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Vegetation composition, tree diversity, Biomass and carbon stock of Kanger Valley National Park

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ABSTRACT

This study focuses on vegetation composition, tree diversity, biomass and carbon stock within Kanger Valley National Park of Bastar district (C.G), a biodiverse hot spot located in central India. The research comprised of systematic field surveys to identify and document tree species present in various zones of the park. A combination of quantitative measures such as Phytosociological analysis, diversity indices, biomass and carbon stock were estimated. Density and basal cover of tree layer across the three study sites were 220 to 520 trees ha⁻¹ and 18.56 to 26 m²ha⁻¹, respectively. Sapling layer density and basal cover across the three study sites were 110-260 trees ha⁻¹ and 0.34-0.74 m²ha⁻¹, respectively. Shannon-Wiener diversity index respectively ranges from 2.88 to 3.39 for tree layer and 2.29 to 3.96 for saplings layer. Equitability were from 1.10-1.25 and 1.29 -1.59, respectively for tree and sapling layer, whereas, species richness was from 3.08-5.53 for tree layer and 3.64 to 13.58 for sapling layer. Total biomass across the study sites was between 286.43 and 3144.44 t ha⁻¹ and was maximum on site-1 and minimum on site III. Litter layer also followed the similar trend being maximum (3.85 t ha⁻¹) on site I and minimum on site III (2.62 t ha⁻¹). The total carbon stock ranged between 110.52t ha⁻¹ and 133.87 t ha⁻¹, being maximum on site I, and minimum on site III. The dominated tree species on site I was *Anogesissus latifolia* and *Casaria graveolens*, site II was dominated by *Shorea robusta* and *Pterocarpus marusupium* and site III was dominated by *Schleichera oleosa* and *Semecarpus anacardium*. Study revealed that the structure, diversity, biomass and carbon stock in present study site are the result of protection and conservation.

Key words: Diversity, Tree, Carbon stock, Kanger Valley National Park, Species

Introduction

India being rich in biodiversity is one of the 12 mega diversity centre of the world. To safeguard this richness, a number of areas like Biosphere Reserve, National Park and Sanctuary have been declared as protected area. Kanger Valley National Park was established on 22 July 1982 and situated 25 km south-east of Jagdalpur, the headquarter of Bastar district on Jagdalpur-Darbha Road, is one of such floristically-rich protected areas. It lies between

18°45' to 18°56'30" N and 81°51'30" to 82°10' E and covers an area of 200 sq km. The park, starting from Tirathgarh waterfall to Kolab river (Orissa state boundary), is nearly 33.5 km long and about 6 km broad. The entire area of the park has been divided into two ranges, Kotamsar and Koleng (Jha and Khanna, 2005). Situated in the heart of central India, this protected area has garnered significant attention due to its remarkable biodiversity and unique ecosystems. Among the pivotal components that contribute to its ecological significance is the intricate

tapestry of tree species that populate its landscapes.

Trees, as the foundational pillars of terrestrial ecosystems, play an indispensable role in maintaining the delicate balance of nature. Their ecological functions range from providing habitat and sustenance for various wildlife species to stabilizing soils, regulating water cycles, and sequestering carbon dioxide. The composition and diversity of tree species within an ecosystem are not only indicative of its health but also offer insights into the historical and environmental forces that have shaped it. The study is aimed to inventories the vegetation composition, diversity, biomass and carbon stock of the Kanger Valley National Park.

Materials and Methods

Study area

The study was conducted at Kanger Valley National Park of the Bastar Forest Division, Bastar District, Chhattisgarh.

Temperature

Mean monthly maximum temperature ranges from 28.9 °C in November to 35.7 °C in June, while the mean monthly minimum temperature ranges from 10.8°C in January to 22.7 °C in June. The mean annual temperature of the site was 24.44 °C (based on the weather data of Jagdalpur for the period from July 2022 to June 2023)

Methods

Based on the repeated reconnaissance survey, Kanger Valley National Park was categorized into three sites e.g. high, medium and low forest which is based on visual interpretation, and representative of the region's vegetation were selected for the present study. A plot of 100 m x100 m area visually representative of the overall vegetations was selected and marked on each of the three sites for the detailed study. The forest stand on each site was analyzed using 10 randomly placed quadrats (each 10 × 10 m in size) within the representative plot of 1 ha. Girth (at breast height, GBH) of each individual tree in every quadrat was measured and recorded. The vegetational data were analyzed to calculate frequency, density and abundance (Curtis and McIntosh, 1950). The IVI was measured as the sum of relative density, relative frequency and relative dominance (Phillips, 1959) and diversity indices

were calculated following Sagar and Singh (1999).

