RESEARCH ARTICLE

Plant population mapping and quantitative assessment of peri-urban vegetation of Ranchi, eastern India

Purabi Saikia[1] · Sandeep Kumar[1] · Amit Kumar[2,3]

Abstract

The composition of species, as well as their population and regeneration status of tree species, provide an important ecological foundation for assessing the current state and rate of ecosystem degradation. Therefore, the present study aimed to determine the plant species composition with population and regeneration status of the 40 different tree species in peri-urban vegetation of Ranchi, eastern India using 52 belt transects each of 0.10 ha. A total of 58 different plant species of 49 genera and 26 families were recorded with the majority (86%) of native Indian origin species. The 14% of exotic origin species included dominant invasives in herb, shrub, and tree layers viz., *Mesosphaerum suaveolens* (L.) Kuntze. (2949 ind. ha^{-1}), *Lantana camara* L. (1667 ind. ha^{-1}), and *Acacia mangium* Willd. (33 ind. ha^{-1}), respectively. On the other hand, 59% of the total plant species were IUCN Red-listed including Endangered (*Tectona grandis* L.f.), Near Threatened (*Aegle maremlos* (L.) Corrêa), Data Deficient (*Mangifera indica* L.), and Least Concern (*Dalbergia sissoo* Roxb. ex DC). Total adult tree density and basal cover were 541 ind. ha^{-1} and 24.93 m^2 ha^{-1}, respectively and *Shorea robusta* C.F.Gaertn. was the most dominant tree (295 ind. ha^{-1}) recorded in the majority of the studied patches (87%) where adult tree density (ind. ha^{-1}) ranged from 10 to 1520 with a mean of 363 ± 49 (SE) signifying that the majority of the studied urban vegetation was Sal dominated forest patches. The total density of tree seedlings (22,627 ind. ha^{-1}) was highest in the studied peri-urban vegetation of Ranchi followed by total tree saplings density (2677 ind. ha^{-1}) and adult tree (GBH ≥ 10 cm) density (541 ind. ha^{-1}) signifying good regeneration status (density of seedlings > saplings > adults) of the peri-urban vegetation of Ranchi. was the most common human disturbance observed in 31% of the total studied patches. No regeneration of 56% of the total tree species, the prevalence of human disturbances in the 48% studied patches, and the occurrence of invasives in all three layers of vegetation in the studied peri-urban vegetation signify the ongoing biotic and abiotic pressure on the survival of different plant species at various growth stages. Besides, the predominance of plant species of rare and very rare occurrences (56.9%), IUCN Red-listed (59%) with a total of 84% native Indian origin species demonstrated the importance of the studied peri-urban vegetation and warrants for immediate conservation measures to protect it from further depletion.

Keywords Eastern India · Peri-urban vegetation · Population structure · Regeneration status · Species diversity

Introduction

Peri-urban landscapes are transition zone between urban and rural environments, where rural and urban activity coexist (Douglas 2006). In comparison to surrounding metropolitan areas, peri-urban areas always contain a diverse vegetation cover, comprising cultivated and natural vegetation types such as timberland, agriculture, grassland, and forest (Su et al. 2014). Climate regulation, soil erosion control, biodiversity maintenance, water quality enhancement, air pollutants absorption, and recreational activities are all provided by peri-urban vegetation (Wagrowski and Hites 1997;

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Pert et al. 2012) but experience increasing pressures from human activities. Vegetation assemblages have emerged in both urban and peri-urban areas in response to land use change, species introduction, ecological disturbance, and socio-political and economic transformations (Raupp et al. 2006; Richardson and Rejmanek 2011; Conway and Bourne 2013). Forest structure and composition have been altered as a result of rapid urbanisation and land-use change in close proximity to urban centres (Wear 2013). The impact of urbanised regions on surviving semi-natural forests offers a significant problem for environmental managers, both in terms of land use planning and nature protection (Godefroid and Koedam 2003a). Forest stands near urban areas support populations of pioneer and invasive species which are considered indicators of disturbance (Godefroid and Koedam 2003b). Fast urban growth has an impact on the structure and functions of peri-urban ecosystems as they have unique ecological and socio-economic characteristics (Huang et al. 2009).

Climate, precipitation, and pre-existing vegetation composition all have a significant influence on the structure and species richness of urban forests (Fahey et al. 2012). Plant species composition may be used as an indicator to find out the effects of human activities on biodiversity, and forest structures (Kowarik 1990). Urban plant species richness increases with the size of forest patches, and the extent of planting; however, mowing and trampling reduces species richness (Hobbs 1988). Invasive woody plant species have a negative impact on both urban and peri-urban landscapes (Motard et al. 2011; Staudhammer et al. 2015; Gaertner et al. 2016). Exotic tree species have grown quite widespread in most urban forests in many cities across the world (Alvey 2006; Aronson et al. 2015), which may impact the economic and ecological benefits of urban forests. Invasive species are more prevalent in cities than in rural areas as a result of several environmental consequences and greater propagule pressure (Gaertner et al. 2016). Understorey vegetation in a peri-urban forest of Paris is poorer in the plots invaded by *Ailanthus altissima*, an invasive tree species compared to the plots under different tree species in the same forest (Motard et al. 2011). Many native forest herbs have been struggling for survival in urban and peri-urban forests, highlighting the need for specialised management approaches to preserve and restore their populations (van Rossum et al. 2002; Godefroid and Koedam 2003b; Honnay et al. 2005).

Species diversity is one of the most important ecological indices used for evaluating the present status and rate of ecosystem degradation (Ardakani 2004) and is also essential to conserve plant diversity for its present and future use (Pimm et al. 1995). Therefore, the present study aimed to determine the (1) structure and plant species composition, along with (2) population and regeneration status of tree species of the peri-urban vegetation of Ranchi, eastern India to evaluate its present status, so that proper conservation and management strategies can be formulated for proper land use planning and conservation of nature.

Materials and methods

Study area

The present study was conducted in the peripheral area of Ranchi city which lies within a 10 km radius of its municipal boundaries (Fig. 1). It comprises six blocks of Ranchi district viz., Ratu, Kanke, Ormanjhi, Angara, Namkum, and Nagri. Ranchi district is located between 23.13°N and 23.21°N latitudes, 85.51°E and 85.54°E longitudes, and has an altitude of 400 to 700 m above sea level (msl). According to the Köppen-Geiger climate classification, Ranchi has a Cwa (Subtropical humid) climate. Forest cover in Ranchi district is 22.85% of the total geographical area of the district which has been increased by 0.49 sq. km as compared to the previous assessment reported in ISFR 2017. The major trees species of Ranchi district are *Shorea robusta* C.F.Gaertn., *Diospyros melanoxylon* Roxb., *Aegle maremlos* (L.) Corrêa, *Pterocarpus marsupium* Roxb., *Glycosmis cochinchinensis* (Lour.) Pierre ex Engl., *Madhuca longifolia* (L.) J.F.Macbr., *Mangifera indica* L., and *Butea monosperma*(Lam.) Kuntze.

