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Provisioning Services of Forest Ecosystem: A Case Study of Southern Achanakmar Tiger Reserve, Central India

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Abstract

The research was carried out in one of the protected areas, the Southern Achanakmar Tiger Reserve in India's Chhattisgarh state aims to estimate the provisioning services of the forest inhabitants in buffer and fringe communities. A self-administered structured questionnaire was used as a tool, and a multistage random sampling method was adopted for the survey. The outcomes of the study found that the total economic value of NTFPs (non-timber forest produces) and fuel wood have more value than the benefits derived from agriculture in both buffer and fringe areas. Additionally, the economic value of the NTFPs collection per household per day ranges from 0.26-1.34 USD for 5-7 notable species near the village area and the average computed fuel wood per household per day was assessed as 5.34 (mean) ± 1.43(SD) kg. The study reveals the consumption pattern, economic importance of the forest, and the favorable conditions that encourage people to establish near the area.

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Introduction

The provisioning service comprises all abiotic and biotic components yielded from ecosystems that can be traded, as well as used by humans directly (Haines-Yong and Potschin, 2012) such as non-wood forest produces, fuel wood, timber, fodder, water, etc. Many forest ecosystem commodities and services are generally free, and their full value is not reflected in society's economic estimations and, as a result, in policy tools (De Groot *et al.*, 2010). Natural ecosystems provide benefits that are both generally acknowledged and poorly understood (Daily *et al.*, 1997). Various forest ecosystem services are necessary for human well-being, but their future provision is at risk. The loss of biodiversity is linked to the loss of a variety of forest ecosystem services (Brockerhoff *et al.*, 2017).

Forest ecosystem services valuation can be used to improve sustainable resource use and persuade policymakers of the relevance of specific management practices (Aslaksen *et al.,* 2015; Acharya *et al.,* 2019), and make root or foundation for sustainable management in the field of economic and environment (Strand *et al.*, 2018). The market price method of ecosystem service valuation techniques is frequently used for the valuation of provisioning services, for the reason that the produces originated by provisioning services are usually traded, the price indicates the private willingness to pay for the advantages that are traded (e.g., timber, fish, fuel wood).

According to the India State of Forest Report 2019, approximately 50% of the villages are situated within a five km distance from the forest area. Almost villages depend upon the forests for firewood, non-timber forest produce, and other livelihood resources. Human interference in natural habitat creates human-wildlife interactions with huge conflicts. There is limited information about the direct and indirect benefits of forests known by society resulting in a less potential market of resources that have come to enforce in the nation. Integrating community perspectives with forest resource management knowledge can make a significant difference in obtaining long-term success (Agrawal and Chhatre, 2011).

The study area, Achanakmar Tiger Reserve (ATR) located in Lormi, Mungeli area of the state of Chhattisgarh, India, and the area known for the largest population of Baiga, where the majority of them exist in 42 forest villages in the area of ATR. The numbers of villages were found reliant on Achanakmar Tiger Reserve (ATR) forest area either partially or fully. Unscientific harvesting and over-exploitation of the forest (wood and non-wood forest products) resulted in the depletion of many species. Van Haldi (*Curcuma aromatica*) was found locally restricted in the Haldikacchar area near Chhirhatta village only. Overuse of NTFPs has resulted in the restricted distribution of Safed Musli (*Chlorophytum borivilianum)*, Mahul leaves (*Phanera vahlii*), Tikhur (*Curcuma angustifolia)*, Satawari (*Asparagus racemosus), Dioscoreas spp.,* Patal Kumbhra (*Pueraria tuberosa*) in the area (Joshi *et al.*, 2010). The study aims to estimate the provisioning services gained by villagers from Southern Achanakmar Tiger Reserve.

