Carbon Sequestration in Sacred Groves of Jammu District, J&K

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Abstract: ***Sacred groves are known as Bani in J&K. Since time immemorial these are virgin patches of trees or forest which are preserved in the name of social or religious beliefs and act as sites of biodiversity conservation. These sacred places provide different types of services like religious, ecological, social, aesthetic, etc. Carbon storage is one of the most significant ecosystem services provided by sacred groves and these carbon estimation studies are very important for UNFCCC (United Nations Framework Convention on Climate Change). The present paper studied about the carbon and carbon dioxide equivalent (CO_2eq) estimation potential of the sacred groves and Willingness to Pay (WTP) by the local people for their conservation. With the help of non - destructive methodology total biomass and carbon were calculated and WTP was recorded using questionnaire. A total of 60 sacred groves were reported from the study area with 71 tree species. Ficus religiosa tree species was found to be the most dominant having carbon value of 100.6 t ha^{-1} and CO_2eq value of 369.3 t ha^{-1}. The total amount of carbon and CO_2eq sequestrated by sacred groves is 362.8 t ha^{-1} and 1331.4 t ha^{-1}. The WTP responses shows that people's attitude towards conservation depends on many factors like age, education, gender, income, etc.***

Keywords: Carbon, Ecosystem Services, Conservation, Willingness to Pay

1. Introduction

Sacred groves are storehouses of biodiversity which perform many ecological, social and cultural functions. The phytodiversity present in these sacred groves act as reservoir of ecosystem services like carbon sequestration, soil erosion control, water conservation, climate control, wildlife conservation, *etc.* Tree species present in these sacred sites play an instrumental role in carbon capture through photosynthesis and can act as big sinks of carbon [8]. In the present era of industrialization and urbanization, the level of Greenhouse Gases (GHGs) is constantly increasing in the atmosphere [1]. Carbon dioxide (CO_2) is the most dominant GHG which accounts for about 77% of the global CO_2eq emissions [4]. An unprecedented rise has been observed in the concentration of CO_2 in last few decades. Here sacred groves can play a very important role in carbon storage, but very less studies has been carried out in this field.

In India, sacred groves are known by different names and in Jammu and Kashmir they are known as '*Bani'*. Since ancient times, these sacred groves are dedicated to different religious and social beliefs. Sacred groves can be a single tree or a patch of trees or a forest, which is mainly growing on a community land protected in the name of some deity or social taboo [1]. There is no formal institution for the management and maintenance of these groves. Thus, sincere efforts are needed for the assessment of these sacred grove resources, to protect them as habitat for wildlife, providers of ecosystem services and abode of our rich cultural heritage. Keeping in view the significant role of sacred groves, the present study was carried out in Jammu district, J&K.

2. Literary Survey

Sacred groves are patches of forest or trees having traditional cultural and ecological value [5]. A lot work has been done on the phytodiversity of sacred groves in India [1] [6] [9]. But very few studies have been conducted on the role of sacred groves as carbon sink [6].

3. Study Area

The present study was conducted in Jammu district which is situated on the banks of river Tawi. It is surrounded by Shivalik hills on one side and plains on the other and is known as '*Kandi'* region. Most of the area here is rain fed with temperature ranging between 6ºC to 47ºC.

4. Methodology

In order to calculate biomass of the tree species found in the sacred groves of the study area, the non - destructive methodology given by Forest Survey of India (FSI) [2] was adopted. A total of 90 sample plots of size 10 × 10 m were laid randomly during the study in sacred groves. For estimation of the above ground biomass of the tree species, data such as girth at breast height (GBH) was collected from the sample plots and was converted into diameter at breast height (DBH). Using DBH, volume was calculated with the help of allometric equations developed by FSI (2006) for tree species of Himalaya. The volume was then multiplied by species specific gravity to obtain above ground biomass (AGB). The below ground biomass (BGB) was calculated by multiplying AGB by 0.26 (as root: shoot ratio) [5] [7]. The carbon stock in the trees was obtained by multiplying the total biomass by conversion factor of 0.47 [9] [3)]. To get the value of CO_2eq sequestered, the carbon value is then multiplied by conversion factor of 44/12 [10].