For the measurement of tree biomass, allometric equations relating tree circumference to biomass developed earlier by Singh and Mishra (1979) were used. Computation protocol as described by Singh and Singh (1991) was used. In brief, mean GBH value for each species for a girth class was used in the regression equation to get mean biomass (by component) for that girth class, these values were then multiplied by the density of the tree in that girth class for each quadrat. The estimates were averaged along the number of quadrats to get the mean estimates for the sites. Forest floor litter was collected by using 10, 50 cm × 50 cm randomly placed quadrates on each site, and then classified into various components such as fresh leaf, wooden and partially decayed litter following Singh (1995). The collections were brought to the laboratory separately by category and oven dry weights were determined.

For the estimation of C storage mean C concentrations estimated earlier by Singh (2010) was used. The C storage for the vegetation components was computed as sum of the products obtained by multiplying dry weights of the components with their mean carbon concentrations. The values for C storage in different components were summed to obtain the total C storage in the vegetation (Jhariya and Yadav, 2018; Khan *et al.*, 2020a, 2020b; Kujur *et al.*, 2021).

Results and Discussion

Vegetation composition

Vegetation composition of tree and sapling layers is given in Table 1 and 2. Tree basal cover in this study ranged from 18.56 to 26.00m²ha⁻¹ on different sites. These basal cover values were compared with the values reported for several dry tropical forest communities in Eastern Ghats (Sahu *et al.*, 2016) where average basal cover was 15.20 m² ha⁻¹. The basal cover in tropical dry deciduous forest was 3.80 to 10.36 m²ha⁻¹ (Singh and Singh, 1991). Basal cover in a Puerto Rican sub-tropical dry forest was 19.8 m² ha (Murphy and Lugo, 1986a). These values compare with Vindhyan region reported by Jha and Singh (1990) ranged from 6.58 to 23.21 m² ha⁻¹ and 26.3 m²ha⁻¹ in sal dominated forest of eastern Himalaya (Shankar, 2001). Leuschner *et al.* (2009) have reported total basal cover at Sulawesi (Indone-

Table 2. Species structure of saplings in high, medium and low forest of study site

S. No.	Scientific name	Family	Site-1 (Dense)			Site-2 (Medium)			Site-3 (Low)			
			Frequen- ncy %	Density (ha)	BA (m ² /ha)	Frequen- ncy %	Density (ha)	BA (m ² /ha)	Frequen- cy %	Density (ha)	BA (m ² /ha)	
1	<i>Psidium guajava</i>	Myrtaceae	20.00	20.00	0.05	25.54						
2	<i>Anogeissus acuminata</i>	Combrataceae	10.00	10.00	0.02	12.50	10.00	10.00	0.04	29.49		
3	<i>Artocarpus lakoocha</i>	Oxalidaceae	30.00	60.00	0.14	58.34					20.00	20.00
4	<i>Bixa Orellana</i>	Bixaceae	30.00	60.00	0.20	66.58					30.00	30.00
5	<i>Flacourtia indica</i>	Flacourtiaceae	10.00	10.00	0.04	15.32						
6	<i>Holarthena Pubescens</i>	Apocynaceae	20.00	20.00	0.08	30.23						
7	<i>Casaria gmeolens</i>	Flacourtiaceae	10.00	20.00	0.03	16.87	20.00	30.00	0.11	72.98	20.00	30.00
8	<i>Bridelia montana</i>	Euphorbiaceae	10.00	10.00	0.03	13.69						
9	<i>Shorea robusta</i>	Dipterocarpaceae	10.00	20.00	0.05	19.86						
10	<i>Zizyphus rugosa</i>	Rhamnaceae	10.00	10.00	0.01	10.58					10.00	10.00
11	<i>Adina caedofolia</i>	Rubiaceae	10.00	10.00	0.06	17.22					10.00	10.00
12	<i>Wendlandia exserta</i>	Rubiaceae	10.00	10.00	0.03	13.27						
13	<i>Terminelia chebula</i>	Combretaceae					10.00	10.00	0.03	27.23		
14	<i>Pterocarpus marsupium</i>	Fabaceae					20.00	20.00	0.08	59.02		
15	<i>Cleistanthus collinus</i>	Phyllanthaceae					20.00	30.00	0.15	82.57		
16	<i>Semecarpus anacardium</i>	Anacardiaceae					10.00	10.00	0.04	28.70	10.00	20.00
17	<i>Schleichera oleosa</i>	Sapindaceae									10.00	10.00
18	<i>Strychnos nux-vomica</i>	Loganiaceae									10.00	10.00
19	<i>Garuga pinnata Roxb.</i>	Burseraceae									10.00	10.00
	Total		180.00	260.00	0.74	300.00	90.00	110.00	0.45	300.00	130.00	150.00
											0.34	300.00

sia) between 21.2 and 52.3 m²ha⁻¹. Mani and Parthasarathy (2007) observed total basal area between 12.4 and 22.1 m²ha⁻¹. A very high value of basal area ie, 131 m²ha⁻¹for the forests of Sariska Tiger Reserve was reported by Rodgers (1990).