Vegetation sampling

The peri-urban vegetation was studied using a belt-transects method each of 0.10 ha (100 m ×10 m) size from December 2019 to March 2020. A total of 52 transects were laid and girth at breast height (GBH) and the height of all the standing trees (GBH ≥ 10 cm) were recorded using a measuring tape and laser range finder, respectively. Plant diversity of understorey vegetation i.e., saplings of trees (GBH < 10 cm and height ≥ 30 cm) and shrubs were investigated in three quadrats of 5 m × 5 m sizes at the starting, middle, and end points of each transect of adults. Similarly, ground vegetation including herbs, grasses, herbaceous climbers, seedlings of trees and shrubs (> 30 cm height), was enumerated in three quadrats of 1 m × 1 m size laid within the quadrats of understorey vegetation (Fig. 2). Each listed individual was identified upto species level, and its life form (trees, shrubs, herbs, and lianas) was noted down. Different types of disturbances like fuelwood and litter collection, non-timber forest products (NTFPs) collection, forest fire, logging, lopping, etc. were noted down in the pre-designed datasheets based on visual observations and also by interacting with the forest guards and locals available during the
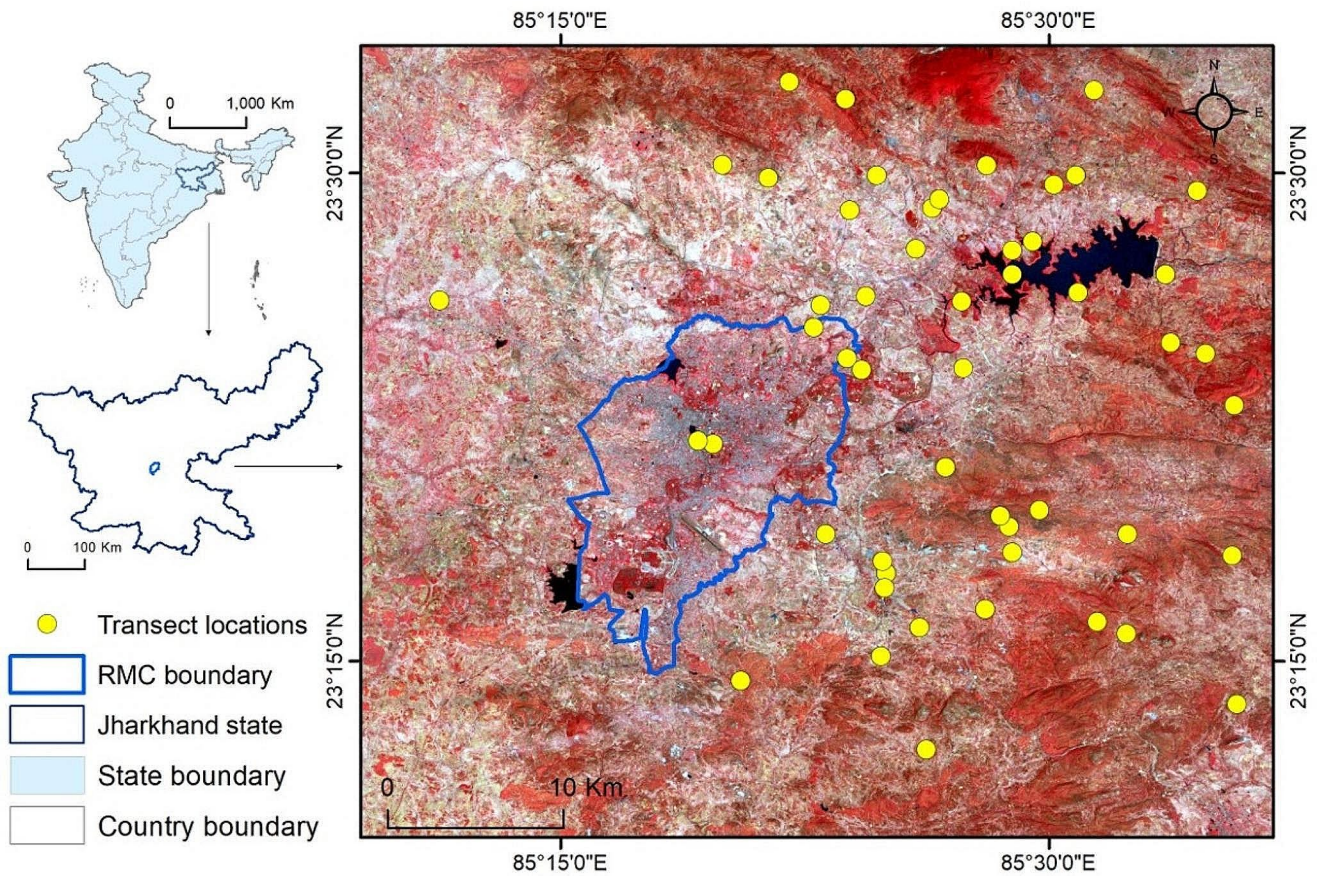
Fig. 1 Map showing the locations of the studied transects (yellow dots) in the peri-urban vegetation of Ranchi, Jharkhand
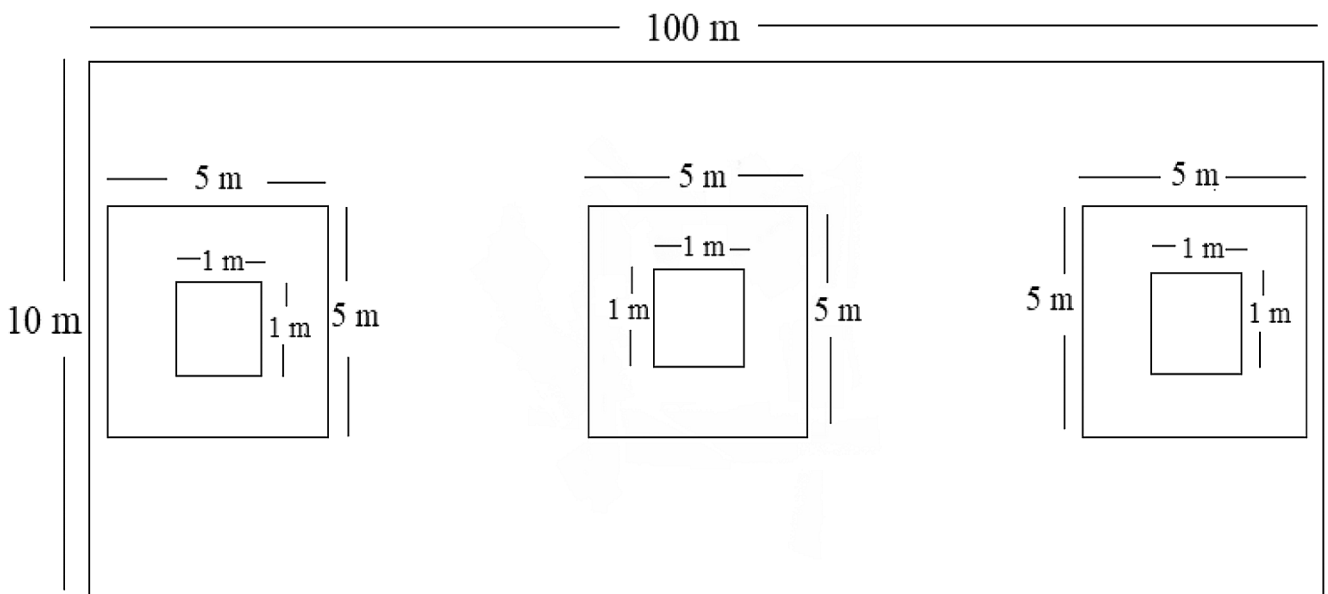