Material and methods

Study area

Achanakmar Tiger Reserve (ATR) extends between 22° 18' to 22° 38' N latitudes and 81° 31' to 81° 57' E longitude. It covers a total area of 914.017 km² and is located in Lormi Tehsil of Mungeli district in the state of Chhattisgarh (MoEFCC 2018). It is a core area of Achanakamar- Amarkantak Biosphere Reserve which is shared by two states Madhya Pradesh and Chhattisgarh, a major tourist attraction place of the state which surrounded by a large number of villages (Chandra and Boaz, 2018). The research area (Fig. 1) was demarcated in the southern region of ATR and has a total area of 478 km².

Research Design and data collection

The sampled households were taken from the buffer and fringe villages that are adjacent or directly open to the buffer limits of the Achanakmar Tiger Reserve.

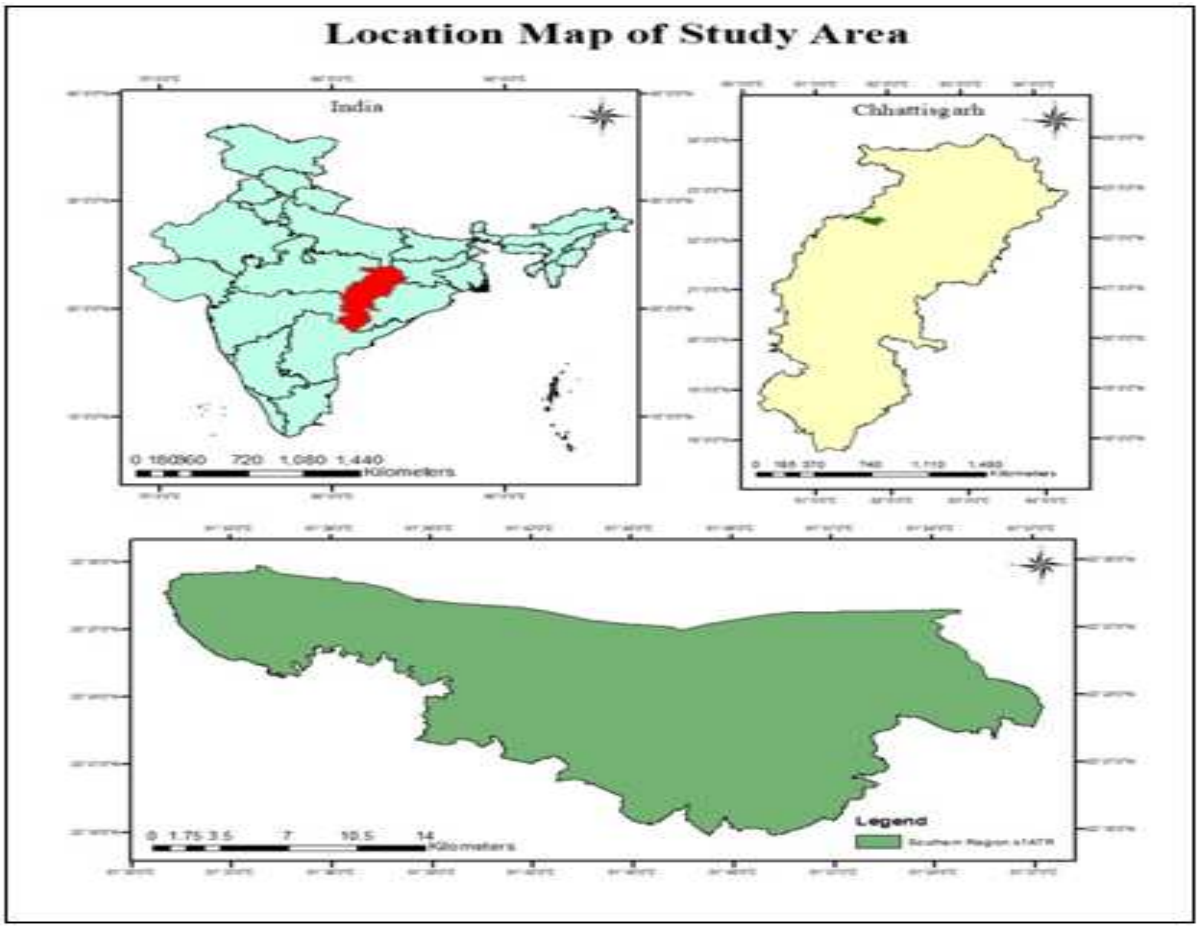

Fig. 1. Location map of the study area.

