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Diversity indices and importance values of a tropical deciduous forest of Chhotanagpur plateau, India

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Key words: Deciduous forest, Forest structure, Species composition, Importance values index, Species diversity.

Abstract

Ecological study was carried out by establishing four one hectare (ha) plots one each in Jiradih (site-I), Chargi (site-II), Sandoi (site-III) and Chiruvabera (site-IV) in December 2012 in the tropical deciduous forest around the Chhotanagpur plateau of Bokaro district, Jharkhand. At each site, 1-ha plot (100 m × 100 m) was demarcated by nylon rope and each plot was divided into 100 quadrats of 10 m × 10 m in size. For each 10 m × 10 m quadrat, the number of species and stem density were recorded. The dbh was used in the measurement of basal area. The forest stands were moderately dense with total 1470 adult stems (> 9.6 cm) in the 4 hectares (mean density 368 stems ha^{-1}). The IVI results show that the tree species with high importance values differs from site to site. The species richness is not uniformly distributed in the forest sites; the three sites were mosaic of low and high diversity patches. Therefore, this study highlights the loss of species richness and species evenness; consequently, the restoration and conservation of tropical deciduous forests.

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Introduction

Tropical forests canopy only 7% of the Earth's land surface (Wilson, 1988), but harbour more or less two-thirds of all biological populations (Hughes *et al.,* 1997). The tropical forests are currently disappearing at an overall rate of between 0.8-2.0% per year (May and Stumpf, 2000). About 14-40 thousand species per year are estimated to be lost due to tropical-forest habitat destruction (Hughes *et al.*, 1997). In spite of the best protection efforts, most natural tropical forests are now under threat due to various human activities (Chaturvedi *et al.*, 2011). On a global basis, 52% of total forests are tropical and over 42% of tropical forests have been classify as dry forest (Holdridge, 1967). It is now widely accepted that forests should be managed in an ecologically sustainable fashion (Kohm and Franklin, 1997; Lindenmayer *et al.*, 2000).

The fragmented and reduced populations that result from human disturbances are issues of growing importance in evolutionary and conservation biology (Sork *et al.,* 2002). The knowledge of the floristic composition of an area is a perquisite for any ecological and phyto-geographical studies and conservation management activities (Jafari and Akhani 2008; Tavankar, 2013). It has been well documented that species composition and diversity can be used as indicators of past management practices in forested areas (Hunter, 1999; Kneeshaw *et al.*, 2000). Species diversity is an important index in community ecology (Mayer and Harms, 2009). Degraded plant communities are generally quite difficult or sometimes impossible to restore (Van Diggelen and Marrs, 2003), moreover the continuous severe disturbances reduce the number of species and alter the species composition (Heydari *et al.*, 2013). The depletion of the resource base of the dry tropical forest is causing concern (Rathore, 2002; Bhuiyan *et al.*, 2009).

Quantitative floristic inventories based on small sized permanent plots (1-2 ha) have been used in recent years to characterize the vegetation in different tropical forests by documentation their structure, composition and diversity (Parthasarathy, 2001; Sagar *et al.*, 2003). There has been increasing interest even in documenting the long-term dynamics of tropical forests through the establishment of permanent plots. The information resulting from forest inventories not only provides data on the floristic composition and abundance of individual species, but also on detailed structural attributes of the vegetation (Palomino and Alvarez, 2009).

The present study was aimed to understand the floristic composition of tropical dry forest in based on four, one hectare (1-ha) plots located at four sites around the Chhotanagpur region of the Bokaro District. In this paper, also assess the spatial variation in phytosociological parameters of tree species in tropical deciduous forests.

Materials and methods

Study area

The study area was located in the tropical deciduous forests around western part of the Bokaro district, Chhotanagpur Plateau, India (latitude 23° 35' 87" N to 23° 37' 03" N, longitude 85° 48' 30" E to 85° 50' 42" E). The elevation of the study area ranges from 200 to 350 m above sea level. The mean annual precipitation of the district is 1363.57 mm. It is characterized by hot and dry summer from March to June and cold winter from November to February. Humidity is high from July to September with mean annual humidity is nearly 60%. The regional slope of the district is towards east and controlled the alignment of the tributaries of Damodar River. Sal (*Shorea robusta*) is by far the predominant species of trees in the study area. The soils of Bokaro district can be broadly grouped into the soil developed in different formations like granite or granite gneiss of Archean age, sandstone and shales of Gondwana formation and alluvial plain.