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The willingness to pay (WTP) response of the local people was recorded with the help of questionnaire based survey. A total of 120 respondents were selected randomly from the people visiting the sacred groves area and personal interview was conducted to know their attitude towards conservation. Their responses were then analyzed with respect to the socio - economic factors like age, education status, income class, gender, *etc*. [6]

5. Results and Discussion

The results of the study show that a total of 71 tree species were found in 60 sacred groves of the study area. *Ficus religiosa* contributes maximum in carbon (100.6 t ha^{-1}) and CO_2eq (369.3 t ha^{-1}) sequestration followed by *Ficus benghalensis* with carbon stock of 71.1 t $ha^{-1}$and CO_2eq value of 260.8 t ha^{-1} and *Mangifera indica* with carbon stock of 42.8 t $ha^{-1}$and CO_2eq value of 157.1 t ha^{-1}. *Ficus religiosa* is the most dominant and sacred tree species in the study area and is found in almost every sacred grove, this may the reason for its highest value of carbon storage and CO_2eq value. Similarly, in Somjaichi Rai sacred grove, Maharashtra, *Terminalia bellirica* was found to be the most dominant tree species [5]. The total value of carbon stock and CO_2eq sequestrated by sacred groves in the study area is 362.8 t ha^{-1} and 1331.4 t ha^{-1}.

Table 1: Carbon and CO_2eq sequestration in sacred groves of Jammu

S. No	Botanical Names	Volume (m^3/ha)	AGB (tons/ha)	BGB (tons/ha)	Total Biomass (tons/ha)	Carbon (tons/ha)	CO_2eq (tons/ha)
1	*Aegle marmelos (*L.) Corr.	40.3	33.9	8.8	42.7	20.1	73.6
2	*Alistonia scholaris* (L.) R. Br.	6.05	3.7	1.0	4.7	2.19	8.04
3	*Adina cordifolia*	58.3	34.4	8.9	43.3	20.4	74.8
4	*Albizia lebbeck* (L.) Benth	11.6	8.1	2.1	10.2	4.80	17.6
5	*Azadirachta indica*	9.37	6.37	1.7	8.0	3.77	13.8
6	*Araucaria cookii*	0.10	0.05	0.0	0.1	0.03	0.11
7	*Acacia catechu*	0.74	0.6	0.2	0.8	0.36	1.30
8	*Acacia modesta*	0.36	0.29	0.1	0.4	0.17	0.63
9	*Acacia torta*	0.54	0.43	0.1	0.5	0.25	0.93
10	*Acacia nilotica*	3.03	2.4	0.6	3.0	1.42	5.22
11	*Annona squamosa*	0.25	0.18	0.0	0.2	0.11	0.39
12	*Anthocephalus cadamba*	9.90	2.9	0.8	3.7	1.72	6.30
13	*Acer caesium*	0.20	0.09	0.0	0.1	0.05	0.20
14	*Bauhinia vahlii*	7.09	5.25	1.4	6.6	3.11	11.4
15	*Bauhinia variegata* Linn.	3.44	2.55	0.7	3.2	1.51	5.54
16	*Butea monosperma* (lam.) Taub.	9.19	5.1	1.3	6.4	3.02	11.1
17	*Bombax ceiba*	9.46	3.2	0.8	4.0	1.90	6.95
18	*Citrus limon*	0.10	0.85	0.2	1.1	0.50	1.85
19	*Citrus medica*	0.65	0.55	0.1	0.7	0.33	1.20
20	*Crataeva nurvala*	5.28	3.1	0.8	3.9	1.84	6.74
21	*Cordia dichotoma*	0.15	0.05	0.0	0.1	0.03	0.11
22	*Cassia fistula*	4.05	3.9	1.0	4.9	2.31	8.48
23	*Cassia gluaca*	4.44	4.26	1.1	5.4	2.52	9.26
24	*Carica papaya* L.	0.10	0.062	0.0	0.1	0.04	0.13
25	*Casuarina equestifolia*	0.95	0.45	0.1	0.6	0.27	0.98
26	*Callistemon citrinus* (Curtis.) Skeels	2.31	1.02	0.3	1.3	0.60	2.22
27	*Dalbergia sisoo* Roxb.	27.4	10.7	2.8	13.4	6.32	23.19
28	*Diospysos cordufolia*	2.63	1.94	0.5	2.4	1.15	4.22
29	*Eucalyptus globules* Labille	9.55	6.5	1.7	8.2	3.85	14.13
30	*Elaeocarpus ganitrus* Roxb.	1.84	1.36	0.4	1.7	0.81	2.96
31	*Ficus racemosa* Linn.	2.47	1.25	0.3	1.6	0.74	2.72
32	*Ficus elastic*	1.76	0.88	0.2	1.1	0.52	1.91
33	*Ficus benghalensis*	203.4	120	31.2	151.2	71.1	260.8
34	*Ficus religiosa*	253.7	169.9	44.2	214.1	100.6	369.3
35	*Ficus palmata*	0.10	0.05	0.0	0.1	0.03	0.11
36	*Ficus virens*	3.52	1.8	0.5	2.3	1.07	3.91
37	*Grevillea robusta*	3.03	1.93	0.5	2.4	1.14	4.19
38	*Grewia optiva* Drumn. exBurret	16	9.12	2.4	11.5	5.40	19.82
39	*Grewia tillifolia*	6.92	3.95	1.0	5.0	2.34	8.58
40	*Kegilia pinnata*	0.61	0.43	0.1	0.5	0.25	0.93
41	*Lannea coromandelica*	5.90	3.2	0.8	4.0	1.90	6.95
42	*Litchi chinensis*	0.10	0.09	0.0	0.1	0.05	0.20
43	*Mimusops elengi*	10.8	8.64	2.2	10.9	5.12	18.78
44	*Morus alba* Linn.	3.75	2.8	0.7	3.5	1.66	6.09
45	*Mangifera indica*	126.8	72.3	18.8	91.1	42.8	157.1
46	*Melia azedarach* L.	12.1	7.02	1.8	8.8	4.16	15.26
47	*Moringa olifera*	2.32	0.64	0.2	0.8	0.38	1.39
48	*Murraya koenigi*	0.10	0.06	0.0	0.1	0.04	0.13
49	*Mallotus philippensis*	2.39	2.1	0.5	2.6	1.24	4.56

