CARBON STOCK IN KANER JHIR SACRED GROVE AND NON-SACRED GROVE OF GWALIOR (M.P.)

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Abstract:
Sacred groves are the natural forest patches and are still conserved due to various traditional beliefs and religious practices. The present study aims to estimate the biomass and carbon stock of Kaner jhir sacred grove in Gwalior district of Madhya Pradesh, India. Various diversity indices are used to assess the diversity. Non destructive method and allometric equations were followed to estimate the aboveground biomass (AGB) of tree species. BGB and carbon content sequestered in trees were estimated by conversion factors. The total biomass and total carbon estimated in trees of sacred grove was 172.37 t/ha and 86.19 t/ha while the non sacred grove reported 28.22 t/ha and 14.11 t/ha, respectively. However, the carbon stock in different pools of sacred grove and non sacred grove was estimated and the total carbon stock was found to be 126.53 t/ha and 43.84 t/ha, respectively. The results of the present study focused on the importance of these valuable small patches conserved on the basis of religious grounds and playing a vital role in ecological functioning. A sacred grove not only restores the biodiversity but also mitigates carbon and play a major role in the carbon cycling.

Key words: sacred grove, biomass, carbon stock

I.INTRODUCTION:

Green plants possess the unique ability to assimilate carbon in the form of carbon dioxide as raw material for their photosynthesis. The increasing carbon emission is one of the major concerns of the entire world. The top four emitting countries are China (27%), US (15%), the European Union(10%) and India (7%) (Quere, 2018). Carbon sequestration is found to be the natural and effective means to store atmospheric carbon dioxide by the plants in the form of biomass that contribute to global carbon cycle. Forest trees are contributing to reduce atmospheric CO_2 concentration by accumulating it as biomass. Sacred groves are ancient forms of conserved natural forests and are often fragments of originally extensive forest ecosystem (Pala *et al*. 2013) that take part in terrestrial carbon sequestration. Kaner jhir is one such small sized sacred grove of Gwalior district in comparison to other groves of this region. The grove is small forest patch with varied floral diversity. The adjacent area of the sacred grove is the non sacred region and very distinct from each other. The different biotic components (trees, shrubs, herbs and litter) and abiotic component (soil) of sacred groves play a vital role in regulating local climate by acting as carbon sinks. The above-ground biomass of woody vegetation is one of the largest carbon pools and is determinant to the ecosystem's potential for carbon storage and also a cost-effective option for mitigation of global warming and climate change (Gupta and Sharma, 2014). These sacred groves have been overlooked so far for their carbon sequestration potential. Hence, the present study was undertaken to estimate the carbon sequestration potential among different pools of Kaner jhir sacred grove to estimate the total carbon stock.

II. MATERIALS AND METHODS:

1) Study Area:

The Kaner jhir sacred grove is located at the geographical coordinate $26^{0}03'48.6''$ N and $077^{0}59'51.6''$E; around 30 km from Gwalior district, Madhya Pradesh. The size of the sacred grove is approximately one hectare with varied plant diversity. The divine deity resides over here is Lord Hanuman, Lord Shiva and Goddess Parvati. The area adjacent to the sacred grove is the non-sacred region with very less biodiversity. The Kaner jhir sacred grove (Site 1 – KJI) was compared with the non-sacred grove (Site 2 – KJO) for various parameters of the study. The average altitude of Kaner jhir is about 315 meters above msl. The climate is hot and dry with three distinct seasons viz. summer, monsoon and winter. Summer is intense and lasts from March to mid-July. The monsoon starts from mid-July and lasts till September end. Winter starts from October and lasts till mid of February. Maximum temperature ranges from 40°C - 48°C during April to June and minimum temperature ranges from 5°C – 0°C. The average rainfall is 80 mm.