Fig. 2 Sampling design of studied transects in the studied peri-urban vegetation of Ranchi Jharkhand, eastern India

field visits to determine the threats to recorded plant species following Kumar and Saikia (2021) (Annexure 1).

Data analyses

Phyto-sociological characteristics of plant communities like frequency, density, and abundance were calculated by analysing the data quantitatively (Curtis and McIntosh 1950; Misra 1968). The Importance Value Index (IVI) was used to examine floristic structure following Curtis and Mcintosh (1950), where the relative values of density, frequency, and dominance of a species were summed together. Margalef's index of species richness (Dmg) (Magurran 1988), Menhinick's index of species richness (Dmn) (Whittaker 1977), Simpson's concentration dominance (Simpson 1949), Shannon-Weiner's Diversity Index (Shannon and Wiener 1963), and Evenness Index (Pielou 1966) were determined using standard formulas. The abundance to frequency (A/F) ratio was used to determine the species distribution pattern (Whitford 1949), while the Effective number of species (ENS) was calculated exponential value of Shannon's H'. Species were classified into five groups based on the number of individuals found: very rare (1–2 individuals), rare (3–20 individuals), common (21–100 individuals), dominant (101–500 individuals), and predominant (>500 individuals) (Pragasan and Parthasarathy 2010). The population status of individual tree species was determined based on the density of seedlings, saplings, and adults. Adults were further classified into various age groups like pole (GBH: ≥10–30 cm), young (GBH: >30–60 cm), mature (GBH: >60–90 cm), and old (GBH: >90 cm) for better analyses of their population structures. The regeneration status of tree species was determined based on the population density of seedlings, saplings, and adults following Shankar (2001).

Results

Floristic composition

In the present study, a total of 58 different plant species of 49 genera and 25 families had been recorded in 5.2 ha sampled plots of Ranchi peri-urban vegetation of which, 40 spp. were of trees, 12 spp. of shrubs, and 6 spp. of herbs. Out of the total species, the majority (86%) were native Indian species, while 14% were of exotic origin including *Mesosphaerum suaveolens* (L.) Kuntze. (2949 ind. ha^{-1}), *Ageratum conyzoides* L. (2244 ind. ha^{-1}), and *Lantana camara* L. (1667 ind. ha^{-1}) were recorded in the understorey vegetation, while *Acacia mangium* Willd. (33 ind. ha^{-1}), *G. cochinchinensis* (31 ind. ha^{-1}), *Senna siamea* (Lam.) H.S.Irwin & Barneby (29 ind. ha^{-1}), and *Eucalyptus globulus* Labill. (3

ind. ha^{-1}) were recorded in the tree layer. On the other hand, 59% of the total plant species were IUCN Red-listed, of which 1 sp. Endangered (*Tectona grandis* L.f.), 2 spp. Near Threatened (*A. maremlos* and *P. marsupium*), 1 sp. Data Deficient (*M. indica*), and the rest 30 plant species were of Least Concern including *Cassia fistula* L. and *Dalbergia sissoo* Roxb. ex DC (Table 1). Per patch tree species richness (no.) in the studied peri-urban vegetation ranged from 1 to 10 with a mean of 4 ± 0.28 (SE). The majority of the studied patches (44%) were having low tree species richness (< 4 spp.) followed by moderate tree species richness (37% with 4–5 spp.) and the least patches (19%) had high tree species richness (> 5 spp.) (Fig. 3a). Fabaceae was the most dominant plant family with 11 (19%) species followed by Moraceae (5 spp.; 9%), Apocynaceae (4 spp.; 7%), 6 families with 3 spp., 4 families with 2 spp., and the remaining 12 families were monotypic (Fig. 4). On the other hand, *Ficus* was the most dominant genus (05 spp.) followed by *Terminalia* (03 spp.), *Albizia, Zizyphus*, and *Sida* each with 02 species, and the rest 44 genera were monotypic (Table 2).

The total tree density in the peri-urban vegetation surveyed was 541 ind. ha^{-1} and *S. robusta* was the dominant tree (295 ind. ha^{-1}) recorded in the majority of the studied patches (87%) where adult tree density (ind. ha^{-1}) ranged from 10 to 1520 with a mean of 363 ± 49 (SE) signifying that the majority of the studied urban vegetation was Sal dominated forest patches. On the other hand, adult tree density (ind. ha^{-1}) per peri-urban vegetation patch ranged from 70 to 1640 with a mean of 590 ± 46 (SE). The majority of the studied patches (36.5%) were low tree density (< 400 ind. ha^{-1}) patches followed by moderate tree density (400–700 ind. ha^{-1}) patches (32.7%) and least patches (30.8%) with high tree density (> 700 ind. ha^{-1}) (Fig. 3b). In the shrub layer, *Clerodendrum infortunatum* L. (941 ind. ha^{-1}) and *Croton persimilis* Müll.Arg. (913 ind. ha^{-1}) were the most dominant shrubs, while *S. robusta* (1210 ind. ha^{-1}) and *D. melanoxylon* (526 ind. ha^{-1}) were the most dominant tree saplings. However, in the herb layer, *H. indicum* (2949 ind. ha^{-1}) and *Alternanthera sessilis* (L.) DC. (2372 ind. ha^{-1}) were the most dominant herbs, while *U. lobata* was the most dominant shrub seedling (7628 ind. ha^{-1}) and *D. melanoxylon* (6474 ind. ha^{-1}) was the most dominant tree seedling. The total basal cover of adult trees (GBH ≥ 10 cm) in the studied peri-urban vegetation of Ranchi was quite low (24.93 m^2 ha^{-1}) and the highest basal cover was contributed by *S. robusta* (54.07%) followed by *M. indica* (9.94%), and *Ficus geniculata* Kurz (9.22%). On the other hand, *S. robusta* was the most frequent tree species in all the tree, shrub, and herb layers with frequencies of 87%, 69%, and 42%, respectively. Other frequent tree species in the adult tree layers were *G. cochinchinensis* (46%), *D. melanoxylon* (40%), *B. monosperma* (19%), and *M. indica*