In present study, tree density was 220 stems ha⁻¹ for sites III and 500 stems ha⁻¹ for site I. Tree density values in present study were higher than 484 stems ha⁻¹ reported for sal dominated forest of eastern Himalaya by Shankar (2001); 82 to 468 stems ha⁻¹ reported for moist deciduous forest by (Upadhyay *et al.*, 2008). Tree density was 981 individuals per hectare in moist tropical forests of eastern Nepal (Gautam and Mandal, 2018). Density values ranges from 458-728 stems ha⁻¹ reported in tropics (Sundarapandian and Swamy, 2000) and of 575- 855 stems/ha for Kalakad, Western Ghat (Parthasarathy, 1999).

This study compared with the density of forest in Pudukottai district of Tamil Nadu of Tropical dry evergreen forest where density was 596 to 886 stems ha⁻¹(Mani and Parthasarathy, 2007) and of 818 to 1540 stems ha in tropical rain forest (Kiratiprayoon, 1986). Tree diversity in the Vindhyan area ranges from 294 to 627 stems / ha for several humid tropical forest communities (Singh and Singh, 1991; Jha and Singh, 1990). The forest canopy in the present forest was three storied. The dry tropical forest usually has 1-3 and three or more humid tropical forest tree layers (Murphy and Lugo, 1986b).

Sapling layer density and basal cover across the three study sites were 110-260 trees ha⁻¹ and 0.34-0.74 m² ha⁻¹ respectively.

Species diversity

Species diversity of trees, viz. the number of species in a community is ecologically and of biological significance. Diversity parameter for trees revealed that the species richness and the Shannon-wiener index (H') for tree species were higher in site I(3.39) while lower in site

III (2.88) (Table 3). The degree of comparative dominance of each species in that region is reflected in equitability or evenness (e). The equitability of trees is higher in site III (1.25) while lower in site II (1.10). The species richness or variety index (d) species in a specific zone depends on the quantity of species found, yet in addition in their numbers. The tree species richness on this site ranged from 3.08 to 5.53. Species diversity of saplings, viz. the number of species in a community is ecological and of biological significance.

Trees and shrub biomass

The stand biomass on three study sites of Kanger Valley National Park study sites is given in Table 5. Total biomass on three study sites ranged between 263.46 t/ha and 314.44 t ha⁻¹, of which 185.58t ha⁻¹ to 243.26 t ha⁻¹ in AGB and 71.18 to 79.03 t ha⁻¹ in BGB. The biomass in different component was distributed as follows: bole 60.49 - 85.44 t ha⁻¹, branch: 115.19 - 143.87 t ha⁻¹, leaf 6.15-7.53 t ha⁻¹ and root 69.24-77.81 t ha⁻¹ in tree vegetation. *Pterocarpus marsupium* had

the highest biomass among the species on site I and II where as on site III *Schleichera oleosa* had the highest biomass.

Above ground shrub biomass varied between 1.12 to 2.55 t ha⁻¹ and below ground shrub biomass varied between 0.86 to 1.96t ha⁻¹. Above ground shrub biomass and below ground shrub biomass were highest on site I and lowest on site III like others component.

Litter biomass on different sites

Total litter biomass on the three study sites varied between 2.62 and 3.85 t ha⁻¹. Site I had a maximum litter biomass (3.85 t ha), whereas Site II had a minimum (2.62 t ha⁻¹) (Table 5).

Brown and Lugo (1982) obtained an inverted U-shaped curve in relation to total biomass to the T/P ratio (Temperature / Precipitation), where T = mean annual temperature and P = total annual rainfall), with peak biomass values in the tropical forest life zone and lower values in wetter and drier forests.