2) Sampling Strategy:

The random sampling method was used and 20m x 20m quadrats were laid down for trees, 5m x 5m for shrubs and 1m x 1m for herbs respectively. The non – destructive and destructive method was used to estimate tree biomass and understory biomass. The DBH was determined by measuring the tree girth at breast height (GBH) approximately 1.3m from the ground. The GBH of all the trees >10cm within the quadrats were measured. For understory biomass, fresh and dry weights were measured. Biomass values were than multiplied by an expansion factor to scale them on per hectare basis. The aboveground biomass was calculated using allometric equation of Anderson and Ingram (1989) and belowground biomass by MacDicken (1997). The biomass in shrubs was estimated by Xu *et al*., (2010) and herbs and litter by Hairiah *et al*., (2001). The carbon was considered as 50% of biomass by Brown and Lugo (1982).Soil organic carbon was determined by following the procedure of Walkley and Black (1934).

3) Data Analysis:

The density of all woody species was determined according to Misra (1968). Species richness, Shannon-Wiener index (H) and Simpson Index were used to calculate the species diversity (Simpson, 1949; Shannon and Wiener, 1963)

a) Simpson Index:

$$D = \frac{\sum n_i(n_i-1)}{N(N-1)}$$

Where, ni = total number of each individual species, N = Total number of all the species.

b) Species Richness:

$$D = \frac{S}{\sqrt{N}}$$

Where, S = number of different species present in sample,
N = Total number of individuals in the sample

c) Shannon Wiener index:

$$H = - \sum (p_i)(\ln p_i)$$

Where, pi = proportion of total sample belonging to i species

Shannon-Weiner diversity index was divided by the log value of total number of species found in the area to determine the evenness (Mueller-Dombois & Ellenberg, 1974; Zobel *et al*. 1987; Yadhav *et al*. 2013; Shrestha *et al*. 2015)

d) Menhinick's Richness (Menhinick's, 1964)

$$D= S/\sqrt{N}$$

where, S = number of different species present in sample

N = total number of individuals in the sample

e) Sorensen coefficient is calculated by using the formula (Sorensen, 1948)

$S_s = 2a/(2a+b+c)$

where,

S_s = Sorensen similarity coefficient

a = number of species common to both quadrats

b = number of species unique to the first quadrat

c = number of species unique to the second quadrat

D_s may be represented in terms of dissimilarity. $D_s = 1.0 - S_s$ which provide the difference of species between two sites.

III. RESULTS AND DISCUSSION:

1. Phytosociological analysis:

The biodiversity status was assessed with different diversity indices for both sites of the study area. Simpson index measures the relative abundance of species and a high value indicates high dominance or low biodiversity. It recorded 0.09 (KJI - site 1) and 0.4 (KJO - site 2), respectively, depicting variety of plant species at former than later. Shannon Weiner index also characterizes the diversity of species in a community. The highest value at site 1 (2.39) indicated more diversity as compared to site 2 (0.96) that accounted for both abundance and evenness. The result of Menhinick's richness index also showed the rich diversity of species at site 1 (1.51) as compared to site 2 (0.73), respectively. Thus, the different diversity indices used confirmed the result that the sacred groves possess rich and varied plant species as compared to non sacred grove. Evenness compares the similarity of the population size of each species present. It ranges from zero to one, where zero signifies no evenness while one refers to complete evenness. The values of both the sites (site 1 - 0.88; site 2 - 0.87), are near to one which signifies the evenness in their community, respectively. Both the similarity and dissimilarity indices value range from zero to one but their interpretations are opposite. As the Sorensen coefficient (S_s) (0.12) is near to zero signifies that both the sites have very rare common species. The result of Dissimilarity coefficient (D_s) (0.88) which is near to one interprets that the communities of sacred grove and non sacred grove are totally different.

Table 1: Quantitative evaluation of study sites

S. No	Site	Simpson diversity index	Shannon Weiner index	Menhinick's richness index	Evenness	Sorensen coefficient (S_s)	Dissimilarity coefficient (D_s)
1	KJI	0.09	2.39	1.51	0.88	0.12	0.88
2	KJO	0.4	0.96	0.73	0.87		

2. Biomass estimation of trees:

The results of quantitative analysis of data revealed that the tree density was greater in site 1 as compared to site 2. The tree density varied from 80 individual/ha to 5 individual/ha in sacred grove and 62.5 individual/ha to 18.75 individual/ha in non sacred grove, respectively. *Diospyros melanoxylon* showed highest density (80 individual/ha) at site 1 and *Boswellia serrata* (62.5 individual/ha) at site 2, respectively. The sacred grove is dominated by *Diospyros melanoxylon* followed by *Syzygium cumini* while non sacred grove is dominated by *Boswellia serrata* followed by *Diospyros melanoxylon*.