Three villages were taken from the buffer area out of a total of five and six villages were taken from adjacent areas to the forest boundaries. The buffer villages were Jamunahi (N = 30), Shivalkhar (N = 12), Chakda (N = 40), and fringe villages were Nagchuwa (N = 24), Ramhepur (N = 12), Gunapur (N = 18), Paraswara (N = 71), Kanchanpur (N = 25), Kansra (N = 13). The survey covered 15% of each village's total household population. In the lack of current statistics, an average decadal population growth rate for the state of Chhattisgarh from 1971 to 2011 was computed to predict households for 2021. For the survey, a self-administered questionnaire had been prepared and a three-phase/stage random sample procedure was used, with villages being randomly picked in the first phase, families in the second phase, and castes being taken for estimation in the third phase. Thus, a total of 245 households were surveyed.

Data analysis

For nutrition (food) primary and secondary data were used to estimate the production of agricultural crops and the meat consumed by local people. In the raw material, the section was broadly classified into NTFPs and fuel wood. Similarly fuel wood relied on primary data from daily collection and usage and the multiple regression analysis was applied to analyze the fuel wood consumption and the regression equation was produced. MS Excel and the basic version of SPSS software were used as analysis tools. Due to the prohibition of extraction of timber from a protected area, timber was excluded from the valuation here. In this area, the number of fish taken for consumption or sale, as well as the amount of water consumed each day estimated under water provisioning services. Additionally, the benefit of fodder was calculated by the benefit transfer approach, under which the amount of green fodder consumed by grazing cattle owned by local households in the forest was multiplied by the average price of fodder in the local area or district of Mungeli, Chhattisgarh (Ninan and Kontoleon, 2016).

The gross average annual income of the families was computed for each provisioning service to establish the amount of access to the services in the Southern ATR. The services income comprises earnings from both self-consumption and sales items. Rather than focusing on just one provisioning service, each family participated in a variety of raw materials collection activities (Kibria *et al.*, 2018).

Results and discussion

Socio economic profile

Small families of buffer villages make the tribal communities that live in most of the settlements near water sources in the area. Aside from farming in little forest acreage, they were somewhat reliant on the forest for food and completely reliant on fodder and firewood. The buffer villages had a large population of scheduled tribes as compared to scheduled castes and other castes. The basic information about the villages was given in table 1.The percentages of farmers in the area were 73.49 of which 95 % of the people work as laborers also in different schemes of the government, the remaining 20.82% of the people were businessmen or craftsman and the least percent of people in a job they either private or government. The income sources of villagers were agriculture and forest area. Fig. 2 depicts the comparison in percentages of income from forest and agricultural crops and found that forests have more ratio than agriculture.

Table 1. Basic Information of the studied villages.

Village	Area(ha)	The average population per household	Percent of Tribes of total population (%)	Distance From Forest Boundaries (km)
Buffer				
Chakda	71.62	3.68	78.10	0
Jamunahi	59.48	4.25	88.37	0
Shivalkhar	17.43	4.08	77.91	0
Fringe				
Kanchanpur	476.72	4.16	78.35	0.84
Kansra	269.05	4.48	10.97	3.11
Gunapur	472.08	4.08	26.23	1.38
Paraswara	725.10	4.20	62.48	1.15
Ramhepur.	102.78	4.69	40.00	0.38
Nagchuwa	790.34	4.27	68.62	1.32

Note: "0" denotes the villages within ATR's boundaries.

According to the study, the per household forest income of the Southern ATR estimated were of 30.10 USD/month and 361.2 USD/year, in the calculation of monthly income from the forest, NTFPs, and fuel wood were considered only, indicating the people receive a big part of the income from the forest area. Fig. 3 depicts per capita monthly income from the forest products and shows the dependency of villages as buffer villages have higher dependency than fringe villages.

