

ALTITUDE BASED TREE SPECIES OCCURRENCE IN THE PROTECTED NATURAL FOREST OF GANDHAMARDAN HILL RANGES, BALANGIR, ODISHA

Bhadra A.K^{1*} Dhal N.K² and Pattanayak, S.K¹

¹Department of Environmental Sciences, Sambalpur University, Jyotivihar-768019, Odisha, India

²Environment and Sustainability Department, IMMT (CSIR), Bhubaneswar- 751013, Odisha, India

E-mail: *abanibhadra@gmail.com, dhalnk@immt.res.in, skp.envsu@gmail.com

ABSTRACT

Study of the tree community was carried out in the forest of Gandhamardan hills belonging to Eastern Ghats at Harishankar of Balangir district, Odisha, India in the year 2008 from January to December. Eighty quadrates of 20m×20m size were laid in the 100ha protected forest (N = 20° 51' 027'', E = 82° 51' 59.2'') across eleven altitude ranges between 350m and 625m. A total of 42 species (39 genera & 25 families) were recorded in the present study. Species occurring at only single altitude range are *Acacia lenticularis* Buch.ham. Ex Benth. In Hook. *Bombax ceiba* L., *Euphorbia nivula* Buch.-Ham., *Holarrhena pubescens* (Buch.-Ham.) wall.ex G.Don., *Pongamia pinnata* (L.) Pierre and *Schrebera swietenoides* Roxb. Only one species i.e *Anogeissus latifolia* (Roxb.ex DC.) wall. Ex Guill. & Perr occur in all the eleven altitude ranges. Throughout all altitude ranges; 47, 75 and 101 species shows regular, random and contiguous distribution pattern. This reflects the contiguous distribution to be prevalent in the forest community. When random and contiguous distribution increase from lower altitude to mid altitude and again decrease from mid to higher altitudes, the reverse trend is observed in case of regular distribution. Total species and family occurrence increases from lower to mid altitude and again in decreases towards higher altitudes. Highest thirty five species occur in the mid altitude range of 400-425m while lowest seven species occur in the higher altitude of 575-600m respectively. Species occurring in all the altitude ranges have been ranked based on their IVI values and D-D (Dominance- Diversity) curves for each range have been drawn. The co-efficient of determination (R^2) of the D-D curves show that the two highest value 0.924 and 0.895 fall in the altitude range of 425-450m and 450-475m. Hence tree species diversity can be best studied at altitude ranges of 425-450m and 450-475m.

Key words : Altitude, Dominance-Diversity, Gandhamardan, Balangir

INTRODUCTION

Variability has a broader interpretation. Variability of tree species occurrence in the different altitude ranges can be an important ecological assessment. A central question in community ecology concerns the control of alpha diversity, or the number of species able to coexist

at small spatial scales (Wright, 2002). Study of plant species composition and diversity has been widely accomplished in order to perform conservation, effective management and logical exploitation of forests (Lovett *et al.* 2000; Andel, 2001; Chiarucci *et al.* 2001; Nebel *et al.* 2001; Parthasarathy, 2001; Aubert *et al.* 2003 and Huang *et al.* 2003). Tropical forests are regarded as one of the most species diverse rich terrestrial

ecosystem. However, most of these forests are under immense anthropogenic disturbances and require careful management intervention to maintain overall biodiversity and sustainability (Kumar *et al.*, 2006). Therefore, species distribution modeling, also known as ecological niche modeling has been growing at a striking rate in the last 20 years (Guisan and Thuiller, 2005). Understanding species diversity and distribution patterns is important for helping managers evaluate the complexity and resources of forests. Information with reference to species diversity and distribution pattern may help in evaluating the ecological significance of the study area. Species distribution models are based on presence, absence, or abundance data from museum vouchers or field surveys and environmental predictors to create probability models of species distribution within landscapes, regions, and continents (Guisan and Thuiller, 2005). Quantifying species diversity on a regional scale is quite challenging because of difficulties in measuring species abundance and distribution (Koellner *et al.*, 2004), and hence floristic inventories and studies of forest dynamics usually rely on sampling plots (Dallmeier and Comiskey, 1998).

Plant diversity inventories in tropical forests have mostly been concentrated on tree species than the other life-forms, because tree species diversity is an important aspect of forest ecosystem diversity (Rennolls and Laumonier, 2000) and also fundamental to total tropical forest diversity (Huang *et al.*, 2003). Trees form the major structural and functional basis of tropical forest ecosystems and can serve as robust indicators of changes and stressors at the landscape scale (Misra, 1968). They provide resources and habitat structure for almost all other species (Cannon, 1998). Competing explanations for patterns of tree diversity have alternately emphasized role of spatial or temporal variability in tree regeneration (e.g. Grubb, 1977; Pacala & Roughgarden, 1982; Huston, 1994; Kelly & Bowler, 2002). An understanding of the distribution of tree species and their assemblages must play an important role in elucidating the larger patterns of distribution of biodiversity (Reddy and Ugle, 2008). Topography data has also been an important component of

species distribution models (Pearson *et al.*, 2004; Eltih *et al.*, 2006). Temporal variability is a fundamental property of any ecological system and as such, it has been the subject of many studies during the last decades (Ruijven and Berendse, 2007). The pattern of vegetation distribution on ground is always associated with particular topographic features (Mahajan and Kale, 2006). On the other hand, the regional variation in species richness is the subject of long standing debates in ecology and biogeography (Piank, 1966; Huston, 1994; Lomolion, 2001; Whittaker *et al.*, 2001). The variation of species richness along elevation gradients has been documented for a variety of taxa and geographical areas (Terborgh, 1977; Stevens, 1992; Rahbek, 1995, 1997; Brown, 2001; Heaney, 2001; Md.nor, 2001; Bhattarai & Vetaas, 2003, 2005; Grytnes, 2003; Bhattarai *et al.*, 2004; Carpenter, 2005). Two general patterns have emerged: a monotonic decrease in species richness (e.g. Yoda, 1967; MacArthur, 1972; Stevens, 1992); or a hump-shaped relationship with a peak in species richness at intermediate elevations (e.g. Grytnes & Vetaas, 2002).

The study of the forest of Gandhamardan hill ranges has attracted the attention of many botanists, ecologists and plant explorers because of its unique geography, biodiversity and phytosociological aspects. A number of floristic works have been carried out by many plant explorers like Haines (1921-25), Mooney (1950), Panigrahi *et al.* (1964), Misra (1990, 1998, 2004), Misra and Das (1998), Saxena and Brahmam (1996), Sahu *et al.* (2009, 2010), and Bhadra *et al.*, (2009, 2010a & 2010b) in the forest of Gandhamardan hill ranges which is the homeland of many diversified economically important species. The present study is unique being the first attempt to examine the tree species occurrence in the protected natural forest across altitudes because they may be more influenced by climate than herbaceous species (Bhattarai & Vetaas, 2003), and elevation ranges for trees are more accurate than for smaller plants. Nevertheless, there have been few attempts to identify patterns of distribution of species in Odisha. The present study focused on analyzing distribution and abundance pattern of tree species

over a protected landscape covering 100ha at Harishankar on the Gandhamardan hill ranges.

MATERIAL AND METHODS

Study area: Gandhamardan Hill ranges lies between 20° 42' to 21° 00' N latitude and 82° 41' to 83° 05' E longitude in the North-West of Bolangir and South-West of Baragarh district, Odisha, India (Fig.1). The hill ranges contain an undulating mountain system ranging from 300m to 1220m height from mean sea level (msl). It extends over several miles in north-east and south-west direction and receives annual rainfall ranging from 750 mm to 1600 mm having average rainfall of 1296.8 mm.

Field sampling: The field study was conducted during months of January to December 2008. The size and number of quadrates were determined by species area curve method (Mishra, 1968). Total 80 sample quadrates of 20m×20m for tree species were taken. All the plots were recorded for trees greater than or equal to 15cm GBH (Marimon *et al*, 2002 and Mishra *et al*, 2005).

Data analysis: The data recorded was quantitatively analysed for frequency, density and abundance and the relative values of these parameters were calculated and summed up for Importance Value Index (IVI) (Curtis, 1959 and Mishra, 1968) of each species in all the 11 altitude ranges. Abundance to Frequency ratio (A/F) of each species was determined to get distribution pattern of various species as indicates, regular (0.025), random (0.025-0.050) and contiguous (0.050) distribution (Curtis and Cotton, 1956). Dominance-Diversity curve has been drawn taking species rank on X axis and IVI value on Y axis for the determination of species correlation. Species were identified following the standard procedure by the help of regional and national flora (Hooker, J.D., 1872-97; Saxena, H.O. and Brahmam, M. 1996).