The total biomass is the sum of aboveground and belowground biomass of the plant species. The total biomass of different tree species of sacred grove is depicted in figure 1.

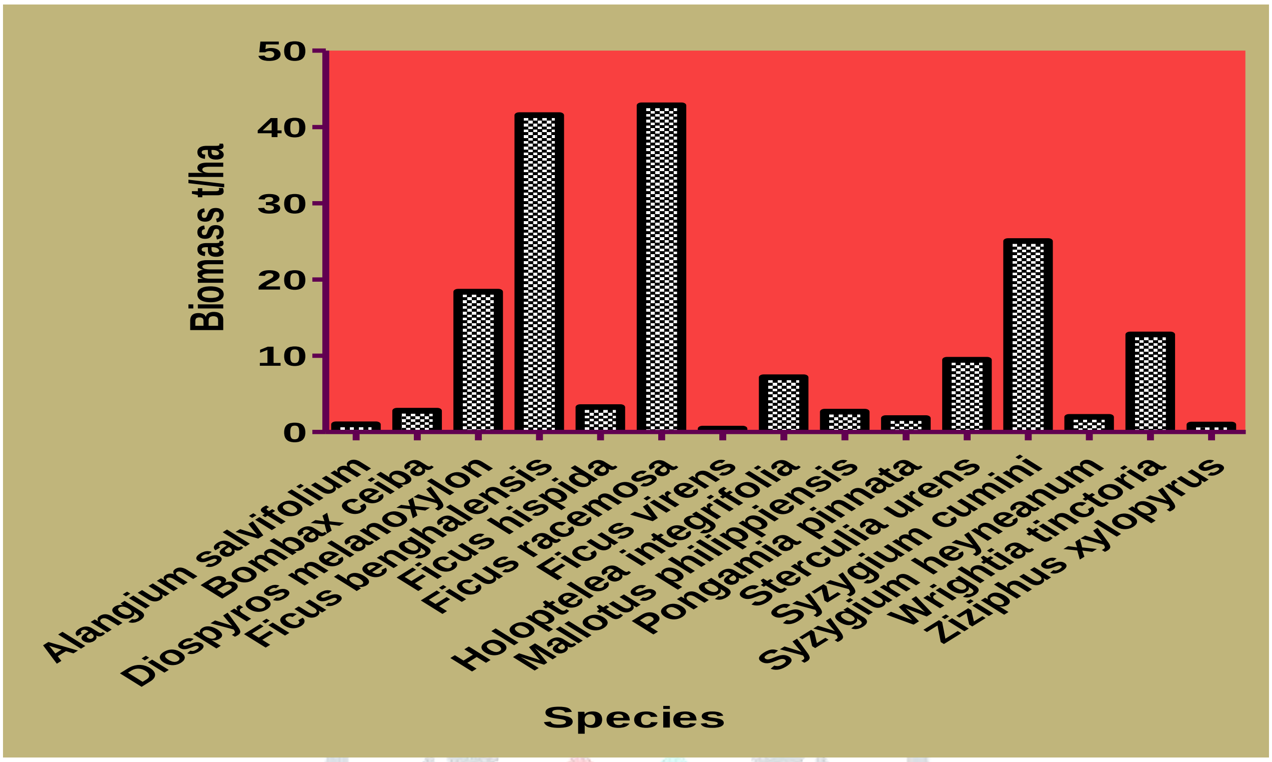

Figure 1: Total biomass (t/ha) of different tree species of sacred grove

The total biomass was greater in site 1 (172.37 t/ha) (table 2) and the maximum contribution was showed by *Ficus racemosa* (42.83 t/ha) and the minimum contribution was reported by *Ficus virens* (0.44 t/ha)while at site 2 the total biomass was 28.22 t/ha (table 1) where *Boswellia serrata*(26.4 t/ha) showed the highest contribution followed by *Diospyros melanoxylon* (1.51 t/ha) and *Acacia catechu* (0.28 t/ha),respectively.The above ground carbon, belowground carbon and total carbon was found more in sacred grove than non sacred grove. Several workers have studied the comparative account for plant diversity of sacred grove and non-sacred grove but not of carbon sequestration.