Field survey

Ecological study was carried out by establishing four one hectare (ha) plots one each in Jiradih (site-I),

Chargi (site-II), Sandoi (site-III) and Chiruvabera (site-IV) in December 2012 in the tropical deciduous forest around Chhotanagpur plateau, India. At each site, 1-ha plot (100 m × 100 m) was demarcated by nylon rope and each plot was divided into 100 quadrats of 10 m × 10 m in size. These sites were located 2 to 7 km apart from each other. In each quadrat, the diameter at breast height (dbh) of all adult trees (≥ 9.6 cm) and saplings (≥ 3.2 to < 9.6 cm) were measured and identified. The inventory of established seedlings was carried out at diameter < 3.2 cm at ≥ 30 cm height (Sagar *et al.*, 2003). The circumference of adults and sapling individuals was measured at 1.37 m from the ground and for seedlings it was measured at 10 cm above the ground. For each 10 m × 10 m quadrat, the number of species and stem density were recorded. The dbh was used in the measurement of basal area.

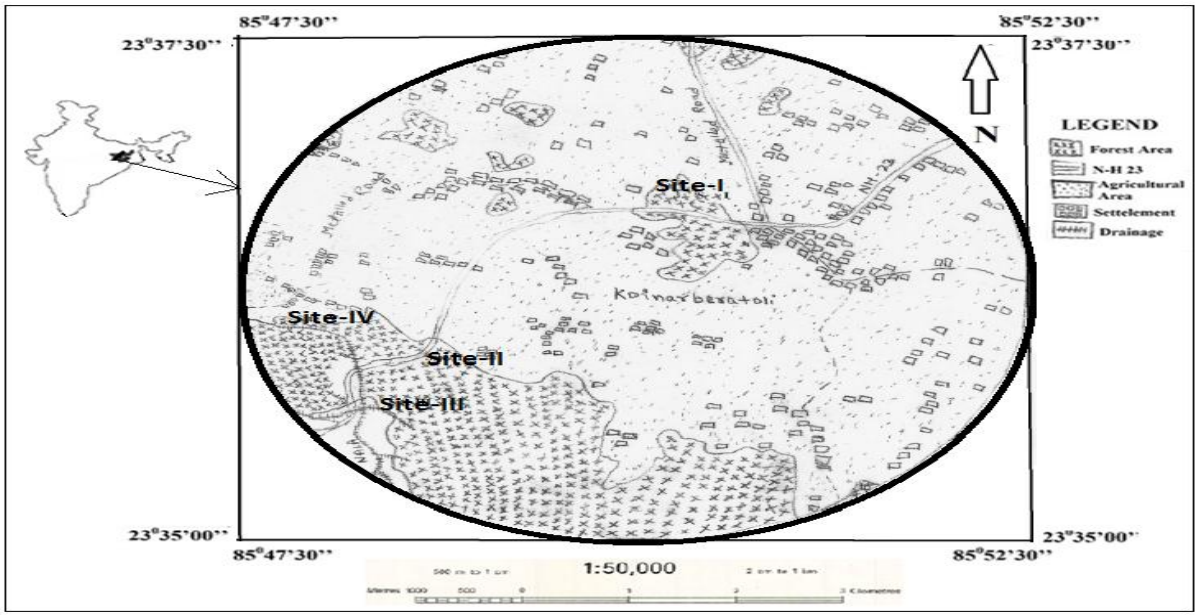

Fig. 1. The location map of the study area.

Data analysis

The vegetation data were quantitatively analysed for basal area, relative density, relative frequency and relative dominance (Phillips, 1959). The Importance Value Index (IVI) for the tree species was determined as the sum of the relative frequency, relative density and relative dominance (Cottam and Curtis, 1956).