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50	*Michelia champaca*	2.39	1.3	0.3	1.6	0.77	2.83
51	*Pinus roxburghii*	2.00	1.2	0.3	1.5	0.71	2.61
52	*Phyllanthus officinalis*	12.6	8.3	2.2	10.5	4.92	18.04
53	*Psidium guajava* L.	0.88	0.59	0.2	0.7	0.35	1.28
54	*Pterospermum acrofolium*	4.44	2.27	0.6	2.9	1.34	4.93
55	*Pogamia pinnata*	0.67	0.55	0.1	0.7	0.33	1.20
56	*Platanus orientalis*	2.00	1.4	0.4	1.8	0.83	3.04
57	*Polyalthia longifolia*	2.47	1.46	0.4	1.8	0.86	3.17
58	*Punica granatum*	0.10	0.07	0.0	0.1	0.04	0.15
59	*Putranjiva roxburghii*	0.10	5.7	1.5	7.2	3.38	12.39
60	*Prunus persica*	0.10	0.05	0.0	0.1	0.03	0.11
61	*Roystonia regia*	1.53	1.3	0.3	1.6	0.77	2.83
62	*Ricinus cummunis*	0.61	0.58	0.2	0.7	0.34	1.26
63	*Syzygium cumini* (L.) Skeels	12.7	7.7	2.0	9.7	4.56	16.73
64	*Toona ciliata* M. Roem	11.7	7	1.8	8.8	4.15	15.21
65	*Tamarindus indica*	2.47	3.2	0.8	4.0	1.90	6.95
66	*Terminalia arjuna*	0.36	0.25	0.1	0.3	0.15	0.54
67	*Tectona grandis*	6.74	4.9	1.3	6.2	2.90	10.65
68	*Terminalia bellirica*	0.36	0.25	0.1	0.3	0.15	0.54
69	*Terminalia chebula*	0.31	0.22	0.1	0.3	0.13	0.48
70	*Vitex negunda*	0.10	0.06	0.0	0.1	0.04	0.13
71	*Ziziphus mauritiana*	32.4	13.9	3.6	17.5	8.23	30.21
Total		**982.1**	**612.6**	**159.3**	**771.9**	**362.8**	**1331.4**