Table 1 List of the recorded plant species with their density, origin, IUCN Red-list category and habit in studied peri-urban vegetation of Ranchi

Sl. No.	Species	Family	Density (ind. ha^{-1})	Origin	IUCN Red-list category	Habit
1	*Andrographis paniculata* (Burm.f.) Wall. ex Nees	Acanthaceae	1667	N	-	H
2	*Alternanthera sessilis* (L.) DC.	Amarantha-ceae	2372	N	LC	H
3	*Ageratum conyzoides* L.	Asteraceae	2244	E	LC	H
4	*Cyanthillium cinereum* (L.) H.Rob.	Asteraceae	1026	N	-	H
5	*Elephantopus scaber* L.	Lamiaceae	1282	N	-	H
6	*Mesosphaerum suaveolens* (L.) Kuntze	Boraginaceae	2949	E	-	H
7	*Carissa spinarum* L.	Apocynaceae	74	N	LC	S
8	*Clerodendrum infortunatum* L.	Verbenaceae	941	N	-	S
9	*Croton persimilis* Müll.Arg.	Euphorbiaceae	913	N	-	S
10	*Hemidesmus indicus* (L.) R.Br.	Apocynaceae	1667	N	-	S
11	*Kalanchoe pinnata* (Lam.) Pers.	Crassulaceae	705	E	-	S
12	*Lantana camara* L.	Verbenaceae	92	E	-	S
13	*Ocimum gratissimum* L.	Lamiaceae	90	N	-	S
14	*Sida cordifolia* L.	Malvaceae	3141	N	-	S
15	*Sida rhombifolia* L.	Malvaceae	3141	N	-	S
16	*Tabernaemontana divaricata* (L.) R.Br. ex Roem. & Schult.	Apocynaceae	56	N	LC	S
17	*Urena lobata* L.	Malvaceae	7628	N	LC	S
18	*Woodfordia fruiticosa* (L.) Kurz	Lythraceae	95	N	LC	S
19	*Acacia mangium* Willd.	Fabaceae	33	E	LC	T
20	*Aegle maremlos* (L.) Corrêa	Rutaceae	0.8	N	NT	T
21	*Albizia lebbeck* (L.) Benth.	Fabaceae	1.0	N	LC	T
22	*Albizia procera* (Roxb.) Benth.	Fabaceae	0.6	N	LC	T
23	*Bauhinia variegata* L.	Fabaceae	0.6	N	LC	T
24	*Bombax ceiba* L.	Bombacaceae	1.0	N	LC	T
25	*Bridelia retusa* (L.) A.Juss.	Phyllanthaceae	1.0	N	LC	T
26	*Butea monosperma* (Lam.) Kuntze	Fabaceae	30.4	N	LC	T
27	*Cassia fistula* L.	Fabaceae	2.1	N	LC	T
28	*Dalbergia sissoo* Roxb. ex DC.	Fabaceae	1.5	N	LC	T
29	*Diospyros melanoxylon* Roxb.	Ebenaceae	54.2	N	-	T
30	*Eucalyptus globulus* Labill.	Myrtaceae	2.7	E	LC	T
31	*Fernandoa adenophylla* (Wall. ex G.Don) Steenis	Bignoniaceae	21.2	N	-	T
32	*Ficus benghalensis* L.	Moraceae	1.0	N	-	T
33	*Ficus geniculata* Kurz	Moraceae	1.2	N	-	T
34	*Ficus hispida* L.f.	Moraceae	0.2	N	LC	T
35	*Ficus recemosa* L.	Moraceae	0.2	N	LC	T
36	*Ficus religiosa* L.	Moraceae	3.5	N	LC	T
37	*Glycosmis cochinchinensis* (Lour.) Pierre ex Engl.	Anacardiaceae	31.0	E	-	T
38	*Gmelina arborea* Roxb. ex Sm.	Verbenaceae	5.0	N	LC	T
39	*Holarrhena pubescens* Wall. ex G.Don	Apocynaceae	1.2	N	LC	T
40	*Lagerstroemia parviflora* Roxb.	Lythraceae	0.2	N	LC	T
41	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	4.0	N	LC	T
42	*Madhuca longifolia* (L.) J.F.Macbr.	Sapotaceae	1.3	N	-	T
43	*Mangifera indica* L.	Anacardiaceae	6.3	N	DD	T
44	*Meyna spinosa* Roxb. ex Link	Rubiaceae	82.1	N	-	T
45	*Phyllanthus emblica* L.	Phyllanthaceae	7.7	N	LC	T
46	*Pongamia pinnata* (L.) Pierre	Fabaceae	0.6	N	LC	T
47	*Pterocarpus marsupium* Roxb.	Fabaceae	10.3	N	NT	T
48	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	1.2	N	-	T
49	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Fabaceae	29.4	E	-	T
50	*Shorea robusta* C.F.Gaertn.	Dipterocar-paceae	294.6	N	LC	T
51	*Syzygium cumini* (L.) Skeels	Myrtaceae	2.1	N	LC	T

Table 1 (continued)

Sl. No.	Species	Family	Density (ind. ha^{-1})	Origin	IUCN Red-list category	Habit
52	*Tectona grandis* L.f.	Lamiaceae	3.8	N	EN	T
53	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Combretaceae	0.2	N	-	T
54	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	1.7	N	LC	T
55	*Terminalia paniculata* B.Heyne ex Roth	Combretaceae	0.4	N	-	T
56	*Vachellia nilotica* (L.) P.J.H.Hurter & Mabb.	Fabaceae	0.2	N	LC	T
57	*Ziziphus mauritiana* Lam.	Rhamnaceae	1.2	N	LC	T
58	*Ziziphus rugosa* Lam.	Rhamnaceae	0.4	N	-	T