Importance Value Index (IVI) =

Relative Frequency + Relative density +

Relative Dominance

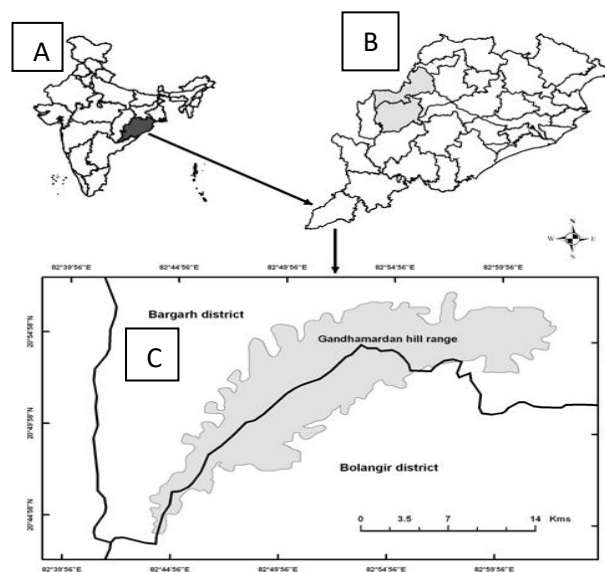


Fig. 1: Map of the Gandhamardan hill range (C), the study area in Orissa (B) & India (A).

RESULTS

Forty two tree species are found in the present study which belongs to 39 genera and 25 families. Out of total 42 species found in total in eleven altitude ranges; 22, 21, 35, 27, 26, 21, 18, 14, 24, 7 and 8 species are traced in 350-375m, 375-400m, 400-425m, 425-450m, 450-475m, 475-500m, 500-525m, 525-550m, 550-575m, 575-600m and 600-625m elevational ranges respectively (Table- 1 to 11, Fig. 14). Highest 35 species and lowest 7 species are occurring in elevation of 400-425m and 575-600m respectively. Species occurring at only single altitude range are *Acacia lenticularis* Buch.-Ham. Ex Benth. In Hook. (475-500m), *Bombax ceiba* L. (475-500m), *Euphorbia nivula* Buch.-Ham. (575-600m), *Holarrhena pubescens* (Buch.-Ham.) wall. ex G. Don. (400-425m), *Pongamia pinnata* (L.) Pierre (550-575m) and *Schrebera swietenoides* Roxb. (550-575m). Only one species i.e. *Anogeissus latifolia* (Roxb. ex DC.) wall. Ex Guill. & Perr occur in all the eleven altitude ranges. When IVI value of all species considered in the single altitude range, *Aegle marmelos* (L.) Corr., *Shorea robusta* Gaertn. f., *Holarrhena pubescens* (Buch.-Ham.) Wall. ex G. Don., *Ziziphus mauritiana* Lam., *Terminalia chebula* Retz., *Syzigium cumini* (L.) Skeels, *Sterculia urens* Roxb. Ex DC., *Euphorbia nivula* Buch.-Ham., *Gardenia*

*latifolia*Aiton. ranks first in the altitude range of 350-375m, 375-400m, 400-425m, 425-450m, 450-475m, 500-525m, 525-550m, 575-600m and 600-625m based on their Dominance-Diversity curve (Fig-2,3,4,5,6,8,9,11,12 & Table-1,2,3,4,5,7,8,10,11 and Appendix - 1). On the other hand, *Acacia lenticularis*Buch.ham. Ex Benth. In Hook. & *Bombax ceiba*L. and *Pongamia pinnata* (L.)Pierre & *Schrebera swietenoides*Roxb. (Fig-7, 10 & Table- 6, 9) jointly dominate in the altitude range of 475-500m and 550-575m respectively with equal IVI (Appendix-I). When the IVI values of above mentioned species are considered across all altitude ranges, all species have highest IVI value in the respective ranges except *Terminalia chebula*Retz. that has highest value in the other range i.e. 400-425m which indicates the constant dominated establishment of species considered in both ways of species-altitude and species-altitudes.

Out of six species occurring in the single altitude range three show contiguous, two show random and one shows regular distribution (Appendix-II). Out of 223 occurrences of species across all altitude ranges, 47 regular, 75 random and 101 contiguous distributions are found (Table-12 & Fig-13, 14). When occurrence of all species and families of trees across all elevational ranges are plotted (Fig-14), it is found that the curve gets a dome shape showing the mid altitudinal increase in the species as well as families. The R^2 values of the D-D curves of the species in the altitude range of 350-375m, 375-400m, 400-425m, 425-450m, 450-475m, 475-500m, 500-525m, 525-550m, 550-575m, 575-600m and 600-625m are 0.763, 0.667, 0.538, 0.924, 0.895, 0.369, 0.623, 0.533, 0.541, 0.211 and 0.296 respectively.

