RESEARCH ARTICLE

POPULATION STRUCTURE OF VEGETATION IN URBAN ENVIRONMENT OF SARGUJA, CHHATTISGARH, INDIA

Nahid Khan, Manoj Kumar Jhariya* and Dhiraj Kumar Yadav

University Teaching Department, Department of Farm Forestry, Sant Gahira Guru Vishwavidyalaya, Sarguja, Ambikapur- 497001 (Chhattisgarh), India
Email: manu9589@gmail.com

Received-01.03.2019, Revised-25.03.2019

Abstract: The present study was conducted in different directions(east, west, north and south) of Ambikapur to explore the urban vegetation in terms of species status, population structure and regeneration potential of species. A total of 10 tree species distributed into 6 families were recorded in east direction, 9 tree species with 4 families in west direction, 12 tree species comprised of 9 families in north direction, and 11 tree species belonging to 8 families were recorded in south direction. The tree density ranged between 170-240 trees/ha across the site being highest under north direction and least at east direction. The rarity and commonness of the species in urban setup reflected that majority of the species are rare in occurrence in different stratum while the intermediate, moderately high and common (high frequency) species class was almost negligible in the entire site in most of the vegetation stratum. Population structure of the species also revealed the younger vegetation stand in all the direction due to absence of the different size classes of the species. The regeneration of the species was not found up to the mark in all the direction. Therefore, there are needs for the conservation priority to manage the urban landscape for better management and planning.

Keywords: Structure, Population dynamics, Regeneration, Urban vegetation

INTRODUCTION

The vegetation such as tree, shrub and herb present in cities play vital role in improving urban environment. It plays a key role in maintaining various components of ecosystem and the biodiversity (Jim and Chen, 2009). Tree species primarily provide fresh air/ oxygen and are essential for social life to the residents of a locality; therefore, it is necessary to have a detailed record of trees of an urban locality. Trees have good potential of tapping atmospheric carbon through photosynthesis and thus reduce atmospheric carbon (Yadav et al. 2017; Jhariya et al. 2019). Tree species also help in mitigating climate change and reduces urban temperature. Plants store carbon in terms of live biomass, which becomes a part of the food chain and enters into the (Gavali and Sheikh, 2016). Urban forests sequester carbon and affect the emission of $CO_2$by reducing its level from urban areas. Thus, urban forests play a major role in managing the increase in level of CO_2. Urban trees store carbon derived from CO_2, which is the major gas contributing to global climate change (Saral et al. 2017).

The net save in carbon emissions that can be achieved by urban planting can be up to 18 kg CO_2/year per tree and this benefit corresponds to that provided by 3 to 5 forest trees of similar size and health (Francesco and Alessio,2011). As in urban area level of pollution is very high, this vegetation helps in pollution control.Vegetation in urban areas, particularly trees, directly removes air pollution and can also provide barriers between sources and exposed populations. Urban trees perform important ecological function in cities by sequestering carbon and reducing automobile pollution. Urban vegetation can provide numerous benefits beyond air quality improvements, including temperature and storm water regulation, noise reduction, aesthetic improvements, and environments conducive to physical exercise and experiencing nature. These co-benefits or ecosystem services of urban vegetation have been associated with improved physical and mental health and community vitality (Baldauf and Nowak, 2014).Therefore, the present investigation is carried out to record the urban vegetation structure, population dynamics and associated ecological attributes in Sarguja (Chhattisgarh), India to enrich the information for better management and conservation of these resources under the urban setup.

MATERIALS AND METHODS

The vegetation was analysed in different sites (i.e., east, west, north and south) of Ambikapur, Sarguja. The trees, saplings, seedlings and shrubs were analysed by randomly laying quadrats of size 10 m x 10 m. The girth at breast height (i.e., 1.37 m above the ground) of all the trees and saplings in each quadrat was measured.While in the case of seedling the numbers of individuals by species were recorded separately. The shrubs were measured at collar height.For herb a quadrat of 50 cm x 50 cm was laid and number of individuals was counted in various seasons.

The species rarity or commonness of the species was calculated as the frequency class of the species (Raunkiaer, 1934; Hewit and Kellman, 2002). As per

*Corresponding Author

frequency classes, the species were categorized as A, B, C, D, and E, where A represents rare (0–20%), B represents low frequency (20–40%), C represents intermediate frequency (40–60%), D represents moderately high frequency (60–80%), and E represents high frequency or common (80–100%).The population structures of vegetation were developed by using thevarious girth classes of tree species. The total number of individuals corresponds to these girth classes was calculated at species level for various direction (Saxena and Singh, 1984; Tripathi et al. 1991; Jhariya et al. 2012). Besides to seedling (A) and sapling (B) classes, three more tree size classes viz., C(31.5−70.0 cm), D(70.1−110.0 cm) and E (>110 cm) were arbitrarily established at species level through graphical representation. The regeneration potential of urban vegetation was determined as per the Khan et al (1987).