The willingness to pay (WTP) response of the respondent's shows that people visiting the sacred groves are well aware of their importance but mainly consider them as religious centers. Some of them value sacred groves as historical, recreational places, biodiversity conservation sites, source of income, *etc*. When WTP response with respect to age groups was analyzed, it was found that younger age group (31 - 45 yrs) respondents have major share (52) in it. Graduate level respondents (40) have more WTP when compared with other education level groups of the respondents. Male respondents have slightly more WTP as compared to female respondents in the study area [6]. When income and WTP ratios were compared, it was observed that with increase in income the WTP number of the respondent increases having maximum value (45) for respondents with income above 1, 00, 000 per month.

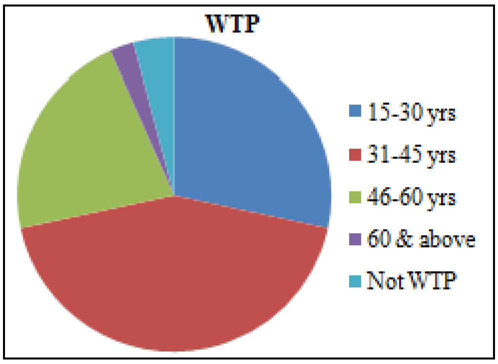

Figure 1: WTP and Age of the respondents

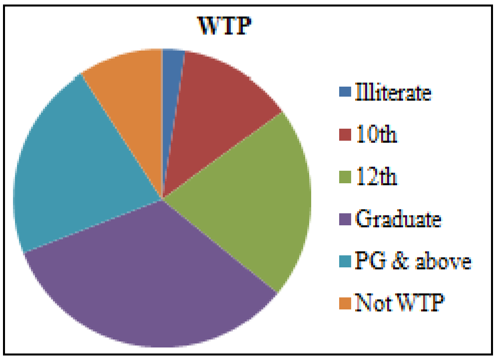

Figure 2: WTP and Education of the respondents

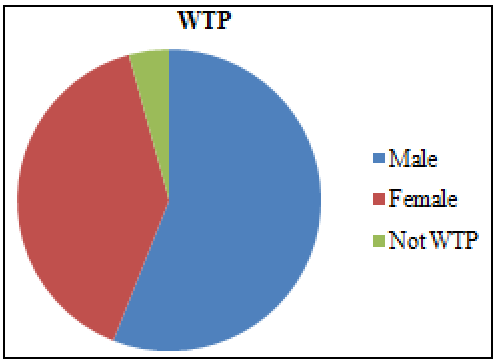

Figure 3: WTP and Gender of the respondents

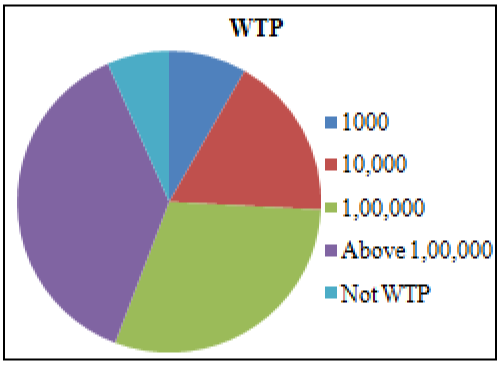

Figure 4: WTP and Income of the respondents

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6. Conclusion

Sacred groves have a big potential to conserve existing carbon stock and increase its carbon sequestration level in future. But it is important to understand the relationship between tree species and their carbon storage potential, so that species specific conservation strategies can be adopted for management of the sacred groves areas. It is important to revive and imbibe our traditions, culture and values among younger generations to ensure the sustainable use of resources of sacred groves along with ecological education.

7. Future Scope

Sacred groves are very important source of ecosystem services especially carbon sequestration. These sacred sites need to be explored more with regard to the services provided by them to the mankind, so that proper management strategies can be developed by the governing bodies with the help of local stakeholders.

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