Table 2: Aboveground, belowground and total biomass of trees

S. No.	Site	AGB (t/ha)	BGB (t/ha)	TB (t/ha)
1	KJI	149.89	22.48	172.37
2	KJO	24.54	3.68	28.22

3. Carbon stock estimation and variation:

The carbon stock estimation of trees was observed at both the sites and results revealed the highest AGC (74.95 t/ha), BGC (11.24 t/ha) and TC (86.19 t/ha) (figure 2) at site 1 as compared to site 2 with AGC (12.27 t/ha), BGC (1.84 t/ha) and TC (14.11 t/ha), respectively. The present carbon stock of sacred grove is within the range of carbon stock (15.6 – 151 t/ha) as reported by Chaturvedi *et al*. (2011) in tropical dry forest of India. Biomass and carbon stock are related to each other as Ravindranath *et al*. (1997) stated that the 50% of standing biomass is carbon itself. The more carbon storage capacity of this sacred grove by the trees might be due to the conservation efforts laid down by the Maharajji by their religious faith and belief. Therefore, the presence of older grown trees in the sacred grove has efficient ability to sequester carbon dioxide.

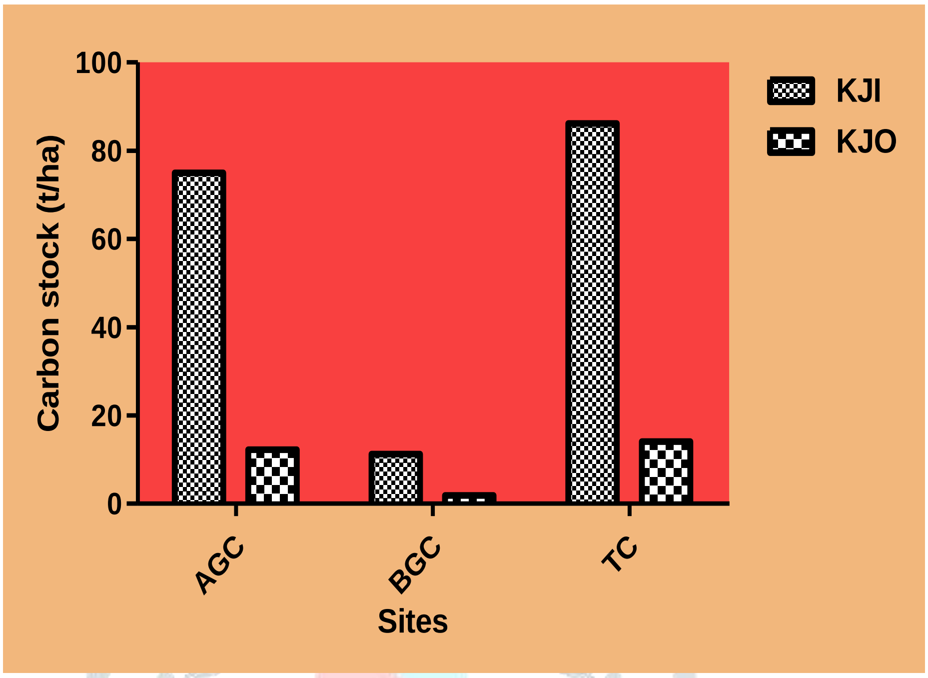

Figure 2. Carbon stock assessment of trees of sacred and non sacred grove

The above ground carbon, belowground carbon and total carbon was found more in well protected sacred grove than non sacred grove. Several workers studied the comparative account for plant diversity in sacred groves and non-sacred groves but not for the carbon sequestration.
However, the carbon stock of trees in Kaner jhir sacred grove is less than the carbon stock of Resunga sacred grove in Nepal (127.75 t/ha) as reported by Sharma *et al*. (2015).