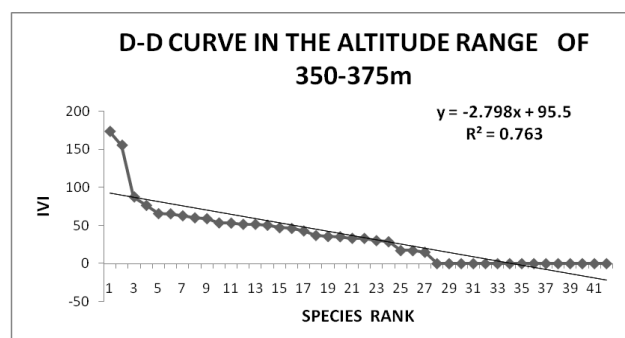


Fig- 2

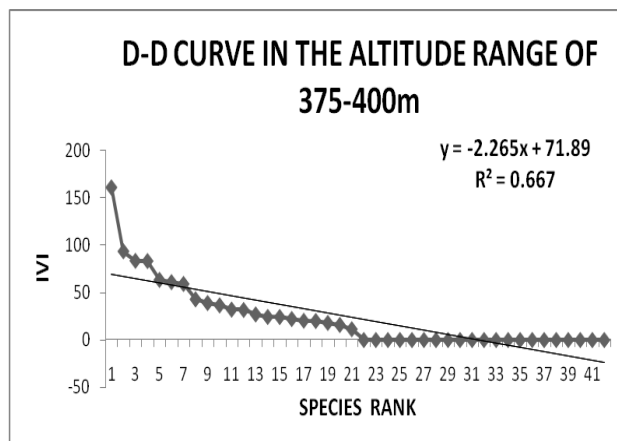


Fig- 3

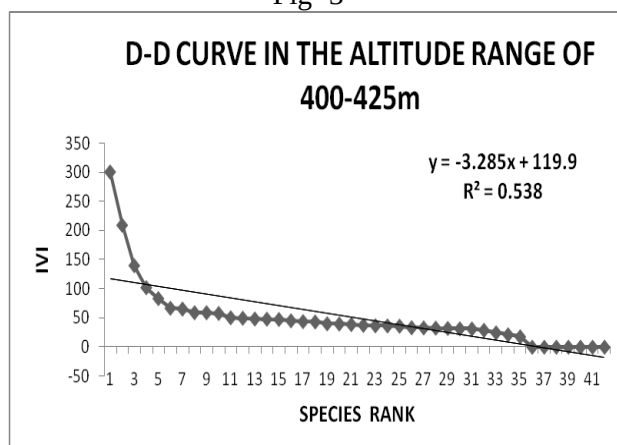


Fig- 4

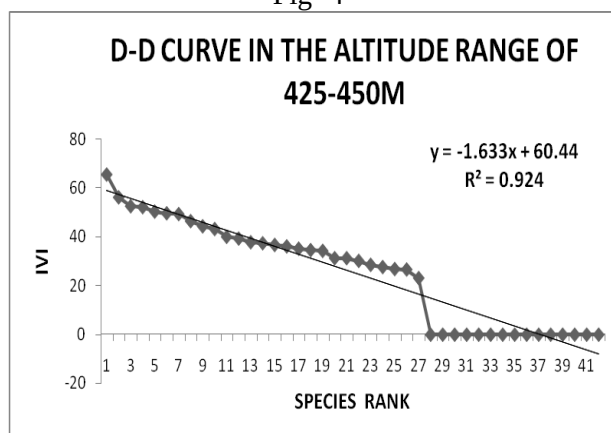


Fig- 5

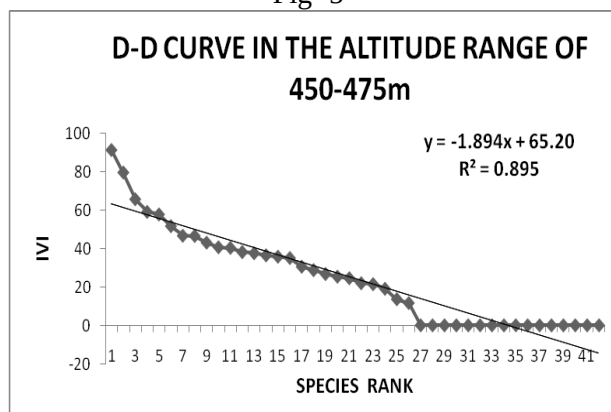


Fig-6

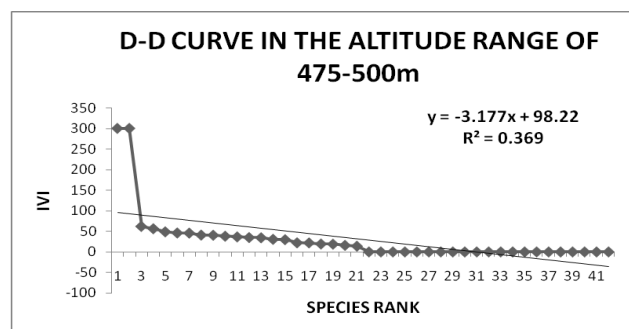


Fig-7

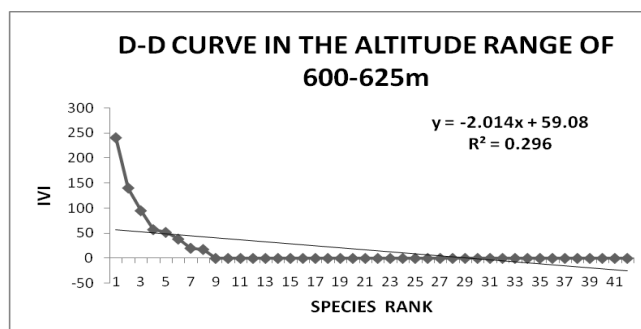


Fig - 12

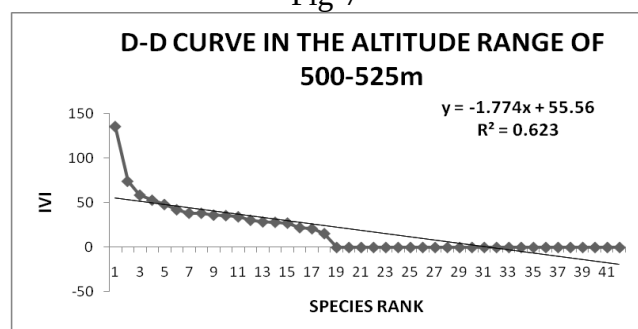


Fig - 8

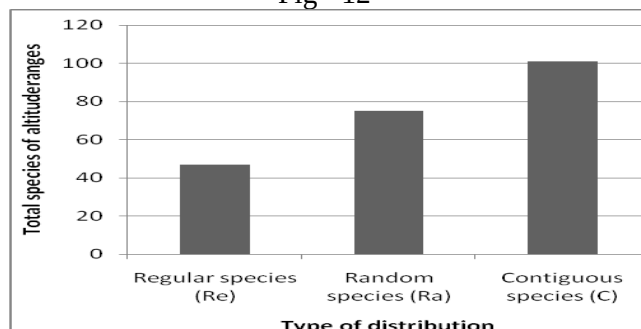


Fig. 13 Species distributed in altitude ranges

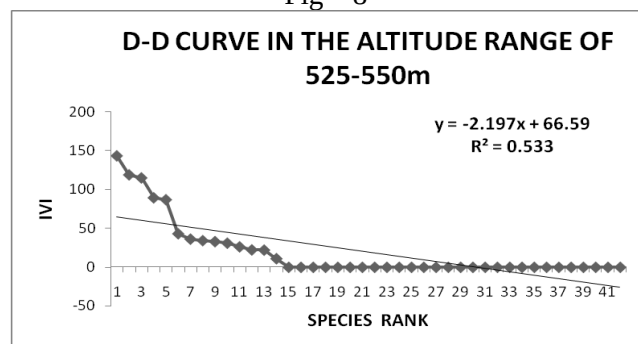


Fig - 9

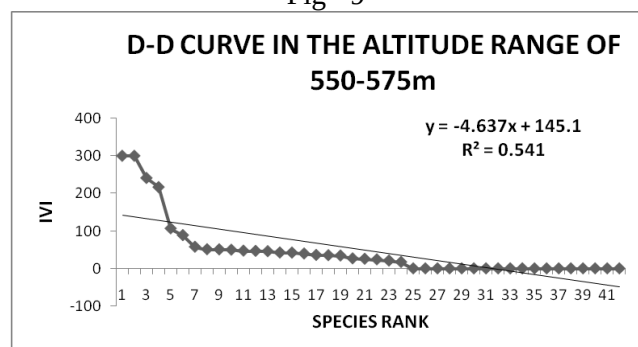


Fig-10

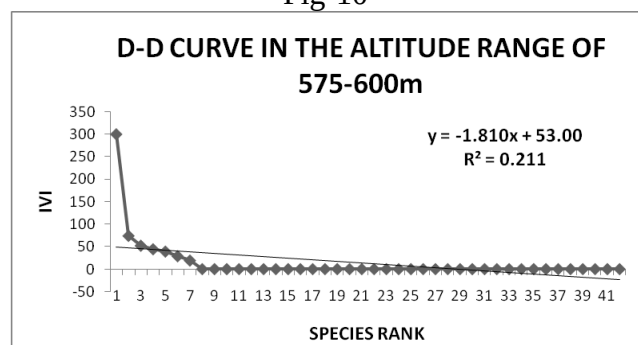


Fig - 11

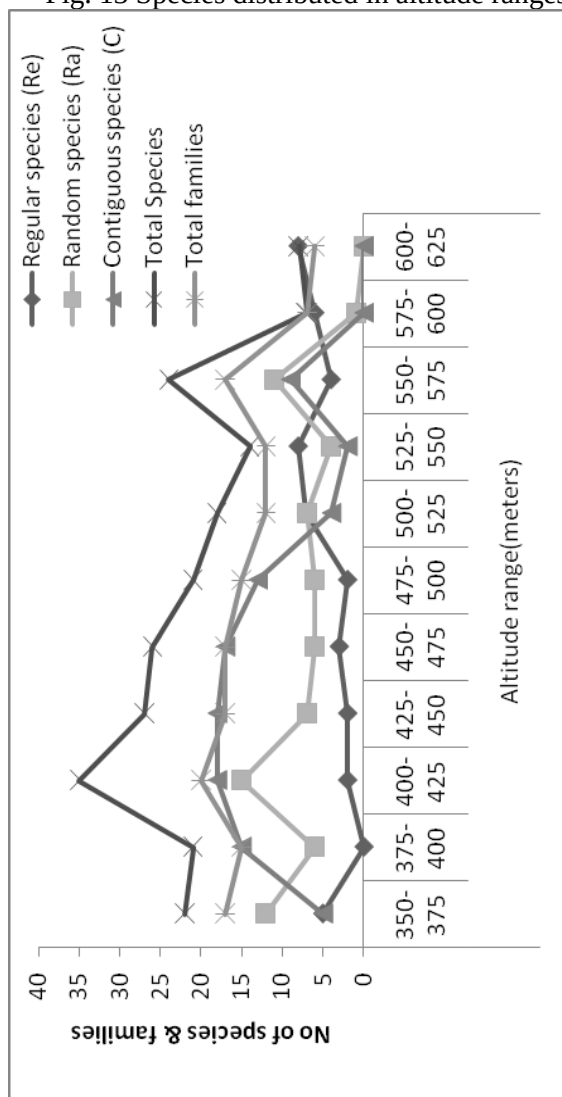


Fig. 14 Plot showing the relationship between trees and elevation

Table–1 Species rank and distribution pattern of tree species in the altitude range of 350-375m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Aegle marmelos</i> (L.) Corr.	173.5	0.043	Ra
2	<i>Lannea coromandelica</i> (Houtt.) Merr.	155.4	0.240	Re
3	<i>Ziziphus xylopyrus</i> (Retz.) Willd.	87.50	0.060	C
4	<i>Terminalia alata</i> Heyne ex Roth	76.40	0.018	Re
5	<i>Dalbergia paniculata</i> Roxb.	65.60	0.033	Ra
6	<i>Madhuca indica</i> Gmel.	65.40	0.031	Ra
7	<i>Careya arborea</i> Roxb.	62.80	0.033	Ra
8	<i>Cassia fistula</i> L.	60.10	0.060	C
9	<i>Terminalia belirica</i> (Gaertn.) Roxb.	59.00	0.030	C
10	<i>Morinda pubescens</i> Sm. in Rees	53.40	0.060	C
11	<i>Schleichera oleosa</i> (Lour.) Oken	53.20	0.034	Ra
12	<i>Diospyros melanoxylon</i> Roxb.	51.60	0.057	C
13	<i>Wrightia arborea</i> (Dennst) Mabb.	51.60	0.060	Ra
14	<i>Bridellia retusa</i> (L.) Spreng.	50.40	0.300	C
15	<i>Semecarpus anacardium</i> L.f.	47.10	0.045	Ra
16	<i>Pterocarpus marsupium</i> Roxb.	46.20	0.014	Re
17	<i>Chloroxylon swietiana</i> DC.	42.90	0.030	Ra
18	<i>Buchanania lanzan</i> Spreng.	36.90	0.047	Ra
19	<i>Anogeissus latifolia</i> (Roxb. ex DC.) wall. Ex Guill. & Perr	35.60	0.094	C
20	<i>Casearia elliptica</i> Willd.	35.30	0.060	C
21	<i>Haldinia cordifolia</i> (Roxb.) Ridsd.	33.20	0.014	Re
22	<i>Desmodium oojeinensis</i> (Roxb.) Ohashi	33.10	0.020	Re
23	<i>Cleistanthus collinus</i> (Roxb.) Benth. Ex Hook.f.	30.20	0.046	Ra
24	<i>Phyllanthus emblica</i> L.	28.70	0.060	C
25	<i>Mitragyna parviflora</i> (Roxb.) Korth.	17.10	0.030	Ra
26	<i>Lagerstroemia parviflora</i> Roxb.	17.00	0.030	Ra
27	<i>Stereospermum chelonoides</i> auct. non (L.f.) DC.	15.00	0.060	C
28	<i>Acacia lenticularis</i> Buch. ham. Ex Benth. In Hook.	0	×	×
29	<i>Bombax ceiba</i> L.	0	×	×
30	<i>Dalbergia latifolia</i> Roxb.	0	×	×
31	<i>Dillenia aurea</i> Sm.	0	×	×
32	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
33	<i>Ficus benghalensis</i> L.	0	×	×
34	<i>Gardenia latifolia</i> Aiton.	0	×	×
35	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall. ex G. Don.	0	×	×
36	<i>Pongamia pinnata</i> (L.) Pierre	0	×	×
37	<i>Schrebera swietenoides</i> Roxb.	0	×	×
38	<i>Shorea robusta</i> Gaertn. f.	0	×	×
39	<i>Sterculia urens</i> Roxb. Ex DC.	0	×	×
40	<i>Syzigium cumini</i> (L.) Skeels	0	×	×
41	<i>Terminalia chebula</i> Retz.	0	×	×
42	<i>Ziziphus mauritiana</i> Lam.	0	×	×

Table–2 Species rank and distribution pattern of tree species in the altitude range of 375-400m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Shorea robusta</i> Gaertn.f.	160.3	0.060	C
2	<i>Casearia elliptica</i> Willd.	93.20	0.027	Ra
3	<i>Careya arborea</i> Roxb.	83.20	0.105	C
4	<i>Terminalia alata</i> Heyne ex Roth	83.00	0.087	C
5	<i>Syzigium cumini</i> (L.) Skeels	63.20	0.060	C
6	<i>Ziziphus mauritiana</i> Lam.	60.90	0.090	C
7	<i>Terminalia belirica</i> (Gaertn.) Roxb.	59.00	0.060	C
8	<i>Madhuca indica</i> Gmel.	42.80	0.047	Ra
9	<i>Pterocarpus marsupium</i> Roxb.	38.90	0.075	C
10	<i>Semecarpus anacardium</i> L.f.	36.50	0.030	Ra
11	<i>Cleistanthus collinus</i> (Roxb.) Benth. Ex Hook.f.	32.00	0.050	Ra
12	<i>Schleichera oleosa</i> (Lour.) Oken	31.60	0.060	C