Table 2. The list of species used for fuel wood by the villagers.

Local Name	Species	Calorific value (kcal/kg)
Arjun	*Terminalia arjuna*	5080
Babool	*Acacia nilotica*	4657
Dhawda	*Anoguissus latifolia*	4900
Jamun	*Syzigium cumini*	830
Kasahi	*Bridelia retusa*	6010
Karra	*Cleistanthus collinus*	4592
Khamhar	*Gmelina arborea*	5700
Kusum	*Schleichera oleosa*	3843
Mahua	*Madhuca latifolia*	8742
Parsa	*Butea monosperma*	5030
Saja	*Terminalia tomentosa*	4923
Sal	*Shorea robusta*	4615
Salai	*Boswellia serrate*	2300
Tendu	*Diospyros melanoxylon*	5030

Nutrition (food)

Agriculture crops

The Kharif crops were Paddy (*Oryza sativa*), Soybean (*Glycine max*), Urad (*Vigna mungo*), and Arhar (*Cajanus cajan)*, whereas the Rabi season is dominated by Chickpea (*Cicerari etinum*) of the region aside from that, some pulses such as Matri *(Lens askulenta*), Makka (*Zea mays)* and Til *(Sesamum indicum)* also grown in the area. In the region, paddy was the main crop that was grown by all farmers. For the year, paddy crops are predicted to be worth 502556.06 USD.

Table 3. Multiple regression analysis for fuel wood consumed by the villagers.

Variables	Constant	Total No. of Collectors per household	Level of Income per household	Total No. of Family Members per household	Time	Distance
Coefficient	2.46	0.287*	0.000	0.392***	0.204*	-0.077*

*showing 10% level of Significance, ** for 5% level of significance, *** for 1 % level of significance.

Since Chhattisgarh is known as the "Rice Bowl," the majority of traditional food items compose of rice (Palta and Aggarwal, 2016) and it works as the main income generation for the people that the state government purchases paddy at 32.83 USD per quintal under the Scheme of Rajiv Gandhi Kisan Nyay Yojana during the 2020-21 Kharif marketing season, which was more than 7.90 USD purchased by the Centre's MSP (Minimum Support Price). Hence inside the forest area, the villagers with the income from forest produce also get more benefit from the paddy purchased by the government.