Basal area (m^2) = Area occupied at breast height (1.3 m) = πr^2 .

Relative density = (Total number of individuals of species/ Total number of individuals of all species)×100.

Relative frequency = (total number of quadrats in which species occurred/total number of quadrats studied)×100.

Relative dominance = (Total basal area of a species/total basal area of all species)×100

Importance Value Index (IVI) = Σ relative density + relative frequency + relative dominance.

Different diversity indices were calculated using the following equations:

$$SR = \frac{S - 1}{ln(N)}$$

$$Ew = \frac{S}{\ln Ni - \ln Ns}$$

$$H' = -\Sigma\, pi \ln pi$$

In the above equations, SR is the Margalef index

(Margalef, 1958) of species richness, *S* the number of species, *N* the total number of individuals, E_w the Whittaker index of evenness (Whittaker, 1972), N_i the number of individuals of most abundant species, N_s the number of individuals of least abundant species, H' the Shannon–Wiener index (Shannon and Weaver, 1949), ln the natural log (i.e. base 2.718), pi the proportion of individuals belonging to species *i*.

Results and discussion

Forest structure and species composition

A total 38 tree species in 33 genera and 21 families were recorded in the four study sites, while two species remain unidentified (Table 1).

Table 1. Density (ha^{-1}) and basal area (m^2ha^{-1}) of tree species in different diameter classes.

	Diameter class									
Species name	<3.2	3.2- <9.6	≥9.6	>19.2	>28.8	>38.4	>48	>57.6	>67.2	Total
Site 1										
Shorea robusta	-	-	-	12(0.6)	116(11.1)	111(15.7)	38(8.1)	11(3.1)	2(0.7)	290(39.3)
Site 2										
Acacia catechu	111(0.078)	53(0.34)	29(0.31)	-	-	-	-	-	-	193(0.728)
Butea monosperma	1250(0.88)	36(0.23)	89(1.4)	-	-	-	-	-	-	1375(2.51)
Bombax ceiba	1(0.001)	-	1(0.02)	2(0.08)	-	-	-	-	-	4(0.1)
Boswellia serrata	29(0.02)	3(0.02)	10(0.25)	-	-	-	-	-	-	42(0.29)
Derris indica	1(0.001)		6(0.077)	-	-	-	-	-	-	7(0.078)
Diospyros melanoxylon	189(0.13)	24(0.15)	44(0.97)	-	-	-	-	-	-	257(1.25)
Ficus glabra	-	-	-	-	3(0.28)	-	-	-	-	3(0.28)
Ficus religiosa	1(0.001)	-	-	-	2(0.2)	-	-	-	-	3(0.201)
Nyctanthes arbortristis	-	-	9(0.1)	-	-	-	-	-	-	9(0.1)
Phoenix dactylifera	62(0.04)	-	4(0.07)	-	-	-	-	-	-	66(0.11)
Shorea robusta	1280(0.9)	70(0.44)	72(1.0)	-	-	-	-	-	-	1422(2.34)
Soymida febrifuga	17(0.01)	-	16(0.26)	-	-	-	-	-	-	33(0.27)
Ziziphus jujuba	1(0.001)	-	4(0.07)	-	-	-	-	-	-	5(0.071)
Total	2942(2.062)	186(1.18)	284(4.5)	2(0.08)	5(0.48)	-	-	-	-	3419(8.3)
Site 3										
Anogeissus latifolia	-	1(0.006)	1(0.028)	5(0.19)	-	-	-	-	-	7(0.224)
Anthocephallus cadamba	22(0.015)	-	4(0.16)	-	-	-	-	-	-	26(0.175)
Azadirachata indica	1(0.001)	-	2(0.03)	-	-	-	-	-	-	3(0.031)
Bombax ceiba	4(0.002)	2(0.013)	3(0.11)	-	-	-	-	-	-	9(0.125)
Buchnania lanzan	117(0.08)	14(0.089)	35(0.35)	-	-	-	-	-	-	166(0.519)
Cassia fistula	-	2(0.013)	18(0.18)	-	-	-	-	-	-	20(0.193)
Dalbergia sissoo	-	-	1(0.02)	2(0.07)	-	-	-	-	-	3(0.09)
Diospyros melanoxylon	110(0.078)	52(0.33)	33(0.588)	15(0.63)	-	-	-	-	-	210(1.626)
Flacourtia indica	-	-	3(0.05)	-	-	-	-	-	-	3(0.05)
Grewia serrulata	-	10(0.06)	2(0.02)	-	-	-	-	-	-	12(0.08)
Lagerstroemia parviflora	93(0.066)	65(0.41)	76(0.79)	-	-	-	-	-	-	234(1.266)
Lannea coromandelica	-	4(0.025)	21(0.32)	-	-	-	-	-	-	25(0.345)
Madhuca indica	19(0.013)	4(0.025)	16(0.37)	9(0.35)	1(0.067)	-	-	-	-	49(0.825)
Manilkara hexandra	58(0.04)	38(0.24)	14(0.15)	-	-	-	-	-	-	110(0.43)
Miliusa tomentosa	2(0.0014)	-	7(0.15)	-	-	-	-	-	-	9(0.151)
Moringa oleifera	-	-	3(0.05)	-	-	-	-	-	-	3(0.05)
Nyctanthes arbortristis	4(0.0028)	1(0.006)	6(0.06)	-	-	-	-	-	-	11(0.069)
Phoenix dactylifera	40(0.028)	1(0.006)	2(0.035)	-	-	-	-	-	-	43(0.069)
Pterocarpus marsupium	1(0.001)	-	2(0.05)	2(0.08)	-	-	-	-	-	5(0.131)