13	<i>Bridellia retusa</i> (L.) Spreng.	26.90	0.045	Ra
14	<i>Cassia fistula</i> L.	24.30	0.060	C
15	<i>Haldinia cordifolia</i> (Roxb.) Ridsd.	24.20	0.060	C
16	<i>Morinda pubescens</i> Sm. in Rees	22.10	0.060	C
17	<i>Anogeissus latifolia</i> (Roxb. ex DC.) wall. Ex Guill. & Perr	20.30	0.073	C
18	<i>Lagerstroemia parviflora</i> Roxb.	20.00	0.120	C
19	<i>Diospyros melanoxylon</i> Roxb.	18.00	0.047	Ra
20	<i>Desmodium oojeinensis</i> (Roxb.) Ohashi	15.90	0.060	C
21	<i>Mitragyna parviflora</i> (Roxb.) Korth.	11.40	0.060	C
22	<i>Lannea coromandelica</i> (Houtt.) Merr.	0	×	×
23	<i>Acacia lenticularis</i> Buch. ham. Ex Benth. In Hook.	0	×	×
24	<i>Aegle marmelos</i> (L.) Corr.	0	×	×
25	<i>Bombax ceiba</i> L.	0	×	×
26	<i>Buchanania lanzan</i> Spreng.	0	×	×
27	<i>Chloroxylon swietenia</i> DC.	0	×	×
28	<i>Dalbergia latifolia</i> Roxb.	0	×	×
29	<i>Dalbergia paniculata</i> Roxb.	0	×	×
30	<i>Dillenia aurea</i> Sm.	0	×	×
31	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
32	<i>Ficus benghalensis</i> L.	0	×	×
33	<i>Gardenia latifolia</i> Aiton.	0	×	×
34	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall. ex G. Don.	0	×	×
35	<i>Phyllanthus emblica</i> L.	0	×	×
36	<i>Pongamia pinnata</i> (L.) Pierre	0	×	×
37	<i>Schrebera swietenoides</i> Roxb.	0	×	×
38	<i>Stereospermum chelonoides</i> auct. non (L.f.) DC.	0	×	×
39	<i>Sterculia urens</i> Roxb. Ex DC.	0	×	×
40	<i>Terminalia chebula</i> Retz.	0	×	×
41	<i>Wrightia arborea</i> (Dennst) Mabb.	0	×	×
42	<i>Ziziphus xylopyrus</i> (Retz.) Willd.	0	×	×

Table-3 Species rank and distribution pattern of tree species in the altitude range of 400 - 425m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall.ex G.Don.	300.0	0.150	C
2	<i>Terminalia chebula</i> Retz.	208.8	0.038	Ra
3	<i>Shorea robusta</i> Gaertn.f.	139.7	0.300	C
4	<i>Syzigium cumini</i> (L.) Skeels	101.9	0.083	C
5	<i>Ficus benghalensis</i> L.	83.30	0.150	C
6	<i>Terminalia belirica</i> (Gaertn.) Roxb.	66.80	0.050	Ra
7	<i>Dalbergia latifolia</i> Roxb.	65.30	0.083	C
8	<i>Dillenia aurea</i> Sm.	59.10	0.150	C
9	<i>Gardenia latifolia</i> Aiton.	59.10	0.050	Ra
10	<i>Pterocarpus marsupium</i> Roxb.	57.90	0.029	Ra
11	<i>Dalbergia paniculata</i> Roxb.	50.50	0.075	C
12	<i>Desmodium oojeinensis</i> (Roxb.) Ohashi	49.70	0.063	C
13	<i>Lannea coromandelica</i> (Houtt.) Merr.	48.30	3.750	C
14	<i>Morinda pubescens</i> Sm. in Rees	48.00	0.038	Ra
15	<i>Madhuca indica</i> Gmel.	47.60	0.061	C
16	<i>Buchanania lanzan</i> Spreng.	45.20	0.092	C
17	<i>Schleichera oleosa</i> (Lour.) Oken	43.90	0.040	Ra
18	<i>Terminalia alata</i> Heyne ex Roth	43.20	0.040	Ra
19	<i>Cleistanthus collinus</i> (Roxb.) Benth. Ex Hook.f.	40.10	0.066	C
20	<i>Casearia elliptica</i> Willd.	39.70	0.050	Ra
21	<i>Aegle marmelos</i> (L.) Corr.	38.80	0.150	C
22	<i>Ziziphus xylopyrus</i> (Retz.) Willd.	37.50	0.150	Ra
23	<i>Diospyros melanoxylon</i> Roxb.	36.70	0.041	Ra
24	<i>Lagerstroemia parviflora</i> Roxb.	36.40	0.038	Ra
25	<i>Semecarpus anacardium</i> L.f.	36.00	0.047	Ra
26	<i>Haldinia cordifolia</i> (Roxb.) Ridsd.	33.40	0.011	Re
27	<i>Anogeissus latifolia</i> (Roxb. ex DC.) wall. Ex Guill. & Perr	33.10	0.051	C
28	<i>Wrightia arborea</i> (Dennst) Mabb.	32.70	0.150	C
29	<i>Cassia fistula</i> L.	32.20	0.038	Ra
30	<i>Bridellia retusa</i> (L.) Spreng.	31.50	0.021	Re
31	<i>Phyllanthus emblica</i> L.	31.30	0.05	Ra
32	<i>Stereospermum chelonoides</i> auct. non (L.f.) DC.	28.90	0.066	C
33	<i>Careya arborea</i> Roxb.	24.50	0.050	Ra
34	<i>Ziziphus mauritiana</i> Lam.	21.30	0.050	C
35	<i>Mitragyna parviflora</i> (Roxb.) Korth.	17.80	0.083	C
36	<i>Acacia lenticularis</i> Buch. ham. Ex Benth. In Hook.	0	×	×
37	<i>Bombax ceiba</i> L.	0	×	×
38	<i>Chloroxylon swietenia</i> DC.	0	×	×
39	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
40	<i>Pongamia pinnata</i> (L.) Pierre	0	×	×
41	<i>Schrebera swietenoides</i> Roxb.	0	×	×
42	<i>Sterculia urens</i> Roxb. Ex DC.	0	×	×