N: Native, E: Exotic; LC: Least Concern, NT: Near Threatened, DD: Data Deficient, EN: Endangered; H: Herb, S: Shrub, T: Tree
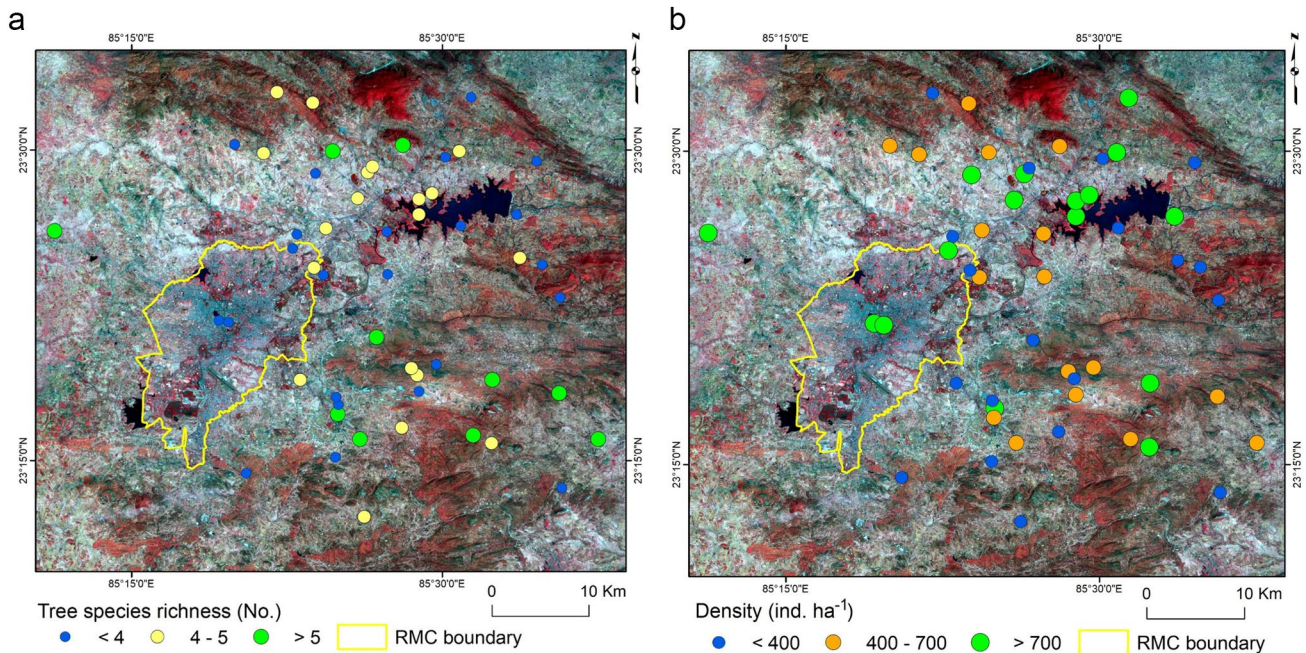
Fig. 3 Spatial pattern of **(a)** tree species richness and **(b)** adult tree density in studied peri-urban vegetation of Ranchi

(17%). In the shrub layer, the most frequent shrubs were *C. infortunatum* (47.44%) and *C. persimilis* (38.46%), while in the herb layer, *A. conyzoides* (10.41%) and *M. suaveolens* (10.26%) were the most frequent herbs. In terms of IVI, the most important tree species in all the tree, shrub, and herb layers of the peri-urban vegetation of Ranchi was *S. robusta* contributed 67.14% of the total IVI in the tree layer.

All 58 recorded plant species were distributed contagiously in the studied peri-urban vegetation of Ranchi because all plant species bear an A/F ratio greater than 0.05. The Shannon-Wiener diversity index was recorded highest in the herb layer (2.80) followed by the shrub layer (2.62), and the tree layer (2.41). Details of the community characteristics including the Shannon-Wiener diversity index, the concentration of dominance (Simpson's index), evenness index, species richness indices (Margalef's and Menhinick's), and the effective number of species (ENS) are mentioned in Table 3.

Species abundance and rarity

Out of the total 58 plant species, the majority of the plant species were either very rare (07 spp.; 12.07%) or rare (26 spp.; 44.83%). There were only one species (*S. robusta*) which was predominant and 8 spp. (13.79%) were dominant, while 16 species (27.59%) were common in the peri-urban vegetation of Ranchi in terms of total no. of individuals (Table 4). Out of a total of 40 tree species, 07 species (17.5%) were very rare including *Ziziphus rugosa* Lam., *Lagerstroemia parviflora* Roxb., and *Vachellia nilotica* (L.) P.J.H.Hurter & Mabb., while 22 species (55%) were rare including *Cassia fistula* L., *A. marmelos*, and *P. marsupium*. On the other hand, out of the 12 shrub species, 02 species were of rare occurrence (*Kalanchoe pinnata* (Lam.) Pers. and *Sida cordifolia* L.), while *Elephantopus scaber* L. and *Cyanthillium cinereum* (L.) H.Rob. were rare herbs out of the total 6 species of herbs.
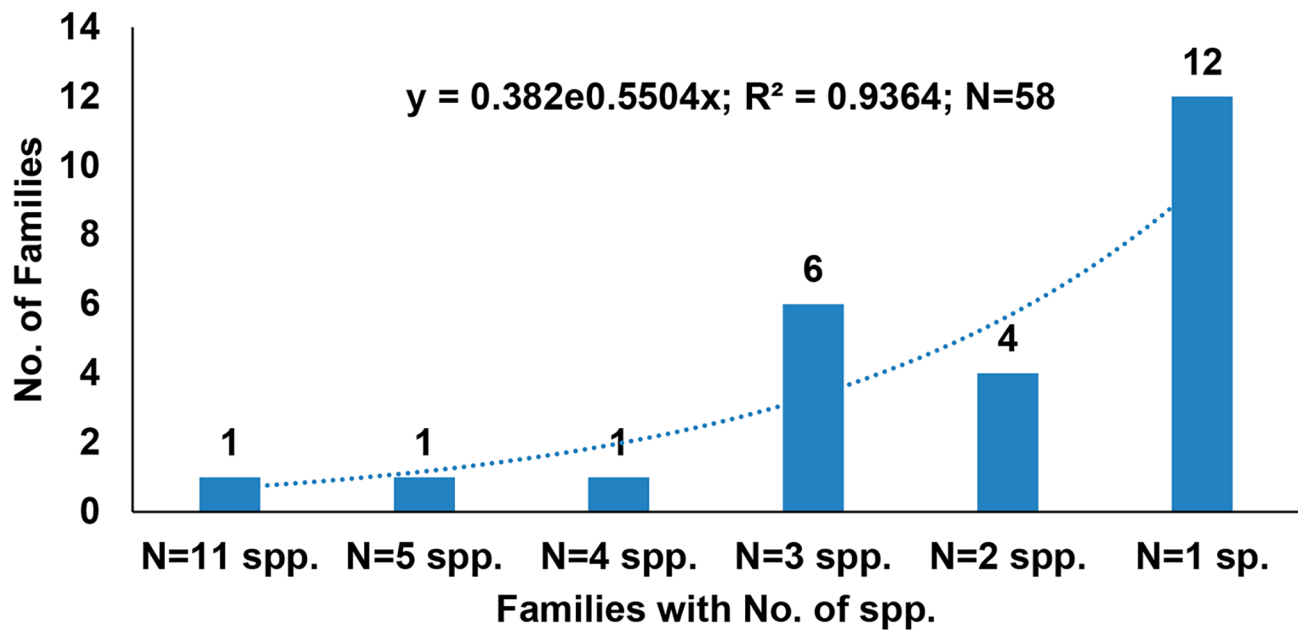
Fig. 4 Distribution of families according to species number in studied peri-urban vegetation of Ranchi