Semecarpus anacardium	1(0.001)	1(0.006)	8(0.088)	-	-	-	-	-	-	10(0.095)
Shorea robusta	2205(1.558)	49(0.31)	47(1.13)	64(2.43)	4(0.37)	3(0.45)	1(0.18)	-	-	2373(6.428)
Syzygium heyneanum	33(0.023)	2(0.013)	14(0.22)	-	-	-	-	-	-	49(0.256)
Terminalia arjuna	19(0.013)	2(0.013)	16(0.38)	1(0.04)	-	-	-	-	-	38(0.446)
Terminalia tomentosa	-	1(0.006)	6(0.15)	5(0.16)	-	-	-	-	-	12(0.316)
Terminalia bellirica	21(0.015)	3(0.019)	1(0.01)	-	-	-	-	-	-	25(0.044)
Terminalia chebula	-	-	2(0.019)	-	-	-	-	-	-	2(0.019)
Total	2750(1.9382)	252(1.6)	343(5.508)	103(3.95)	5(0.44)	3(0.45)	1(0.18)	-	-	3457(14.06)
Site 4	12.297									
Acacia catechu	52(0.018)	3(0.005)	8(0.087)	-	-	-	-	-	-	63(0.11)
Anogeissus latifolia	34(0.01)	14(0.038)	-	4(0.17)	-	-	-	-	-	52(0.218)
Butea monosperma	241(0.07)	116(0.26)	27(0.38)	-	-	-	-s	-	-	384(0.78)
Bombax ceiba	1(0.0002)	-	-	-	-	-	-	-	-	1(0.0002)
Boswellia serrata	28(0.01)	13(0.026)	7(0.18)	-	-	-	-	-	-	48(0.216)
Buchnania lanzan	194(0.06)	14(0.046)	18(0.31)	-	-	-	-	-	-	226(0.416)
Cassia fistula	4(0.002)	18(0.06)	3(0.028)	-	-	-	-	-	-	25(0.09)
Diospyros melanoxylon	1183(0.76)	229(0.47)	10(0.24)	2(0.07)	-	-	-	-	-	1424(1.54)
Lagerstroemia parviflora	412(0.29)	2(0.002)	38(0.39)	-	-	-	-	-	-	452(0.682)
Manilkara hexandra	228(0.15)	25(0.07)	5(0.47)	-	-	-	-	-	-	258(0.69)
Moringa oleifera	10(0.003)	19(0.3)	12(0.2)	-	1(0.08)	-	-	-	-	42(0.583)
Phoenix dactylifera	146(0.017)	15(0.02)	4(0.096)	1(0.03)	-	-	-	-	-	166(0.156)
Semecarpus anacardium	12(0.005)	12(0.029)	4(0.06)	2(0.06)	-	-	-	-	-	30(0.154)
Shorea robusta	3430(2.26)	305(1.58)	117(2.35)	87(3.2)	8(0.7)	12(1.84)	11(2.45)	5(1.5)	-	3975(15.84)
Soymida febrifuga	10(0.003)	30(0.05)	17(0.2)	-	-	-	-	-	-	57(0.253)
Syzygium cuminii	25(0.007)	12(0.03)	3(0.068)	-	-	-	-	-	-	40(0.105)
Terminalia arjuna	120(0.03)	35(0.06)	21(0.28)	-	-	-	-	-	-	176(0.37)
Terminalia tomentosa	12(0.003)	-	-	5(0.2)	-	-	-	-	-	17(0.203)
Woodfordia fruticosa	3(0.001)	9(0.017)	-	-	-	-	-	-	-	12(0.018)
A*	1(0.0002)	1(0.005)	1(0.027)	1(0.05)	-	-	-	-	-	4(0.0822)
B*	1(0.0001)	2(0.004)	-	-	-	-	-	-	-	3(0.0041)
Total	6147(3.69)	874(3.072)	295(5.366)	102(3.78)	9(0.78)	12(1.84)	11(2.45)	5(1.5)	-	7455(22.5)