Table – 4Species rank and distribution pattern of tree species in the altitude range of 425-450m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Ziziphus mauritiana</i> Lam.	65.3	0.114	C
2	<i>Terminalia belirica</i> (Gaertn.) Roxb.	56.0	0.065	C
3	<i>Casearia elliptica</i> Willd.	52.4	0.058	C
4	<i>Dalbergia latifolia</i> Roxb.	52.0	0.098	C
5	<i>Sterculia urens</i> Roxb. Ex DC.	50.2	0.130	C
6	<i>Lannea coromandelica</i> (Houtt.) Merr.	49.5	13.00	C
7	<i>Wrightia arborea</i> (Dennst) Mabb.	49.2	0.065	C
8	<i>Cassia fistula</i> L.	46.3	0.049	Ra
9	<i>Morinda pubescens</i> Sm. in Rees	44.2	0.087	C
10	<i>Buchanania lanzan</i> Spreng.	43.1	0.039	Ra
11	<i>Bridellia retusa</i> (L.) Spreng.	39.9	0.013	Re
12	<i>Lagerstroemia parviflora</i> Roxb.	39.2	0.054	C
13	<i>Terminalia alata</i> Heyne ex Roth	37.7	0.033	Ra
14	<i>Pterocarpus marsupium</i> Roxb.	37.3	0.130	C
15	<i>Schleichera oleosa</i> (Lour.) Oken	36.6	0.022	Re
16	<i>Desmodium oojeinensis</i> (Roxb.) Ohashi	36.0	0.065	C
17	<i>Madhuca indica</i> Gmel.	35.1	0.057	C
18	<i>Dalbergia paniculata</i> Roxb.	34.5	0.058	C
19	<i>Cleistanthus collinus</i> (Roxb.) Benth. Ex Hook.f.	34.2	0.082	C
20	<i>Diospyros melanoxylon</i> Roxb.	31.2	0.033	Ra
21	<i>Haldinia cordifolia</i> (Roxb.) Ridsdak	31.2	0.047	Ra
22	<i>Stereospermum chelonoides</i> auct. non (L.f.) DC.	30.1	0.163	C
23	<i>Semecarpus anacardium</i> L.f.	28.5	0.043	Ra
24	<i>Phyllanthus emblica</i> L.	27.6	0.065	C
25	<i>Careya arborea</i> Roxb.	26.8	0.043	Ra
26	<i>Anogeissus latifolia</i> (Roxb. ex DC.) wall. Ex Guill. & Perr	26.6	0.073	C
27	<i>Mitragyna parviflora</i> (Roxb.) Korth.	23.1	0.057	C
28	<i>Acacia lenticularis</i> Buch. ham. Ex Benth. In Hook.	0	×	×
29	<i>Aegle marmelos</i> (L.) Corr.	0	×	×
30	<i>Bombax ceiba</i> L.	0	×	×
31	<i>Chloroxylon swietenia</i> DC.	0	×	×
32	<i>Dillenia aurea</i> Sm.	0	×	×
33	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
34	<i>Ficus benghalensis</i> L.	0	×	×
35	<i>Gardenia latifolia</i> Aiton.	0	×	×
36	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall. ex G. Don.	0	×	×
37	<i>Pongamia pinnata</i> (L.) Pierre	0	×	×
38	<i>Schrebera swietenoides</i> Roxb.	0	×	×
39	<i>Shorea robusta</i> Gaertn. f.	0	×	×
40	<i>Syzigium cumini</i> (L.) Skeels	0	×	×
41	<i>Terminalia chebula</i> Retz.	0	×	×
42	<i>Ziziphus xylopyrus</i> (Retz.) Willd.	0	×	×

Table –5 Species rank and distribution pattern of tree species in the altitude range of 450-475m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Terminalia chebula</i> Retz.	91.2	0.060	C
2	<i>Casearia elliptica</i> Willd.	79.5	0.180	Re
3	<i>Dalbergia paniculata</i> Roxb.	65.6	0.033	Ra
4	<i>Terminalia belirica</i> (Gaertn.) Roxb.	59.0	0.060	C
5	<i>Semecarpus anacardium</i> L.f.	57.7	0.060	C
6	<i>Wrightia arborea</i> (Dennst) Mabb.	51.6	0.060	C
7	<i>Pterocarpus marsupium</i> Roxb.	46.6	0.040	Ra
8	<i>Careya arborea</i> Roxb.	46.5	0.020	Re
9	<i>Madhuca indica</i> Gmel.	43.0	0.026	Re
10	<i>Dalbergia latifolia</i> Roxb.	40.6	0.060	C
11	<i>Schleichera oleosa</i> (Lour.)Oken	40.3	0.040	Ra
12	<i>Haldinia cordifolia</i> (Roxb.)Ridsdak	38.1	0.053	C
13	<i>Cassia fistula</i> L.	37.5	0.030	Ra
14	<i>Stereospermum chelonoides</i> auct.non (L.f.) DC.	36.4	0.180	C
15	<i>Terminalia alata</i> Heyne ex Roth	35.7	0.180	C
16	<i>Cleistanthus collinus</i> (Roxb.)Benth. Ex Hook.f.	35.0	0.153	C
17	<i>Anogeissus latifolia</i> (Roxb.ex DC.) wall. Ex Guill. & Perr	30.5	0.127	C
18	<i>Phyllanthus emblica</i> L.	28.7	0.060	C
19	<i>Aegle marmelos</i> (L.) Corr.	26.7	0.060	C
20	<i>Buchanania lanzan</i> Spreng.	25.3	0.180	C
21	<i>Desmodium oojeinensis</i> (Roxb.)Ohashi	24.5	0.030	Ra
22	<i>Mitragyna parviflora</i> (Roxb.)Korth.	21.9	0.045	Ra
23	<i>Diospyros melanoxylon</i> Roxb.	21.4	0.060	C
24	<i>Ziziphus mauritiana</i> Lam.	19.0	0.060	C
25	<i>Bridellia retusa</i> (L.)Spreng.	13.6	0.060	C
26	<i>Lagerstroemia parviflora</i> Roxb.	11.6	0.060	C
27	<i>Acacia lenticularis</i> Buch.ham. Ex Benth. In Hook.	0	×	×
28	<i>Bombax ceiba</i> L.	0	×	×
29	<i>Chloroxylon swietiana</i> DC.	0	×	×
30	<i>Dillenia aurea</i> Sm.	0	×	×
31	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
32	<i>Ficus benghalensis</i> L.	0	×	×
33	<i>Gardenia latifolia</i> Aiton.	0	×	×
34	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall.ex G.Don.	0	×	×
35	<i>Lannea coromandelica</i> (Houtt.) Merr.	0	×	×
36	<i>Morinda pubescens</i> Sm.in Rees	0	×	×
37	<i>Pongamia pinnata</i> (L.)Pierre	0	×	×
38	<i>Schrebera swietenoides</i> Roxb.	0	×	×
39	<i>Shorea robusta</i> Gaertn.f.	0	×	×
40	<i>Sterculia urens</i> Roxb. Ex DC.	0	×	×
41	<i>Syzigium cumini</i> (L.)Skeels	0	×	×
42	<i>Ziziphus xylopyrus</i> (Retz.)Willd.	0	×	×