Using the relationship given by Brown and Lugo

Table 3. Diversity parameter for tree and sapling layers on three study sites of Kanger Valley National Park study sites

	Shannon- Winner Index (H')	Equitability (e)	Species richness (D)
Tree layer			
Site-1	3.39	1.15	5.53
Site-2	3.19	1.10	5.35
Site-3	2.88	1.25	3.08
Sapling layer			
Site-1	2.29	1.28	7.26
Site-2	3.96	1.59	13.58
Site-3	2.84	1.29	3.64

Table 4. Stand Biomass (t ha⁻¹) on three study sites of Kanger Valley National Park study sites

Tree components	Biomass (t ha ⁻¹)				SD	SEM
	Site-1	Site-2	Site-3			
Bole	85.44	78.73	60.49		12.91	7.45
Branch	143.87	116.87	115.19		16.10	9.29
Leaf	7.53	6.50	6.15		0.72	0.41
Root	69.24	77.81	77.02		4.73	2.73
Total	306.09	279.91	258.86			
Aboveground shrubs	2.55	1.57	1.12		0.73	0.42
Belowground shrubs	1.94	1.22	0.86		0.55	0.32
Litter Biomass	3.85	3.73	2.62		0.68	0.39
Vegetation Components						
Aboveground biomass	243.26	207.40	185.58			
Belowground Biomass	71.18	79.03	77.88			
Total	314.44	286.43	263.46			

(1982), $Y=596+478 \log (X-224)$; where Y is the total biomass $t ha^{-1}$, and X is T:P multiplied by 100, the expected biomass for present study given by Brown and Lugo (1982), the expected biomass for the present forest (T/P=1.04, T=24.44°C and P=2370 mm) is about $291 t ha^{-1}$. The estimated biomass (263-314) mean $288 t ha^{-1}$ is around the predicted value.

Total biomass in most of the dry forests it ranged from $78-320 t ha^{-1}$ and $269-1186 t ha^{-1}$ and in tropical moist forests (Murphy and Lugo, 1986). Total biomass in moist tropical forests was between 452 and $960 t ha^{-1}$ (Gautam and Mandal, 2018). Total biomass in the present study was 263.46 to $314.44 t ha^{-1}$. Rai and Proctor (1986) have reported $434-669 t ha^{-1}$ total biomasses for tropical rain forests of India (Karnataka).

Aboveground biomass in the present study (185.58 to $243.26 t ha^{-1}$) was towards the middle of the range ($28-513 t ha^{-1}$) reported for a variety of tropical forests. Global pattern of AGB in tropical dry and wet forests was $30-273 t ha^{-1}$ and $213-1173 t ha^{-1}$, respectively (Murphy and Lugo, 1986b). For subtropical dry forests, Rodin and Bazilevich (1967) have reported $408 t ha^{-1}$ AGB, which is more than five times greater than the current values.

Carbon storage

Total carbon stock on three study sites of Kanger Valley National Park study sites is given in Table 6. Total carbon stock on three study sites ranged between 82.29 and $133.87 t ha^{-1}$, of which 82.29 to $107.5 t carbon ha^{-1}$ in above ground part and 26.35 to $28.82 t carbon ha^{-1}$ in below ground parts. The carbon in different component were distributed as follows: bole 26.31 to $37.17 t ha^{-1}$, branch: $52.61-65.71 t ha^{-1}$, leaf $2.87-3.52 t ha^{-1}$ and root $24.74-27.80 t ha^{-1}$ in tree vegetation.

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Table 5. Litter biomass ($t ha^{-1}$) on three study sites of Kanger Valley National Park study sites.

S. No	Component	Site-1	Site-2	Site-3	SD	SEM
		Mean	Mean	Mean		
1	Fresh leaf litter	1.00	0.63	0.47	0.28	0.159075
2	Litter layer	1.24	1.51	0.77	0.37	0.215646
3	Partially decayed Litter	0.78	0.68	0.82	0.07	0.041644
4	Woody litter	0.83	0.91	0.56	0.18	0.105334
	Total	3.85	3.73	2.62	0.68	0.39

Table 6. Carbon stock ($t ha^{-1}$) on three study sites of Kanger Valley National Park study sites

Tree component	Carbon ($t ha^{-1}$)			SD	SEM
	Site-1	Site-2	Site-3		
Bole	37.17	34.25	26.31	5.62	3.24
Branch	65.71	53.38	52.61	7.35	4.24
Leaf	3.52	3.03	2.87	0.34	0.19
Root	24.74	27.80	27.52	1.69	0.98
Total	131.13	118.46	109.31		
Aboveground shrubs	1.14	0.72	0.50	0.32	0.19
Belowground shrubs	1.61	1.02	0.71	0.46	0.26
Vegetation Components					
Aboveground Carbon	107.53	91.38	82.29		
Belowground Carbon	26.35	28.82	28.23		
Total	133.87	120.20	110.52		

Conflict of interest: None

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