*A, B = Unidentified plant species.

Combretaceae and Fabaceae with 6 species each dominated the forest canopy, followed by Anacardiaceae (3), Lythraceae, Meliaceae, Moraceae, Myrtaceae and Sapotaceae (2 species each). Density-wise, Dipterocarpaceae (721 trees) and Fabaceae (187 trees) dominated the stand.

Genera with a large number of plant species include *Terminalia* (4 species), *Ficus* (2) and *Syzygium* (2). Sagar and Singh (2005) enumerated 49 species belonging to 44 genera and 24 families in the Vindhyan dry tropical forests from the 15-ha area distributed over five sites. Kumar *et al.* (2011) recorded a total of 53 species of 29 families in 25 plots (20 m × 20 m) of dry deciduous forest in Rajasthan and the families that had the number of species were Fabaceae (9), Combretaceae (5), Verbenaceae and Rubiaceae. Sagar *et al.* (2008) recorded a total of 28 species, distributed in 14 families in nine plots (10 m × 10 m) woody plant canopies. Rahmad *et al.* (2014) recorded 480 trees representing 39 species, 32 genera and 15 families were identified of four transects (1 km long and 20 m wide) in the Penang, Malaysia of which 29 species (79 %) belonging to 24 genera and 13 families hosted mistletoes. Fabaceae was the most dominant host family (8 species), followed by Myrtaceae (4 species), Moraceae, Apocynaceae, Rubiaceae, and Sapindaceae (3 species). Mishra and Anshumali (2014), a total of 32 species (2 unidentified) belonging to 27 genera and 18 families

were recorded from three 1 ha plots (100 m × 100 m) of highly disturb forests in the Jharia Coal Field (JCF).

The Fabaceae and Moraceae were the most species family in the JCF. Upadhaya *et al.* (2015) a total of 131 tree species that belong to 107 genera and 49 families were recorded from the 6 forests stands in 5 ha plots (500 m × 100 m) of Garo hills of north-eastern India. Mohandass *et al.* (2015) enumerated a total of 1658 lianas stems (≥ 1 cm dbh) belonging to 33 species, 24 genera and 18 families were identified across four sites in ~13.58 ha in the Nilgiri hills and one from Palni hills.

Table 2. IVI of the most important species in the three sites (Site II, III and IV), Bokaro district Jharkhand.