Table –6 Species rank and distribution pattern of tree species in the altitude range of 475-500m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Acacia lenticularis</i> Buch.ham. Ex Benth. In Hook.	300	0.120	C
2	<i>Bombax ceiba</i> L.	300	0.060	C
3	<i>Mitragyna parviflora</i> (Roxb.) Korth.	62.0	0.053	C
4	<i>Ziziphus xylopyrus</i> (Retz.) Willd.	56.3	0.060	C
5	<i>Cassia fistula</i> L.	48.8	0.045	Ra
6	<i>Haldinia cordifolia</i> (Roxb.) Ridsdak	46.0	0.017	Re
7	<i>Ziziphus mauritiana</i> Lam.	45.7	0.060	C
8	<i>Schleichera oleosa</i> (Lour.) Oken	40.9	0.023	Re
9	<i>Buchanania lanzan</i> Spreng.	40.6	0.053	C
10	<i>Bridellia retusa</i> (L.) Spreng.	38.1	0.033	Ra
11	<i>Semecarpus anacardium</i> L.f.	36.5	0.030	Ra
12	<i>Lagerstroemia parviflora</i> Roxb.	34.9	0.040	Ra
13	<i>Aegle marmelos</i> (L.) Corr.	34.3	0.060	C
14	<i>Diospyros melanoxylon</i> Roxb.	30.6	0.027	Ra
15	<i>Chloroxylon swieteniana</i> DC.	29.8	0.060	C
16	<i>Careya arborea</i> Roxb.	22.1	0.060	C
17	<i>Madhuca indica</i> Gmel.	21.9	0.120	C
18	<i>Anogeissus latifolia</i> (Roxb.ex DC.) wall. Ex Guill. & Perr	19.2	0.038	Ra
19	<i>Cleistanthus collinus</i> (Roxb.) Benth. Ex Hook.f.	18.8	0.135	C
20	<i>Desmodium oojeinensis</i> (Roxb.) Ohashi	15.9	0.060	C
21	<i>Pterocarpus marsupium</i> Roxb.	13.9	0.060	C
22	<i>Casearia elliptica</i> Willd.	0	×	×
23	<i>Dalbergia latifolia</i> Roxb.	0	×	×
24	<i>Dalbergia paniculata</i> Roxb.	0	×	×
25	<i>Dillenia aurea</i> Sm.	0	×	×
26	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
27	<i>Ficus benghalensis</i> L.	0	×	×
28	<i>Gardenia latifolia</i> Aiton.	0	×	×
29	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall.ex G.Don.	0	×	×
30	<i>Lannea coromandelica</i> (Houtt.) Merr.	0	×	×
31	<i>Morinda pubescens</i> Sm.in Rees	0	×	×
32	<i>Phyllanthus emblica</i> L.	0	×	×
33	<i>Pongamia pinnata</i> (L.) Pierre	0	×	×
34	<i>Schrebera swietenoides</i> Roxb.	0	×	×
35	<i>Shorea robusta</i> Gaertn.f.	0	×	×
36	<i>Stereospermum chelonoides</i> auct.non (L.f.) DC.	0	×	×
37	<i>Sterculia urens</i> Roxb. Ex DC.	0	×	×
38	<i>Syzigium cumini</i> (L.) Skeels	0	×	×
39	<i>Terminalia alata</i> Heyne ex Roth	0	×	×
40	<i>Terminalia belirica</i> (Gaertn.) Roxb.	0	×	×
41	<i>Terminalia chebula</i> Retz.	0	×	×
42	<i>Wrightia arborea</i> (Dennst) Mabb.	0	×	×

Table –7 Species rank and distribution pattern of tree species in the altitude range of 500-525m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Syzigium cumini</i> (L.)Skeels	135.0	0.020	Re
2	<i>Desmodium oojeinensis</i> (Roxb.)Ohashi	73.90	0.031	Ra
3	<i>Morinda pubescens</i> Sm.in Rees	58.40	0.013	Re
4	<i>Dalbergia latifolia</i> Roxb.	52.80	0.040	Ra
5	<i>Dalbergia paniculata</i> Roxb.	48.00	0.020	Re
6	<i>Ziziphus mauritiana</i> Lam.	42.10	0.020	Re
7	<i>Stereospermum chelonoides</i> auct.non (L.f.) DC.	38.30	0.030	Ra
8	<i>Diospyros melanoxylon</i> Roxb.	38.20	0.038	Ra
9	<i>Cleistanthus collinus</i> (Roxb.)Benth. Ex Hook.f.	36.10	0.076	C
10	<i>Bridellia retusa</i> (L.)Spreng.	35.60	0.030	Ra
11	<i>Aegle marmelos</i> (L.) Corr.	34.25	0.040	Ra
12	<i>Lagerstroemia parviflora</i> Roxb.	30.40	0.013	Re
13	<i>Mitragyna parviflora</i> (Roxb.)Korth.	28.60	0.030	Ra
14	<i>Pterocarpus marsupium</i> Roxb.	28.10	0.080	C
15	<i>Schleichera oleosa</i> (Lour.)Oken	27.20	0.080	C
16	<i>Buchanania lanzan</i> Spreng.	22.10	0.020	Re
17	<i>Haldinia cordifolia</i> (Roxb.)Ridsdak	20.90	0.080	C
18	<i>Anogeissus latifolia</i> (Roxb.ex DC.) wall. Ex Guill. & Perr	15.50	0.018	Re
19	<i>Acacia lenticularis</i> Buch.ham. Ex Benth. In Hook.	0	×	×
20	<i>Bombax ceiba</i> L.	0	×	×
21	<i>Careya arborea</i> Roxb.	0	×	×
22	<i>Casearia elliptica</i> Willd.	0	×	×
23	<i>Cassia fistula</i> L.	0	×	×
24	<i>Chloroxylon swietenia</i> DC.	0	×	×
25	<i>Dillenia aurea</i> Sm.	0	×	×
26	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
27	<i>Ficus benghalensis</i> L.	0	×	×
28	<i>Gardenia latifolia</i> Aiton.	0	×	×
29	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall.ex G.Don.	0	×	×
30	<i>Lannea coromandelica</i> (Houtt.) Merr.	0	×	×
31	<i>Madhuca indica</i> Gmel.	0	×	×
32	<i>Phyllanthus emblica</i> L.	0	×	×
33	<i>Pongamia pinnata</i> (L.)Pierre	0	×	×
34	<i>Schrebera swietenoides</i> Roxb.	0	×	×
35	<i>Semecarpus anacardium</i> L.f.	0	×	×
36	<i>Shorea robusta</i> Gaertn.f.	0	×	×
37	<i>Sterculia urens</i> Roxb. Ex DC.	0	×	×
38	<i>Terminalia alata</i> Heyne ex Roth	0	×	×
39	<i>Terminalia belirica</i> (Gaertn.) Roxb.	0	×	×
40	<i>Terminalia chebula</i> Retz.	0	×	×
41	<i>Wrightia arborea</i> (Dennst) Mabb.	0	×	×
42	<i>Ziziphus xylopyrus</i> (Retz.)Willd.	0	×	×

Table –8 Species rank and distribution pattern of tree species in the altitude range of 525-550m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Sterculia urens</i> Roxb. Ex DC.	143.2	0.02	Re
2	<i>Ziziphus xylopyrus</i> (Retz.)Willd.	118.8	0.02	Re
3	<i>Wrightia arborea</i> (Dennst) Mabb.	114.9	0.02	Re
4	<i>Dalbergia latifolia</i> Roxb.	89.30	0.02	Re
5	<i>Chloroxylon swietiana</i> DC.	86.90	0.04	Ra
6	<i>Bridellia retusa</i> (L.)Spreng.	43.10	0.04	Ra
7	<i>Cleistanthus collinus</i> (Roxb.)Benth. Ex Hook.f.	36.20	0.16	C
8	<i>Mitragyna parviflora</i> (Roxb.)Korth.	34.30	0.04	Ra
9	<i>Anogeissus latifolia</i> (Roxb.ex DC.) wall. Ex Guill. & Perr	33.00	0.14	C
10	<i>Haldinia cordifolia</i> (Roxb.)Ridsdak	31.00	0.04	Ra
11	<i>Schleichera oleosa</i> (Lour.)Oken	26.30	0.02	Re
12	<i>Lagerstroemia parviflora</i> Roxb.	22.40	0.02	Re
13	<i>Buchanania lanzan</i> Spreng.	22.10	0.02	Re
14	<i>Diospyros melanoxylon</i> Roxb.	11.10	0.02	Re
15	<i>Acacia lenticularis</i> Buch.ham. Ex Benth. In Hook.	0	×	×
16	<i>Aegle marmelos</i> (L.) Corr.	0	×	×
17	<i>Bombax ceiba</i> L.	0	×	×
18	<i>Careya arborea</i> Roxb.	0	×	×
19	<i>Casearia elliptica</i> Willd.	0	×	×
20	<i>Cassia fistula</i> L.	0	×	×
21	<i>Dalbergia paniculata</i> Roxb.	0	×	×
22	<i>Desmodium oojeinensis</i> (Roxb.)Ohashi	0	×	×
23	<i>Dillenia aurea</i> Sm.	0	×	×
24	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
25	<i>Ficus benghalensis</i> L.	0	×	×
26	<i>Gardenia latifolia</i> Aiton.	0	×	×
27	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall.ex G.Don.	0	×	×
28	<i>Lannea coromandelica</i> (Houtt.) Merr.	0	×	×
29	<i>Madhuca indica</i> Gmel.	0	×	×
30	<i>Morinda pubescens</i> Sm.in Rees	0	×	×
31	<i>Phyllanthus emblica</i> L.	0	×	×
32	<i>Pongamia pinnata</i> (L.)Pierre	0	×	×
33	<i>Pterocarpus marsupium</i> Roxb.	0	×	
34	<i>Schrebera swietenoides</i> Roxb.	0	×	×
35	<i>Semecarpus anacardium</i> L.f.	0	×	×
36	<i>Shorea robusta</i> Gaertn.f.	0	×	×
37	<i>Stereospermum chelonoides</i> auct.non (L.f.) DC.	0	×	×
38	<i>Syzigium cumini</i> (L.)Skeels	0	×	×
39	<i>Terminalia alata</i> Heyne ex Roth	0	×	×
40	<i>Terminalia belirica</i> (Gaertn.) Roxb.	0	×	×
41	<i>Terminalia chebula</i> Retz.	0	×	×
42	<i>Ziziphus mauritiana</i> Lam.	0	×	×