Table 2 Family-wise distribution of various genera and species in numbers recorded in studied peri-urban vegetation of Ranchi

Family	Genera (No.)	Species (No.)
Acanthaceae	1	1
Amaranthaceae	1	1
Anacardiaceae	3	3
Apocynaceae	4	4
Asteraceae	3	3
Bignoniaceae	1	1
Bombacaceae	1	1
Combretaceae	1	3
Crassulaceae	1	1
Dipterocarpaceae	1	1
Ebenaceae	1	1
Euphorbiaceae	1	1
Fabaceae	10	11
Lamiaceae	3	3
Lythraceae	2	2
Malvaceae	2	3
Moraceae	1	5
Myrtaceae	2	2
Phyllanthaceae	2	2
Rhamnaceae	1	2
Rubiaceae	1	1
Rutaceae	1	1
Sapindaceae	1	1
Sapotaceae	1	1
Verbenaceae	3	3
Total	**49**	**58**

## Population structure and regeneration status of tree species

The total density of tree seedlings (22,627 ind. ha^{-1}) was highest in the studied peri-urban vegetation of Ranchi contributed by a total of 7 tree species, followed by the total tree saplings density (2677 ind. ha^{-1}) contributed by a total of 18 tree species and adult tree (GBH $\geq$ 10 cm) density (541 ind. ha^{-1}) contributed by a total of 37 tree species signifying good regeneration status (density of seedlings > saplings > adults) of the peri-urban vegetation of Ranchi. There were significant differences in the proportion of seedlings (range: 192–6474 ind. ha^{-1} with a mean of 3232 $\pm$ 1035 SE), saplings (range: 8-1210 ind. ha^{-1} with a mean of 149 $\pm$ 71 SE), and adults (range: 0.2–295 ind. ha^{-1} with a mean of 15 $\pm$ 8 SE) density between different tree species. The highest density of seedlings was contributed by *D. melanoxylon* (29% of the total seedling density), while both saplings (45% of the total sapling density) and adults (55% of the total adult density) density were contributed by *S. robusta*. The highest density of adult trees (259 ind. ha^{-1}) was observed in the pole stage (10–30 cm GBH) followed by successive stages with increasing girths, and the lowest density (21 ind. ha^{-1}) in the old stage (> 90 cm GBH) (Fig. 5). Old-age tree groups had the highest species richness (24 species) followed by pole, young, and mature trees. Out of the total 40 tree species, the majority (22 spp., 55% of total trees) were not regenerating (no regeneration) present only in the adult stage, followed by poor regenerating species (11 spp., 27.5%) having individuals in both sapling and adult stage

Table 3 Community characteristics of studied peri-urban vegetation of Ranchi, Eastern India

Community Characteristics	Trees	Shrubs	Herbs
Species richness (No.)	40	12	9
Total density (ind. ha^{-1})	541	2533	11,540
Total basal area of tree species (m^2 ha^{-1})	24.93	-	-
Diversity (Shannon's H')	2.41	2.62	2.80
Concentration of dominance (Simpson index)	0.21	0.11	0.07
Evenness index (E)	0.67	0.79	0.92
Margalef's index of species richness (Dmg)	0.66	0.74	0.68
Menhinick's index of species richness (Dmn)	4.48	4.69	2.92
Effective No. of Species (ENS)	11	14	16
Most dominant species	*Shorea robusta* C.F.Gaertn. (295 ind. ha^{-1})	*Clerodendrum infortunatum* L. (941 ind. ha^{-1})	*Mesosphaerum suaveolens* (L.) Kuntze (2949 ind. ha^{-1})

Table 4 Rarity of different plant species in studied peri-urban vegetation of Ranchi, Eastern India