Species	Relative dominance	Relative density	Relative frequency	IVI
Site II				
Acacia catechu	6.19	9.97	9.89	26.04
Butea monosperma	27.58	30.58	36.81	94.98
Bombax ceiba	1.96	1.03	1.65	4.64
Boswellia serrata	4.93	3.44	5.49	13.86
Derris indica	1.51	2.06	3.30	6.86
Diospyros melanoxylon	19.02	15.12	10.99	45.13
Ficus glabra	5.46	1.03	1.65	8.14
Ficus religiosa	3.93	0.69	1.10	5.72
Nyctanthes arbortristis	1.92	3.09	3.85	8.86
Phoenix dactylifera	1.36	1.37	2.20	4.93
Shorea robusta	19.68	24.74	14.29	58.71
Soymida febrifuga	5.14	5.50	6.59	17.23
Ziziphus jujuba	1.31	1.37	2.20	4.88
Site III				
Anogeissus latifolia	2.13	2.39	2.39	6.91
Anthocephallus cadamba	1.50	1.59	1.59	4.69
Azadirachata indica	0.29	0.80	0.80	1.88
Bombax ceiba	1.08	1.20	1.20	3.47
Buchnania lanzan	3.33	3.98	3.98	11.30
Cassia fistula	1.74	5.98	5.98	13.70
Dalbergia sissoo	0.90	1.20	1.20	3.29
Diospyros melanoxylon	11.55	7.57	7.57	26.69
Flacourtia indica	0.49	1.20	1.20	2.88
Grewia serrulata	0.19	0.80	0.80	1.79
Lagerstroemia parviflora	7.46	16.73	16.73	40.93
Lannea coromandelica	3.04	5.98	5.98	14.99
Madhuca indica	7.44	8.37	8.37	24.17
Manilkara hexandra	1.38	3.98	3.98	9.35
Miliusa tomentosa	1.44	1.59	1.59	4.63
Moringa oleifera	0.50	1.20	1.20	2.90
Nyctanthes arbortristis	0.60	1.59	1.59	3.79
Phoenix dactylifera	0.33	0.80	0.80	1.93
Pterocarpus marsupium	1.29	1.59	1.59	4.48
Semecarpus anacardium	0.83	1.99	1.99	4.82
Shorea robusta	43.20	17.13	17.13	77.46
Syzygium heyneanum	2.05	3.59	3.59	9.23

Terminalia arjuna	3.97	3.98	3.98	11.93
Terminalia tomentosa	2.94	3.59	3.59	10.11
Terminalia bellirica	0.12	0.40	0.40	0.91
Terminalia chebula	0.18	0.80	0.80	1.77
Site IV				
Acacia catechu	0.57	1.84	3.08	5.49
Anogeissus latifolia	1.11	0.92	1.54	3.57
Butea monosperma	2.50	6.22	8.85	17.56
Boswellia serrata	1.15	1.61	2.69	5.46
Buchnania lanzan	2.00	4.15	6.92	13.07
Cassia fistula	0.18	0.69	1.15	2.03
Diospyros melanoxylon	2.07	2.76	4.62	9.45
Lagerstroemia parviflora	2.56	8.76	13.08	24.39
Manilkara hexandra	0.30	1.15	1.92	3.38
Moringa oleifera	1.87	3.00	5.00	9.87
Phoenix dactylifera	0.83	1.15	1.92	3.90
Semecarpus anacardium	0.84	1.38	2.31	4.53
Shorea robusta	78.54	55.30	29.23	163.07
Soymida febrifuga	1.43	3.92	6.15	11.51
Syzygium cuminii	0.44	0.69	1.15	2.29
Terminalia arjuna	1.83	4.84	8.08	14.75
Terminalia tomentosa	1.33	1.15	1.92	4.41
*A**	0.50	0.46	0.38	1.34

*A = Unidentified plant species.