Table – 9 Species rank and distribution pattern of tree species in the altitude range of 550-575m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Pongamia pinnata</i> (L.)Pierre	300.0	0.030	Ra
2	<i>Schrebera swietenoides</i> Roxb.	300.0	0.030	Ra
3	<i>Dillenia aurea</i> Sm.	240.9	0.060	C
4	<i>Ficus benghalensis</i> L.	216.7	0.030	Ra
5	<i>Sterculia urens</i> Roxb. Ex DC.	106.6	0.030	Ra
6	<i>Phyllanthus emblica</i> L.	88.60	0.023	Re
7	<i>Semecarpus anacardium</i> L.f.	57.70	0.060	C
8	<i>Desmodium oojeinensis</i> (Roxb.)Ohashi	51.00	0.090	C
9	<i>Cassia fistula</i> L.	50.70	0.020	Re
10	<i>Lagerstroemia parviflora</i> Roxb.	49.70	0.038	Ra
11	<i>Stereospermum chelonoides</i> auct.non (L.f.) DC.	47.30	0.023	Re
12	<i>Lannea coromandelica</i> (Houtt.) Merr.	46.70	3.000	C
13	<i>Ziziphus mauritiana</i> Lam.	45.70	0.060	C
14	<i>Diospyros melanoxylon</i> Roxb.	42.30	0.043	Ra
15	<i>Haldinia cordifolia</i> (Roxb.)Ridsdak	42.00	0.126	C
16	<i>Anogeissus latifolia</i> (Roxb.ex DC.) wall. Ex Guill. & Perr	39.60	0.050	Ra
17	<i>Dalbergia paniculata</i> Roxb.	35.80	0.030	Ra
18	<i>Pterocarpus marsupium</i> Roxb.	35.10	0.015	Re
19	<i>Careya arborea</i> Roxb.	34.30	0.030	Ra
20	<i>Mitragyna parviflora</i> (Roxb.)Korth.	26.60	0.060	C
21	<i>Buchanania lanzan</i> Spreng.	25.60	0.060	C
22	<i>Terminalia alata</i> Heyne ex Roth	24.00	0.030	Ra
23	<i>Bridellia retusa</i> (L.)Spreng.	20.90	0.030	Ra
24	<i>Cleistanthus collinus</i> (Roxb.)Benth. Ex Hook.f.	17.20	0.120	C
25	<i>Acacia lenticularis</i> Buch.ham. Ex Benth. In Hook.	0	×	×
26	<i>Aegle marmelos</i> (L.) Corr.	0	×	×
27	<i>Bombax ceiba</i> L.	0	×	×
28	<i>Casearia elliptica</i> Willd.	0	×	×
29	<i>Chloroxylon swietiana</i> DC.	0	×	×
30	<i>Dalbergia latifolia</i> Roxb.	0	×	×
31	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
32	<i>Gardenia latifolia</i> Aiton.	0	×	×
33	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall.ex G.Don.	0	×	×
34	<i>Madhuca indica</i> Gmel.	0	×	×
35	<i>Morinda pubescens</i> Sm.in Rees	0	×	×
36	<i>Schleichera oleosa</i> (Lour.)Oken	0	×	×
37	<i>Shorea robusta</i> Gaertn.f.	0	×	×
38	<i>Syzigium cumini</i> (L.)Skeels	0	×	×
39	<i>Terminalia belirica</i> (Gaertn.) Roxb.	0	×	×
40	<i>Terminalia chebula</i> Retz.	0	×	×
41	<i>Wrightia arborea</i> (Dennst) Mabb.	0	×	×
42	<i>Ziziphus xylopyrus</i> (Retz.)Willd.	0	×	×

Table–10 Species rank and distribution pattern of tree species in the altitude range of 575-600m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Euphorbia nivula</i> Buch.-Ham.	300.0	0.01	Re
2	<i>Morinda pubescens</i> Sm.in Rees	73.90	0.01	Re
3	<i>Stereospermum chelonoides</i> auct.non (L.f.) DC.	52.00	0.01	Re
4	<i>Madhuca indica</i> Gmel.	44.20	0.01	Re
5	<i>Buchanania lanzan</i> Spreng.	39.00	0.01	Re
6	<i>Anogeissus latifolia</i> (Roxb.ex DC.) wall. Ex Guill. & Perr	28.70	0.03	Ra
7	<i>Diospyros melanoxylon</i> Roxb.	19.00	0.01	Re
8	<i>Acacia lenticularis</i> Buch.ham. Ex Benth. In Hook.	0	×	×
9	<i>Aegle marmelos</i> (L.) Corr.	0	×	×
10	<i>Bombax ceiba</i> L.	0	×	×
11	<i>Bridellia retusa</i> (L.)Spreng.	0	×	×
12	<i>Careya arborea</i> Roxb.	0	×	×
13	<i>Casearia elliptica</i> Willd.	0	×	×
14	<i>Cassia fistula</i> L.	0	×	×
15	<i>Chloroxylon swietiana</i> DC.	0	×	×
16	<i>Cleistanthus collinus</i> (Roxb.)Benth. Ex Hook.f.	0	×	×
17	<i>Dalbergia latifolia</i> Roxb.	0	×	×
18	<i>Dalbergia paniculata</i> Roxb.	0	×	×
19	<i>Desmodium oojeinensis</i> (Roxb.)Ohashi	0	×	×
20	<i>Dillenia aurea</i> Sm.	0	×	×
21	<i>Ficus benghalensis</i> L.	0	×	×
22	<i>Gardenia latifolia</i> Aiton.	0	×	×
23	<i>Haldinia cordifolia</i> (Roxb.)Ridsdak	0	×	×
24	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall.ex G.Don.	0	×	×
25	<i>Lagerstroemia parviflora</i> Roxb.	0	×	×
26	<i>Lannea coromandelica</i> (Houtt.) Merr.	0	×	×
27	<i>Mitragyna parviflora</i> (Roxb.)Korth.	0	×	×
28	<i>Phyllanthus emblica</i> L.	0	×	×
29	<i>Pongamia pinnata</i> (L.)Pierre	0	×	×
30	<i>Pterocarpus marsupium</i> Roxb.	0	×	×
31	<i>Schleichera oleosa</i> (Lour.)Oken	0	×	×
32	<i>Schrebera swietenoides</i> Roxb.	0	×	×
33	<i>Semecarpus anacardium</i> L.f.	0	×	×
34	<i>Shorea robusta</i> Gaertn.f.	0	×	×
35	<i>Sterculia urens</i> Roxb. Ex DC.	0	×	×
36	<i>Syzigium cumini</i> (L.)Skeels	0	×	×
37	<i>Terminalia alata</i> Heyne ex Roth	0	×	×
38	<i>Terminalia belirica</i> (Gaertn.) Roxb.	0	×	×
39	<i>Terminalia chebula</i> Retz.	0	×	×
40	<i>Wrightia arborea</i> (Dennst) Mabb.	0	×	×
41	<i>Ziziphus mauritiana</i> Lam.	0	×	×
42	<i>Ziziphus xylopyrus</i> (Retz.)Willd.	0	×	×

Table– 11Species rank and distribution pattern of tree species in the altitude range of 600 - 625m