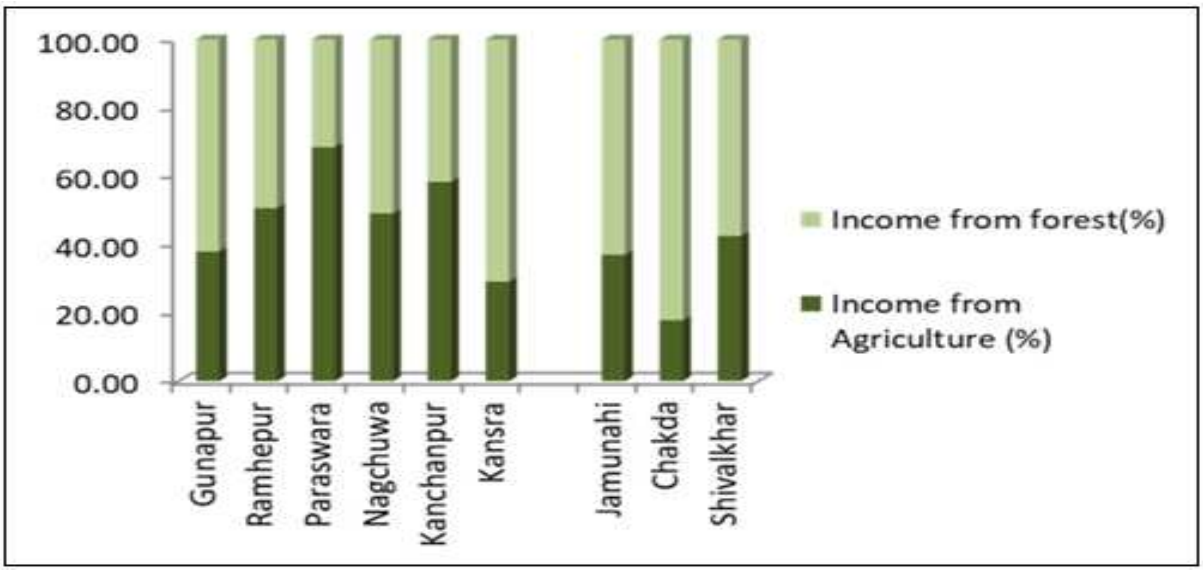

Fig. 2. Percentages of income from the forest and agriculture.

Meat

Under the nutritional value, the chicken was kept for consumption and sold by the locals. The price of chicken in the local area discovered was a higher price than the price of the city area because it assumed that the birds have a better quality which is produced locally in forest villages. The approximate meat price of a chicken was 13,809.04 USD during the assessment, the price was estimated once based on the current chicken population.

Raw material

NTFPs

The people of the studied villages were get benefitted from different levels of NTFPs stock, with a few with a high level of NTFPs and others having a low level of NTFPs collection. Based on the availability of NTFPs near each village's area, services were calculated for the 6-7 most notable NTFPs were Mahua (*Madhuca indica*), Char (*Buchanania lanzan),* Jamun *(Syzygium cumini),* Tikhur ***(****Curcuma angustifolia),*

Ber*(Ziziphus mauritiana),* Karil*(Bamboo Rhizome),* Mushroom sp. Tendu fruit*(Diospyros melanoxylon),* Safed Musli *(Chlorophytum borivilianum),* Amla*(Phyllanthus emblica),* etc. As a nationalized product, Tendu leaves (*Diospyros melanoxylon)* were picked by all villagers of the villages and during the summer, Tendu leaves collection provides the main revenue source to the villagers. In the collection of Tendu leaves women's participation was equal to or even more than men's in some of the villages, the percentages of their participation are shown in Fig. 4b (buffer area) and Fig. 4d (fringe area). Thus, the profit from NTFPs was estimated at 392442.77 USD per year. The average economic value of the NTFPs collection per household per day was estimated at USD 0.71 ± 0.046 SD.