4. Total Carbon stock in different pools of sacred and non sacred grove:

The carbon stock was stored by different components i.e. trees, shrubs, herbs litter and soil at both the sites. The total carbon content contributed by trees was 86.19 t/ha at KJI and 14.11 t/ha at KJO, respectively. Understory vegetation (shrubs + herbs) contributed 0.73 t/ha to the carbon pool at site KJI while at site KJO it was 0.26 t/ha. Litter contains 2.43 t/ha of total carbon content at site KJI while it was 1.08 at site KJO.Soil organic carbon was estimated to be 37.18 t/ha (site KJI) and 28.39 t/ha (Site KJO), respectively. Similar work has been done by Devagiri *et al*. (2012) and estimated the total carbon stock (207 t/ha) of sacred grove in Kodagu district that is more as compared to the present study (126.53 t/ha).

Table 3: Total carbon stock (t/ha) among different components of two sites

SITE	TREES	SHRUBS	HERBS	LITTER	SOC	TOTAL
KJI	86.19	0.58	0.15	2.43	37.18	126.53
KJO	14.11	0.19	0.07	1.08	28.39	43.84

The total carbon stock of the whole ecosystem of sacred grove was estimated to be 126.53 t/ha (table 3) at site KJI of which 68.1% was contributed by trees, 0.46% by shrubs, 0.79% by herbs, 1.92% by litter and

29.4% by soil (figure 3).The total carbon stock of non sacred grove (KJO) was 43.84 t/ha of which 32.2% was contributed by trees, 0.42% by shrubs, 0.16% by herbs, 2.47% by litter and 64.8% by soil (figure 4).

