventory, the three most frequently encountered fuel wood species



(Fig-1 Map of study area along with road map)

(*Mangifera indica L, Madhuca longifolia var. latifolia Gmel, Diospyros melanoxylon Roxb.)* were selected, and three individuals of each species were then felled (*M. indica*: M1, M2, M3; *M. longifolia*: MD1, MD2, MD3; *D. melanoxylon*: D1, D2, D3). These three species accounted for roughly 48% of all individuals in the inventory plot. The trees were then sectioned and weighed in the field (wet weights).

Wood sample from the main stem at breast

height were then taken from each of the felled nine trees. The volume was estimated by treating each as a cylinder. Average diameter for each sample was taken as the average of two perpendicular diameters of the sample. Average thickness reflects the average of four measurements of the wood sample, each 90 degrees from the previous. The samples were brought back to laboratory and dried for two weeks at 85^0 C. The samples were weighed and allometric equations correlating volume with dry weight by species were developed. An average dry weight per unit volume (cc) across all species was then calculated.

This average dry weight per volume value was then applied to the estimated standing volume within the inventory subplots to establish a standing biomass. The volumes the standing tree stems were calculated assuming a conical shape of the bole where the tree dbh is taken as the base of the cone. This then gives an estimate of the mass accumulated for each inventory subplot over the two years. Yearly averages for each subplot were calculated by dividing by two. This value was then scaled up for reference.

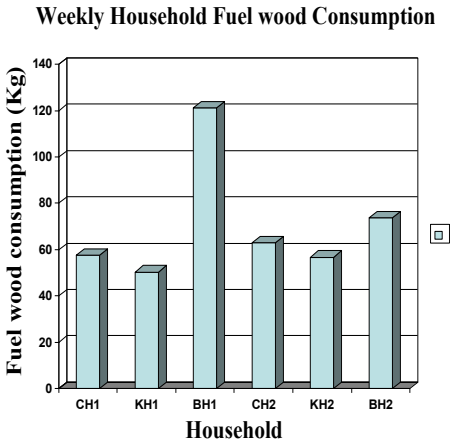
RESULTS

Fuel wood Consumption

Total weekly fuel wood consumption values were presented in **Fig-2**. Estimated fuel wood consumption per person per year based upon each household's observed consumption is presented in **Table-1**. The average amount of fuel wood consumed per person per week is 7.43 kilograms while the average weight of fuel wood consumed per person annually is 380.64. Given the three village's population of 687, this data estimates that 261,499 kilograms of fuel wood are consumed by the tribal of the three villages each year.

Forest regeneration

The bulk densities of the nine trees selected for allometric analysis are listed in **Table-2**. I calculated the average bulk density of the three species to be 0.62 g/cc. Based upon the estimates of standing wood volume after two year fallow period, the woody biomass accumulation rate of the sum of the subplots were calculated to be 1659 kg/ha/year **(Table-3).**



(Figure- 2 Total weekly fuel wood consumption in the village ecosystem)

DISCUSSION

At the high level of consumption in which a person consumes 552.48 kg of fuel wood per year, each villager would need to access to 0.33 ha of fallow land to meet their fuel wood demand given the regeneration rate of 1659 kg/ha/year. At the average consumption rate of 380 kg/person/year, each person needs access to about 0.23 ha of fallow land. Under the low estimate of 292 kg/person/year, 0.17 ha of fallow land could supply the fuel wood demands of one person. Restated, one hectare of land could support the consumption of roughly 4, 3 and 2 people under the low, mean and high estimates of fuel wood consumption respectively **(Table-4).**

Under the low and high estimates of fuel wood consumption, a family of 12 would need access to a little over 3 and 4 ha of fallow respectively. The villages as a whole would

Table 1 Per capita fuel wood consumption at the village complex

Household	Fuel wood consumption (Kg/week)	People in household	Fuel wood consumption (Kg/person/week)	Fuel wood consumption (Kg/person/year)
CH1	57.60	10	5.76	300.48
KH1	50.31	9	5.59	292.32
BH1	121.11	11	11.01	552.48
CH2	63.00	7	9.00	456.00
KH2	56.72	8	7.09	364.32
BH2	73.68	12	6.14	318.72
Mean		**10**	**7.43**	**380.64**