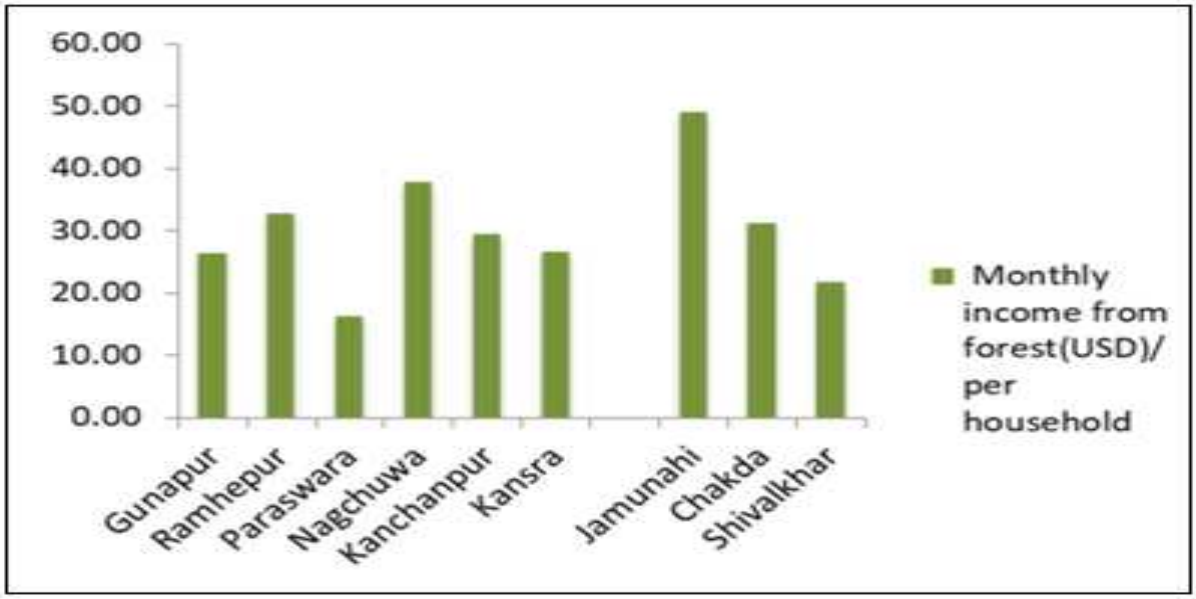

Fig. 3. Per capita monthly income from the forest (USD).

As a tiger reserve, many forest species are restricted in the buffer zone for collection, except fuel wood, Tendu leaves, and Sal seeds. In India, NTFPs collection is supported by the state and central government both to reduce poverty with legal rights to the tribal communities for the collection of Tendu Patta, fuel wood, and other NTFPs also. The present study shows that buffer villages had high income from the forest than fringe villages.

Fuelwood

The average computed fuel wood per household per day was assessed as 5.34 (mean) ± 1.43(SD)kg. The communities consumed 2985232.80 kg of fuel wood for the year, with a total value of 172821.141 USD. Table 2 shows a list of the fuel wood species consumed by villagers with their calorific value. Whereas mainly fuel wood collection is done by women as compared to men, Fig. 4a (buffer area) and Fig. 4c (fringe area) show the percentages. The calorific values of the species of fuel wood were obtained from Bhatt and Todaria, 1992; Jain, 1993; Sharma *et al.*, 2014; Sarkar *et al.*, 2021. In the analysis of fuel wood, the degree of income had no bearing on the amount of fuel wood consumed.

The regression analysis shows (table 3), that the total number of family members was highly significant to the fuel wood consumption followed by the total number of collectors, time spent in the collection, and distance travel for the collection of fuel wood.

The regression equation for the fuel wood consumption,

$Y = A + B_1X_1+B_2X_2+B_3X_3+B_4X_4+\varepsilon_i$

Here, Y = Amount of fuel wood consumption(kg); A= intercept or constant of the regression equation; $B_1,B_2,B_3....B_n$ = regression coefficient; X_1,X_2,X_3,X_4 = independent variables; ε = the regression residual; i = 1,2,3,4.....n.