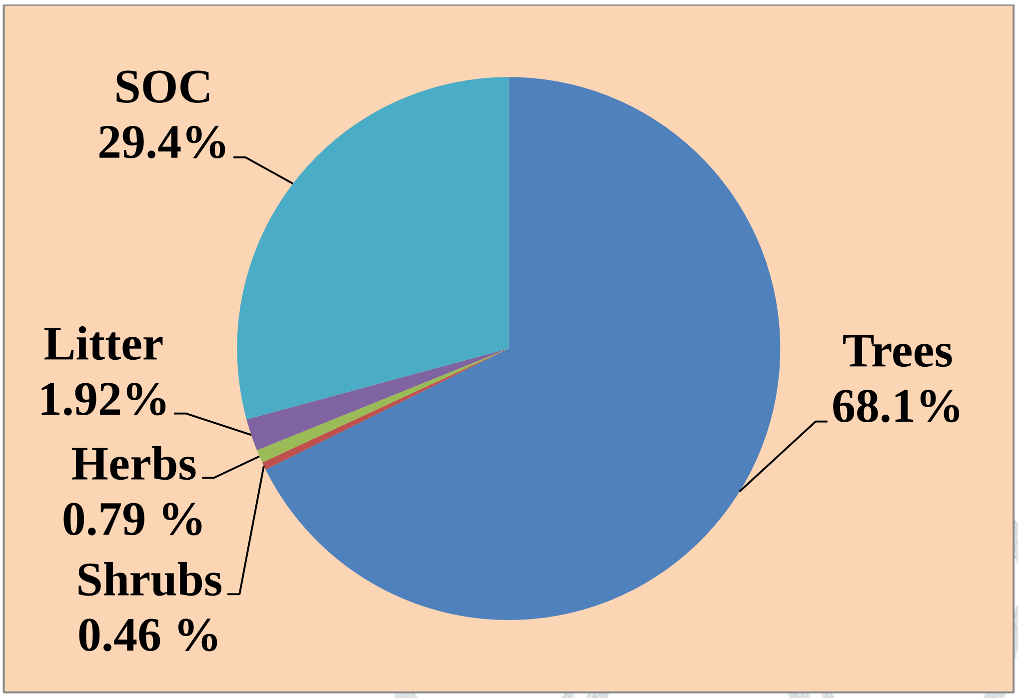

Figure 3: Contribution of total carbon content by different pools at KJI

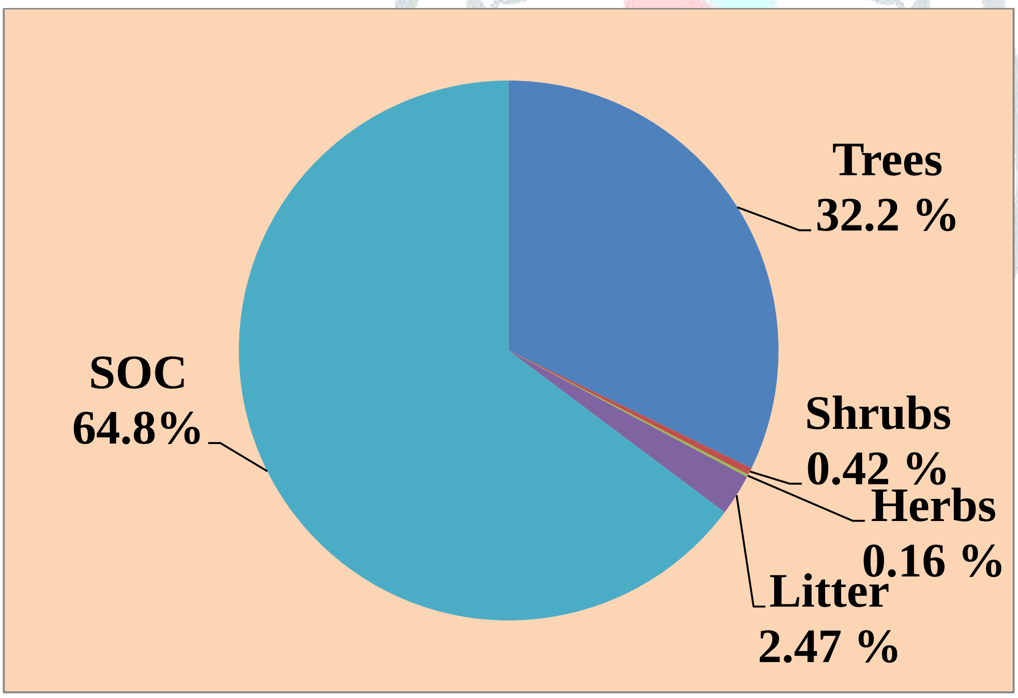

Figure 4: Contribution of total carbon content by different carbon pools at KJO

The percent contribution of AGB to total biomass was estimated as 87.53% (Site KJI) and 86.95% (Site KJO) in the present study which is more than the over story biomass contribution (81% and 81.9%) as reported by Henry *et al*. (2009) and Nascimento and Laurance (2002). However, Clark and Clark (2000) reported 92.7 to 94% of overstorey contribution that is more than the present study. The percentage contribution of the understory to the total forest biomass in site KJI was 0.82% and 0.43% at site KJO, respectively. However, the current findings are less than 0.9% understory biomass contribution as reported by Negi (1984).The ratio of SOC and biomass carbon was 1.25 as reported by Ravindranath *et al*. (1997). In the present study, the SOC and biomass carbon ratio at site-KJI was 2.3 and KJO was 0.4, respectively that are less than Kaul (2010) findings, as the reported range of this ratio lies between 0.7 and 2.

IV. CONCLUSION:

The studies undertaken in Kaner jhir sacred grove of Gwalior district provide enough indications that the landscape as whole has high carbon stock and sequestration potential as compare to the adjacent area that may significantly contribute to reduce the major greenhouse gas.These forest patches are conserved in a unique traditional way due to various restrictions laid down by Maharajji. Due to this conservation, the sacred grove provides all ecosystem services in different ways. But there is more need to bring awareness and awaken the local people scientifically as that can bring the sustainable development of environment in nearby future. Finally, it is important to acknowledge the efforts of the people in preserving the small sacred patches of forests as local biodiversity.

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