Category based on number of individuals	Number of species				Percentage of species (in each growth form)			
	Tree	Shrub	Herb	Total	Tree	Shrub	Herb	Total
Predominant (> 500 ind.)	1	—	—	1	2.5	—	—	1.72
Dominant (101–500 ind.)	6	2	—	8	15.0	16.67	—	13.79
Common (21–100 ind.)	4	8	4	16	10.0	66.67	66.67	27.59
Rare (3–20 ind.)	22	2	2	26	55.0	16.67	33.33	44.83
Very rare (1–2 ind.)	7	—	—	7	17.5	—	—	12.07
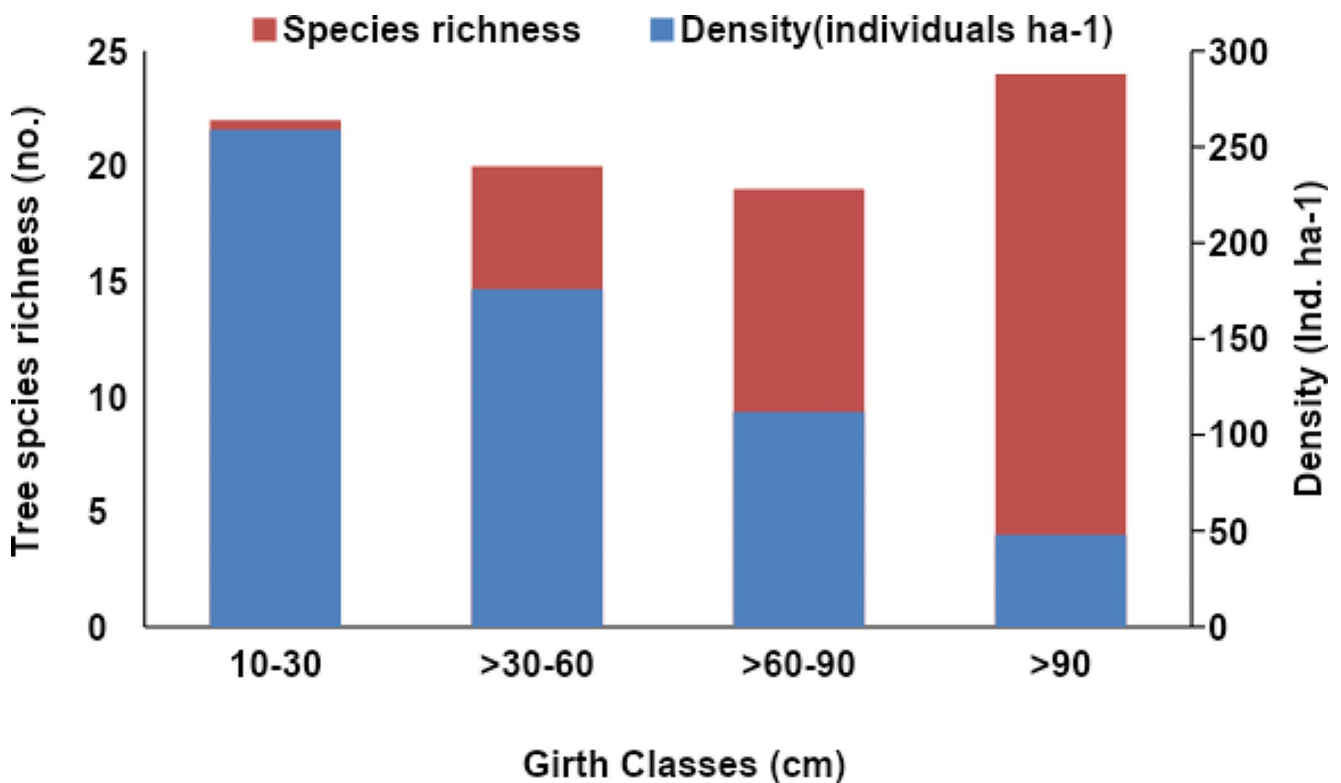
Fig. 5 Species richness (no.) and density (ind. ha^{-1}) in various girth classes of different tree species in studied peri-urban vegetation of Ranchi, Eastern India

or only in sapling stage, and good regenerating species (07 spp., 17.5%) with individuals in all seedling, sapling, and adult stage (Fig. 6). Some of the common non-regenerating tree species include *A. marmelos*, *M. longifolia, Pongamia pinnata* (L.) Pierre, and *Tectona grandis* L.f.

Out of the total 52 studied forest patches, 48% patches were disturbed and collection of fuelwood and leaf litter was the most common human disturbance observed in 31% of the total studied forest patches followed by grazing (13%), timber felling (12%), collection of NTFPs (in the form of edible fruits) (10%), and looping (6%). On the other hand, all the studied forest patches were disturbed by the invasion of exotics and *Mesosphaerum suaveolens* (L.) Kuntze. (2949 ind. ha^{-1}), *Lantana camara* L. (1667 ind. ha^{-1}), and *Acacia mangium* Willd. (33 ind. ha^{-1}), were the dominant invasives in herb, shrub, and tree layers, respectively. Although the species richness of exotic invasives was quite low (14% of the total plant species richness), it contributed 45% of the total herb density (by only two invasives, viz., *A. conyzoides* and *M. suaveolens*), 18% of the total tree density (by 4 invasives, viz., *A. mangium*, *G. cochinchinensis*, *S. siamea*, and *E. globulus*), and only 4% of the total shrub density (by *L. camara*). The common biotic interferences observed in the studied peri-urban vegetation of Ranchi are shown in Fig. 7.

Discussion

The reduction of species richness and decrease in population sizes are the major consequences of forest fragmentation due to a range of anthropogenic activities (Laurance and Useche 2009). The present study reported poor plant species richness (58 species) in the peri-urban vegetation of Ranchi which was quite lower than the species richness of urban forests of Guangzhou, China (Jim and Liu 2001) and the USA (Riley et al. 2018) but higher than the peri-urban vegetation of Chongming, China (Zhao et al. 2013). In the tropics, species richness is highly influenced by competition and niche diversification (Pianka 1996), as well as high humidity and temperature (Ojo and Ola-Adams 1996). On the other hand, the recorded tree species richness (40 spp.) in this study was also lower than the recorded tree species richness of urban forests in Cleveland, Ohio, USA (Riley et al. 2018), Ibadan, Nigeria (Agbelade et al. 2016), and Changchun, northeast China (Zhang et al. 2016). The predominance of plant species of native Indian origin (84% of the total plant species) and the majority of it in the IUCN red list (59% of the total plant species) signifies the importance of the peri-urban vegetation of Ranchi. These native species have been struggling for survival in peri-urban vegetation, which underlines conservation needs to prevent further species loss. In conformity with the present report, Fabaceae
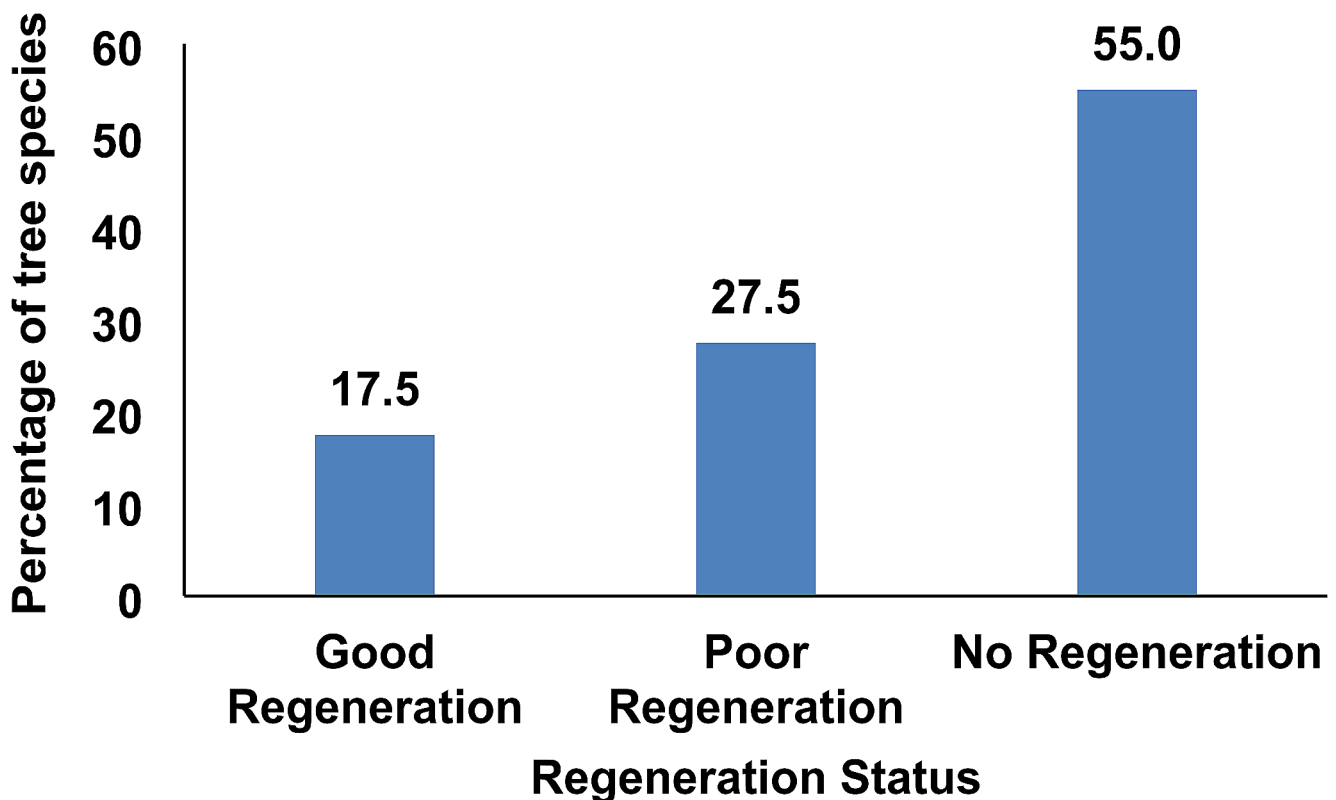