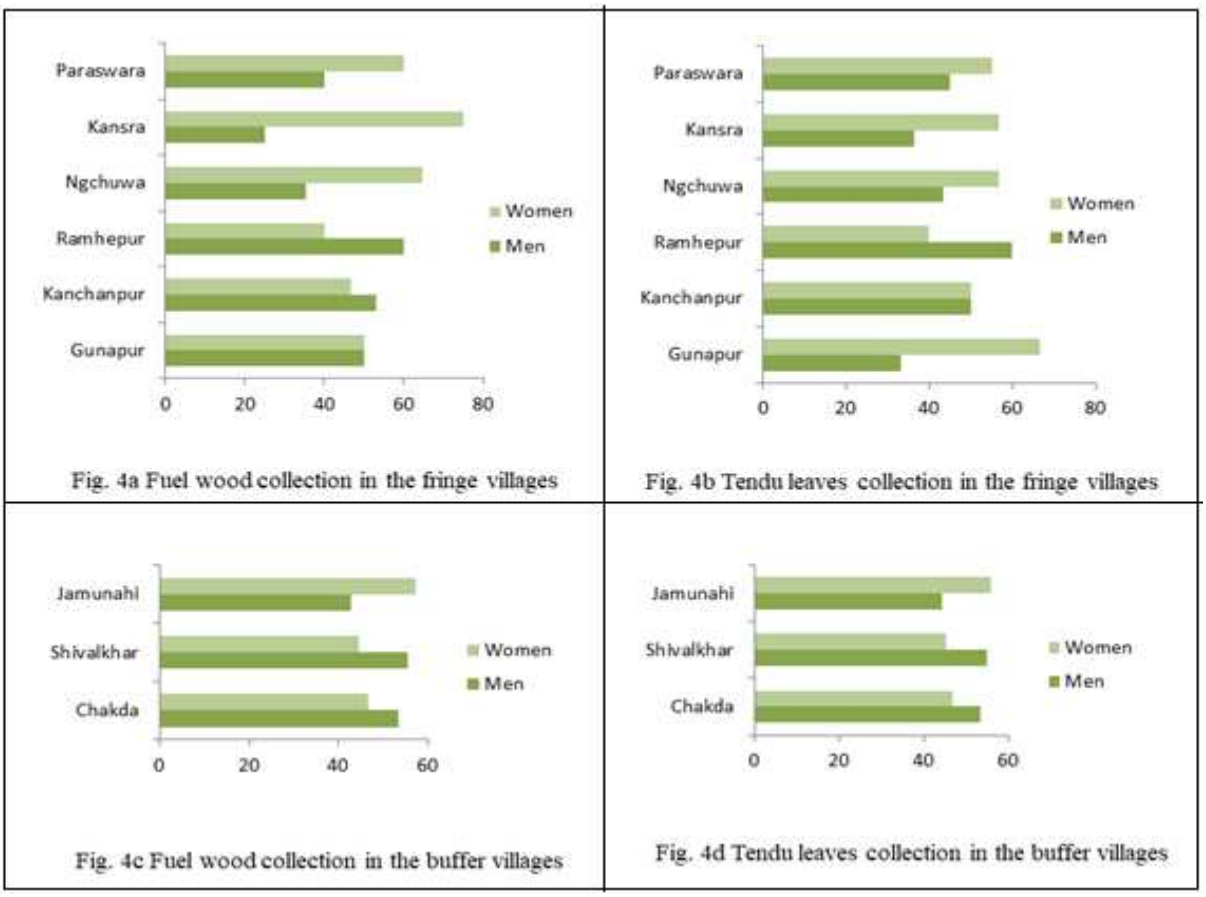

Fig. 4. Man women's participation in the collection of raw materials in buffer and fringe villages.
4a) Fuel wood collection in the fringe villages
4b) Fuel wood collection in the buffer villages
4c) Tendu leaves collection in the fringe villages
4d) Tendu leaves collection in the buffer villages

Fodder benefits

The demand for forage by a cow was 11.79 kg per day, for a goat 1.81 kg per day, and a bull 14.52 kg per day (Redfearn and Bidwell, 2017). The price of forage in the local market was 0.04 USD per kg, therefore the forest met the demand for fodder for the year for 675,822.42 USD. The fodder demand was estimated at 27.62±2.54 kg/day/household resulting in approximately 80% of the requirement for fodder being met by forest areas, while 20% was met by agricultural areas such as paddy straw. As a result, those with limited income or agricultural productivity take benefit from the forest.

Water provisioning services

The average monthly water consumed by the villagers per home was 22160.92 liters. The cost of water consumption was estimated to range from 4.57- 82.32 USD for a household per year and the economic value of water was 38742.07 USD in the total villages. The agricultural area was completely reliant on rain, this was the reason 75% of the population only grows one seasonal crop. Additionally, the value of the fisheries in the sample communities was approximately 63462.89 USD estimated under the water provisioning services.

Conclusion

In the study area demand for fodder was lower but the number of villages depends on the area where more and the NTFPs lower value indicating the less availability of the produces due to more biotic pressure as many species are under the condition of extinction in the area. Additionally, the distance from

a forest area to selected villages had an impact on economic gains as well as dependency on the forest, despite collection restrictions on many products, buffer villages had a higher level of dependency and income than fringe villages. Thus, the favourable conditions for establishment, a population increase in the area and the fellow land covered by establishments of outsiders resulted in unequal sharing of the natural resources in the area and they have effects on the forest, wildlife, and the life of the tribal people.

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