Table 2 Tree bulk densities sampled at the village complex

Wood sample	Dry weight (g)	Average diameter (cm)	Average thickness (cm)	Volume of wood (cc)	Dry density (g/cc)
M1	26.20	4.85	2.5	45.3	0.58
M2	78.75	7.40	3.5	149.5	0.53
M3	11.40	3.55	2.5	24.5	0.47
MD1	56.70	5.95	3.0	83.4	0.68
MD2	16.20	3.80	2.2	24.7	0.66
MD3	32.40	4.20	3.1	42.6	0.76
D1	68.20	7.55	2.5	111.9	0.61
D2	35.30	4.55	3.3	53.7	0.66
D3	30.00	4.40	3.0	45.2	0.66

Species	Average dry density (g/cc)
Mangifera indica L.	0.52
Madhuca longifolia var. latifolia Gmel.	0.69
Diospyros melanoxylon Roxb.	0.64
Average dry density of all species (g/cc)	0.62

consume the equivalent of 183 ha of fallow to meet its fuel demand under the low estimate; a little more than 345 ha would be needed by the villages under high estimate. This land requirement range is not unreasonable. Even under the high estimate, a family of 20 could meet its fuel wood needs from a little less than 8 ha of fallow land.

With regard to notion that fuel wood consumption leads to deforestation, observations of fuel wood collection does not support the theory. All women observed during the course of study collected fuel wood by breaking dead limbs and felling snags. Further they reported that they do not fell live trees for fuel wood. This fuel wood collection technique is corroborated to some degree by Abbot and Homewood (1999) and explicitly by Leach (1996).

Future Research

This study definitely opened a path for future research on the following areas so that better understanding of the fuel wood consumption and its

Table 3 Woody biomass accumulation in plots sample in the village ecosystem

Plot	Total plot volume (m^3)	Estimated plot weight (Kg)	Growth rate (Kg^{-1})
A5	0.01	3.26	1.63
A6	0.02	6.05	3.02
A7	0.03	8.09	4.05
A8	0.04	11.16	5.57
A9	0.02	4.26	2.13
A10	0.05	12.14	6.08
A11	0.04	8.74	4.37
A12	0.16	38.68	19.35
A13	0.09	21.63	10.81
A14	0.03	6.46	3.23
A15	0.11	26.17	13.08
A16	0.01	3.34	1.67
A17	0.07	17.66	8.82
A18	0.04	9.86	4.93
A19	0.1	28.58	14.30
A20	0.19	46.48	23.24
A21	0.06	14.05	7.02
A22	0.03	6.31	3.15
A23	0.05	12.66	6.35
A24	0.19	46.28	23.14

Total growth rate for all sub-plots (0.1 ha) kg/year 165.96
Woody biomass accumulation estimate (kg/ha/year) 1659.60

Table 4 Sensitivity analysis of estimated fuel wood consumption at three levels of use

Estimate level	Consumption rate estimate		Fuel wood area: Human population	
	(Kg/person/week)	(Kg/person/year)	(Ha/person)	(People/ha)
Low	5.59	292	0.17	3.6
Mean	7.43	380	0.23	2.3
High	11.01	552	0.33	1.5

relation to the woody biomass could be established.

1. Focus should be on the rate of urban fuel wood consumption in addition to rural fuel wood consumption.
2. To gain a better understanding of the present status of forests and possible future trends, a better base of knowledge regarding land use should be established.
3. The composition and selection process of field trees should be studied in greater depth. A broader inventory will give a clear picture of the expression of farmer's preference. Species found in fields can also be compared to those found in fallow and other land use inventories to determine their overall presence.
4. A detail focus should be on individual species.

CONCLUSION

The data support the notion that woody biomass accumulation is sufficient to meet fuel wood demand in the village complex. At present, women and children do not make special trips to find and collect fuel wood. None of the women who took part in this study felt that fuel wood supplies were inadequate.

Although fuel wood is not perceived as scarce and does not result in deforestation, fuel wood collection within this system may not be wholly benevolent. The collection of dead woody biomass for fuel wood does remove nutrients from the system Mohapatra and Sahoo (2009). So this paper gives an illustrative idea about the comparison of fuel wood consumption and woody biomass accumulation in the tribal village ecosystem.

ACKNOWLEDGEMENTS

I would first like to thank my research guide Dr. Hara Prasad Sahoo for his timely advice and a lot of support. I sincerely appreciate the cooperation of the tribal women of the study village of Bolangir which they have shown during my visit and spot verification of the fuel wood consumption.

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