Fig. 6 Percentage of recorded tree species in different regeneration statuses in studied peri-urban vegetation of Ranchi, Eastern India

Fig. 7 Biotic interferences observed in the studied peri-urban vegetation of Ranchi **(a)** Lopping, **(b)** Tree felling, and **(c)** Invasive shrub (*Lantana camara*)

(with 17 species) was the most dominant family in the Sal forests of Ranchi, Eastern India reported in an earlier study (Kumar and Saikia 2020a). Tree density in natural forests was influenced by seed dispersal efficiency, seedlings' survival, and establishment, and also by the amount of human interference (Kadavul and Parthasarathy 1998). The present study recorded a high tree density (541 ind. ha^{-1}) in the peri-urban vegetation of Ranchi which was quite than the tree densities reported from different Indian tropical forests (Murali et al. 1996; Utkarsh et al. 1998; Shankar 2001; Reddy et al. 2007; Pitchairamu et al. 2008; Kumar and Sakia, 2020). The total basal cover of adult trees (GBH ≥ 10 cm) in the studied peri-urban vegetation of Ranchi was quite poor (24.93 m^2 ha^{-1}) and it was lower than that of the reported basal cover of the majority of Indian tropical forests (Murali et al. 1996; Swamy et al. 2000; Shankar 2001; Reddy et al. 2007; Kumar and Saikia 2020a), but higher than the Indian Central Himalayan tropical forests (Khera et al. 2001).

The distribution pattern of species in a forest is one of the important aspects of ecological studies. Natural forests are known for their contiguous distribution of species (Odum 1971), which reflects the extent of biotic interferences (e.g., grazing and lopping). Because all plant species have an A/F ratio greater than 0.05, all plant species were dispersed contagiously in this study. Several workers have also reported contagious or clumped distribution of plant species in natural forests (Kershaw 1973; Singh and Yadava 1974; Greig-Smith 1983; Rao et al. 1990). Shannon H' for Indian forests ranged from 0.83 to 4.10 (Singh et al. 1984; Visalakshi 1995). The recorded Shannon H' in the present study lies within the range of the diversity index recorded for tropical forests. A total of 56.9% of total plant species (26 rare and 07 very rare) were of rare occurrence in the present study of peri-urban vegetation of Ranchi. Similarly, high species rarity (55.07%) was also reported in the human-disturbed

Indian tropical evergreen forests of Eastern Ghats (Chittibabu and Parthasarathy 2000).

The presence of a large number of saplings and seedlings exhibits ongoing natural regeneration in tropical forests (Devi and Yadava 2006). The present study reported good regeneration status of the peri-urban vegetation of Ranchi with density (ind. ha^{-1}) of seedlings (22,627) > saplings (2677) > adults (541) trees signifies the sustainability of the peri-urban vegetation for the future. However, no regeneration of the majority of the tree species (56%) in the present study, signifies the ongoing biotic and abiotic pressure on the survival of different plant species at various growth stages. Natural and anthropogenic disturbances both have a significant impact on community dynamics and aid in the structuring of plant communities (Palit and Banerjee 2013). The differences in the relative proportions of seedlings, saplings, and adults among different tree species could be attributed to differences in the level of disturbance faced by different tree species in different patches (Saikia and Khan 2013). The area is still facing anthropogenic pressure in the form of prohibited timber felling, fuelwood extraction, collection of non-timber forest products, overgrazing by cattle, and anthropogenic forest fire for the collection of *M. longifolia* flowers for local alcohol production (Kumar and Saikia 2020b).

Conclusions

Although species richness in the peri-urban vegetation of Ranchi was very poor (58 spp.), high adult tree density (541 ind. ha^{-1}), and the prevalence of native Indian-origin species (84%) signifies its importance despite the occupancy of invasives in all three strata of the peri-urban vegetation. No regeneration of 56% of the total tree species, the prevalence

of human disturbances in the 48% studied patches, and the occurrence of invasives in all three layers of vegetation in the studied peri-urban vegetation signify the ongoing biotic and abiotic pressure on the survival of different plant species at various growth stages. Besides, the predominance of plant species of rare and very rare occurrences (56.9%) and IUCN Red-listed species (59%) indicates that certain species are facing serious threats that demonstrated the importance of the studied peri-urban vegetation and warrants immediate conservation interventions to protect it from further depletion. Additionally, assessment of peri-urban vegetation is necessary to formulate appropriate management strategies which will help to protect these ecosystems of unique species composition with ecological and socio-economic significance.

Data availability All data generated or analyzed during this study are included in this article. Rest, raw data may be available with proper request to the corresponding author.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare that they have no competing interests.

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