The forest stands were moderately dense with total 1470 adult stems (> 9.6 cm) in the 4 hectares (mean density 368 stems ha^{-1}). Tree density was greatest (455 stems ha^{-1}) in site-III and lowest (290 stems ha^{-1}) in site-I. Stand density was almost similar for site-I (290 stems ha^{-1}) and site-II (291 stems ha^{-1}). The stem density (> 9.6 cm) of *Shorea robusta* varied from 72 ha^{-1} to 290 ha^{-1} followed by *Butea monosperma*, *Diospyros melanoxylon*, and *Buchnania lanzan*. The density of seedling (diameter <3.2 cm) varied from 0 to 6147 ha^{-1}; while the sapling density (>3.2 to <9.6 cm) recorded in the range of 0 to 874 ha^{-1}. The *Shorea robusta* was common tree species on all sites. In addition to this, *Bombax ceiba*, *Diospyros melanoxylon* and *Phoenix dactylifera* were also common on three sites. Basal area was least (5.1 m^2ha^{-1}) in site-II and greatest (39.3 m^2ha^{-1}) in site-I. Based on basal area site-I, III and IV was dominated by *Shorea robusta,* while site-II was dominated by *Butea monosperma*.

Table 3. Summary of diversity indices in the study area.

Study site	Number of species	Total number of individuals (N)	Species richness (SR)	Species evenness (E_w)	Shannon-wiener index (H')
Site-I	1	290	0	1	0
Site-II	13	291	2.1	3.6	1.9
Site-III	26	455	4.1	7.3	2.5
Site-IV	18	434	2.8	4.1	1.8

Important values index

Based adult population, there was a significant changes in the phytosociological parameters of tree species across four sites. The most predominated species with their relative frequency, relative density, relative dominance, and IVI are given in Table 2.

There were 13 tree species showed IVI > 10. In terms of the overall ecological dominance, the IVI results show that the tree species with high importance values differs from site to site. It is commonly found (wide niched) in all dry deciduous forests.

The relative values of frequency (RF), density (RD) and dominance (RDo) were highest for *Butea monosperma* in site-II. The *Shorea robusta* showed relatively high values of RF, RD and RDo in site-III and site-IV. Hence, the IVI of *Butea monosperma* and *Shorea robusta* was greater than other species across four sites. The dominance of *Butea monosperma* indicates the poor availability of moisture and open nature of habitat at site-II, while the high IVI of *Shorea robusta* at site-III and site-IV indicates high moisture availability in forest floor. The high importance values of such species, thus, suggest their ability to grow in the different environments as they are the successional and light demanding species. Other species that showed significant IVI were identified as *Diospyros melanoxylon, Lagerstroemia parviflora* and *Madhuca indica*.

Diversity indices

Species richness depends upon number of species and number of their individuals. If any site having less number of species and large number of their individuals causes low species richness and vice-versa. The high species richness in site-III may be attributed to less anthropogenic activities, higher soil moisture and greater topographic variations in habitat conditions (Table 3). The species richness is also significant in site-II and sites-IV. Substantial differences in the values of species richness of plant species within site and between sites reveals that the site-III and site-IV are more heterogeneous, and provide conducive environment for the regeneration of native species compared to highly disturbed site-I. The evenness of plant species exceptionally high in site-III because the number of adult individuals of most abundant species is extremely greater than the least abundant species. The Shannon-Weiner index is also greater for the site-III (2.5), which is close to the values of tropical dry forests in Jharia coalfield and Vindhyan region (Mishra and Anshumali, 2014).

Conclusion

In the present study, forest structure reveals dominance of timber yielding trees like *Shorea robusta* and *Butea monosperma*. This combination reveals occurrence of mixed *Sal* forests experiencing different degree of natural and anthropogenic pressure as evident from complete absence of seedling and sapling stages of plant species in site-I. The IVI values show variation in ecologically dominant from site to site. Hence, the IVI has helped in understanding the ecological significance of the species in the tropical dry deciduous forest. The species richness was not uniformly distributed in the forest sites; the three sites (except site-I) were mosaic of low and high diversity patches. This appears to be the result of the combined effect of climatic, edaphic and biotic factors. Therefore, this study highlights the loss of species richness and species evenness; consequently, the restoration and conservation of tropical deciduous forests need to be addressed by plantation of native species in the Chhotanagpur plateau region of eastern India.

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