SPECIES RANK	SPECIES	IVI	A/F	DISTRIBUTION
1	<i>Gardenia latifolia</i> Aiton.	240.9	0.02	Re
2	<i>Chloroxylon swietiana</i> DC.	140.5	0.02	Re
3	<i>Phyllanthus emblica</i> L.	95.10	0.01	Re
4	<i>Mitragyna parviflora</i> (Roxb.)Korth.	57.40	0.02	Re
5	<i>Stereospermum chelonoides</i> auct.non (L.f.) DC.	52.00	0.01	Re
6	<i>Lagerstroemia parviflora</i> Roxb.	38.50	0.01	Re
7	<i>Cleistanthus collinus</i> (Roxb.)Benth. Ex Hook.f.	20.20	0.01	Re
8	<i>Anogeissus latifolia</i> (Roxb.ex DC.) wall. Ex Guill. & Perr	17.80	0.01	Re
9	<i>Acacia lenticularis</i> Buch.ham. Ex Benth. In Hook.	0	×	×
10	<i>Aegle marmelos</i> (L.) Corr.	0	×	×
11	<i>Bombax ceiba</i> L.	0	×	×
12	<i>Bridellia retusa</i> (L.)Spreng.	0	×	×
13	<i>Buchanania lanzan</i> Spreng.	0	×	×
14	<i>Careya arborea</i> Roxb.	0	×	×
15	<i>Casearia elliptica</i> Willd.	0	×	×
16	<i>Cassia fistula</i> L.	0	×	×
17	<i>Dalbergia latifolia</i> Roxb.	0	×	×
18	<i>Dalbergia paniculata</i> Roxb.	0	×	×
19	<i>Desmodium oojeinensis</i> (Roxb.)Ohashi	0	×	×
20	<i>Dillenia aurea</i> Sm.	0	×	×
21	<i>Diospyros melanoxylon</i> Roxb.	0	×	×
22	<i>Euphorbia nivula</i> Buch.-Ham.	0	×	×
23	<i>Ficus benghalensis</i> L.	0	×	×
24	<i>Haldinia cordifolia</i> (Roxb.)Ridsdak	0	×	×
25	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall.ex G.Don.	0	×	×
26	<i>Lannea coromandelica</i> (Houtt.) Merr.	0	×	×
27	<i>Madhuca indica</i> Gmel.	0	×	×
28	<i>Morinda pubescens</i> Sm.in Rees	0	×	×
29	<i>Pongamia pinnata</i> (L.)Pierre	0	×	×
30	<i>Pterocarpus marsupium</i> Roxb.	0	×	×
31	<i>Schleichera oleosa</i> (Lour.)Oken	0	×	×
32	<i>Schrebera swietenoides</i> Roxb.	0	×	×
33	<i>Semecarpus anacardium</i> L.f.	0	×	×
34	<i>Shorea robusta</i> Gaertn.f.	0	×	×
35	<i>Sterculia urens</i> Roxb. Ex DC.	0	×	×
36	<i>Syzigium cumini</i> (L.)Skeels	0	×	×
37	<i>Terminalia alata</i> Heyne ex Roth	0	×	×
38	<i>Terminalia belirica</i> (Gaertn.) Roxb.	0	×	×
39	<i>Terminalia chebula</i> Retz.	0	×	×
40	<i>Wrightia arborea</i> (Dennst) Mabb.	0	×	×
41	<i>Ziziphus mauritiana</i> Lam.	0	×	×
42	<i>Ziziphus xylopyrus</i> (Retz.)Willd.	0	×	×

Table - 12

DISTRIBUTION TYPES	Altitude range(meters)											Total
	350-375	375-400	400-425	425-450	450-475	475-500	500-525	525-550	550-575	575-600	600-625	
Regular species (Re)	5	0	2	2	3	2	7	8	4	6	8	47
Random species (Ra)	12	6	15	7	6	6	7	4	11	1	0	75
Contiguous species (C)	5	15	18	18	17	13	4	2	9	0	0	101
Total Species	22	21	35	27	26	21	18	14	24	7	8	223
Total families	17	15	20	17	17	15	12	12	17	7	6	155

DISCUSSION

The forest of Gandhamardan hill ranges falls under Tropical Deciduous (Champion and Seth, 1968). Its phytosociological study is of prime importance because of the ever increasing biotic pressure and unaccountable exploitation of its natural resources. If it is judiciously studied, species diversity and dynamic features of the ecosystem will be known. One of features is the elevational variation in species occurrence and many hypotheses have been proposed to explain the variation in species richness along elevational gradients. One hypothesis proposes that there is a positive correlation between elevation and the elevational range of species. This pattern called Rapoport's elevation rule (Stevens, 1992), derived from earlier work on latitudinal gradients by Rapoport (1975, 1982), that found that latitudinal ranges of species increase with increasing latitude (Rapoport, 1982; Stevens, 1989). Rapoport's elevation rule arises as a result of the ever-narrowing range of climatic conditions that species experience with decreasing elevation (Stevens, 1992). It suggests that species occurring at higher elevations must be able to withstand a broad range of climatic conditions and this leads to a wide elevation range. Species found at lower elevations are adapted to more specific temperature and rainfall conditions so they have narrow climatic tolerances and hence a smaller range, resulting in more species. Pattern consistent with Rapoport's rule have been documented for trees, mammals, amphibians, grasshoppers, and reptiles (Stevens, 1992 and references there in). Colwell and Hurt (1994) proposed a new hypothesis called 'hard

boundary' or 'mid-domain effect' to explain mid-elevational peaks in species richness. They suggested that mid-elevation peaks in species richness arise because of the increasing overlap of species ranges towards the centre of the domain, as the extent of the elevational ranges of species is bounded by the highest and lowest elevations. The present study confirms to the finding of Colwell and Hurt (Fig-14 & Table – 12). Contrary to Rapoport's rule, the hard boundary hypothesis predicts that species ranges at higher elevations are narrow which again supports the present finding as total number of species decreases from lower altitude (400-425m) to high altitude (600-625m). From a review of literature, Rahbek (1995) concluded that hump-shaped relationships are most common in both tropical and non-tropical biomes. In the present study, the graph of the distribution of species and family from lower to higher altitude ranges is hump shaped (Fig-14) confirming to the finding of Rahbek.

The R^2 values of the D-D curves of the species in the studied altitude ranges of 350-375m, 375-400m, 400-425m, 425-450m, 450-475m, 475-500m, 500-525m, 525-550m, 550-575m, 575-600m and 600-625m show that approximately 76%, 66%, 53%, 92%, 89%, 36%, 62%, 53%, 54%, 21% and 29% variation in the occurrence of the species can be explained by this model and rest 24%, 34%, 47%, 8%, 11%, 64%, 38%, 47%, 46%, 79% and 71% is caused by other inherent factors which need further in-depth research. The D-D curves show sharp decreasing relationship of the species due to wide differences in their IVI values among all Dominance-Diversity (D-D) curves.

The curve in range of 425-450m shows highest correlation which is best suitable for the diversity study of tree community in the natural forest of Gandhamardan hill ranges.

Odum (1971) have emphasized that contiguous distribution is the commonest pattern in nature. Contiguous distribution has been reported by several workers Greig-Smith (1957); Kershaw (1973); Singh and Yadav (1974). Kumar and Bhatt (2006) also reported contiguous distribution pattern in foot-hill forests of Garhwal Himalaya. In the present study, out of six species occurring at only single altitude range, three shows contiguous type of distribution. In conformity with the Odum's finding, out of 223 occurrences of species across all altitude ranges, 101 cases are contiguous, 47 are regular and 75 are random type. Regular distribution of species decreases from lower elevation to mid elevation and again increases from mid elevation to higher elevation. But on contrary, random and contiguous distribution increases from lower elevation to mid elevation and further it decreases from mid elevation to higher elevation. This corroborates with the previous findings. It shows contiguous distribution to be prevalent and this can be attributed to the interaction of many factors that are acting together on the population. As such, clumping indicates inefficient mode of seed dispersal (Richards, 1996). While comparing dispersion pattern of trees in tropical to temperate climates of the world, Armesto *et al.* (1986) concluded that clumping is the characteristics of natural forests which confirms with the prevalent contiguous distribution of tree species in the natural forest of Gandhamardan hill ranges.

The spatial distribution of species is considered as adaptability potential and suitability of a species to the environment. Climatic factors and biotic interferences also influence the regeneration of different species in the vegetation. Good and Good (1972) have considered three major components which cause the successful regeneration of tree species. These components are the ability to initiate new seedlings, ability of seedlings and saplings to survive and ability of seedlings and saplings to

grow. The IVI value of *Anogeissus latifolia* (Roxb. ex DC.) wall. Ex Guill. & Perr in each altitude range shows its more relative abundance, uniform distribution and wide climatic tolerance and adaptation with respect to other tree species in the community. Hence this species can be considered as best suitable to the existing environmental conditions from present study.

CONCLUSION

Vegetation is an essential element of all major ecosystems. Precise estimates of vegetation structure variables are critical to the understanding of landform ecology. Exact knowledge of vegetation structure and distribution is also vital for assessment of habitat use and selection by animals. Tree diversity data have become available from high diversity and low diversity tropical forests over the past decades and they could be potentially used for planning and managing forest biodiversity. In this context, quantitative assessment of the tree community across altitude ranges has been conducted for sustainable management and monitoring of species inside protected forest area. Out of 223 occurrences of species, 101 are contiguous type of distribution reflecting the species gregariousness in the forest. Only one species i.e. *Anogeissus latifolia* (Roxb. ex DC.) wall. Ex Guill. & Perr is found in all the studied eleven altitude ranges showing its wide adaptation in existing landform system. Highest R^2 value in the altitude range of 425-450m shows it to be the best elevational range for the study of plant diversity inside the protected forest area.

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