RESULTS AND DISCUSSION

Species status and vegetation statistics

The present study revealed that total 10 species of tree species distributed into6 families were recorded in east direction, in west direction total 9 tree species with 4 families, in north direction 12 tree species comprised of 9 families, and in south direction 11 tree species belonging to 8 families were recorded (Table 1). The tree density ranged between 170-240 trees/ha across the site being highest under north direction and least at east direction. The north direction was found rich in number of species, families as well as density as compared to other direction.Under sapling layer, in west direction 3 species with 1 family was found while in north and south direction 2 species with 1 family was recorded. The sapling density was highest in west direction while least towards north direction (Table 1). Seedling stratum revealed that the higher number of species and families were recorded towards north direction and least at south direction. The higher seedling density was found in north direction while least at east direction. Higher shrub species was found in the both east and north directions while least at south direction (5 species). The highest shrub density was recorded at east direction and least towards south direction (Table 1).The herbaceous vegetation reflects substantial seasonal variation across the site in different season in terms of herb richness, families and density.During rainy season, a total of 5 herb species belonging to 4 families were found in the east direction.In west direction total 7 herb species with 4 families were recorded, in north direction 9 herb species with 7 families, and in south direction 5 herb species belongs to 4 families were noticed. The density of herb was found higher towards north direction in rainy season. During winter season the highest number of species and families were recorded at north direction while least at east direction. The herb density during winter was also found more in north direction and lowest in both east and south directions, respectively. In summer season, higher number of herb species was found in west direction, and higher family was found both in west and north direction, respectively. The least number of species and families were recorded towards south direction. The density of herb in summer was found highest at north and lowest at south direction, respectively (Table 1).

Table 1. Vegetation statistic at different direction in an urban setup of Sarguja

Attributes	East	West	North	South
Tree				
Number of species	10	9	12	11
Number of families	6	4	9	8
Number of individuals (per hectare)	170	220	240	190
Sapling				
Number of species	0	3	2	2
Number of families	0	1	1	1
Number of individuals (per hectare)	0	50	20	40
Seedling				
Number of species	3	4	8	2
Number of families	1	1	4	1
Number of individuals (per hectare)	30	400	420	70
Shrub				
Number of species	7	6	7	5

Number of families	5	6	6	4
Number of individuals (per hectare)	570	260	450	230
Herb				
Rainy				
Number of species	5	7	9	5
Number of families	4	4	7	4
Number of individuals (per hectare)	138000	114000	152000	90000
Winter				
Number of species	3	6	7	4
Number of families	3	3	5	3
Number of individuals (per hectare)	72000	94000	104000	72000
Summer				
Number of species	5	12	9	4
Number of families	3	7	7	2
Number of individuals (per hectare)	100000	134000	184000	88000

The urban vegetation reflects significant variation among them. The vegetation in different stratum shows rich diversity in terms of number, species and family across the sites. The present findings were comparable withOgwu et al. (2016), they reported 20 tree species with 12 families during their investigation. Further, Agbelade et al. (2017) mentioned 69 species with 29 family of tree species in urban centre whereas 20 species with 12 family of tree species in peri-urban area of Nigeria.

Species rarity and commonness

The tree layer reflectstotal 10 speciesin east sitewhich revealed all the species found in class Arepresenting rare frequency (Table 2). Towards west direction total 9species occurred, which revealed only two frequency classes *viz*., class A (comprised of 77.78% species) and class B(22.22% species). Towards north direction 12 species occurred, in class A 91.67% species found representing rare frequency,in class B 8.33% species recorded. In south direction 11 species occurred, in class A 90.91% species was found representingrare frequency, in class B 9.09% species was recorded, representing low frequency. It reflected from the Table 2 in tree layer the frequency classes C,D, E were totally absent in all the direction.Thesapling layer reflects that towards east direction no presence of species under this layer while in other directions sapling were represented only in rare class (A) while the class B, C, D and E was totally absent. The seedling layer showed rare and low frequency classes for west and north direction while east and south direction reflects only by class A. The frequency class C, D and E were totally absent in the entire site studied (Table 2).

Total 7 shrub species occurred in east direction (Table 2), 57% species found in class A representing rarefrequency, 14% species found in class B showing low frequency and 29% species found in classD representing moderately high frequency while in C and E class species were totally absent. Towards west direction 6 species occurred, in class A 67% species was found, in class B 17% specieswas recorded, and in class C 17% species found showing intermediatefrequency while in class D and E species were totally absent. At north direction 7 species occurred, in class A57% species found, in class B 29% species recorded, representing low frequency in class D 14%species representing moderately high frequency while in class C and E species were absent. At south direction 5species occurred, in class A 60% species was found, in class B 40%species was recorded, while species were totally absent in C, D and E classes (Table 2).

During rainy season (Table 2)5 herb species in east direction was recorded in which 60%species found in class B and remaining in class C (40%). Towards west direction 7 speciesoccurred, in class A 57.14% species were found and in class B42.86% species were recorded. At north site 9 species occurred, in which class A comprised of 55.56% species, in class B 11.11% species was recorded, and in class C33.33% species were found. In south direction 5 species occurred, in class A 60% species were found and remaining in class B (40%). In winter season 3 species occurred in east site, 33.33% species in class A and in class B 66.67% species were found. At west direction 6 species occurred, 50% species in each frequency class i.e., A and B were found. Towards north direction 7 species occurred, inclass A 71.43% species were found, and remaining by class B

(28.57%). At south direction4 species occurred, in class A 75% species were found, and in classB 25% species was recorded. Herbs in summer season at east direction reflected 2 species,of which 80% species was in class A and 20% species in class B. At west direction 6 species occurred which was distributed only frequency class A (100%). Towards north direction 9species occurred, in class A 66.67% species were found, and in classB 33.33% species were recorded. South direction contains 4 species, in class A 75% species was found, and remaining (25%) in class B. The size class C, D, E are mostly absent in case of herb layer across the site in all the season except rainy season in east and north direction, respectively (Table 2).

The species occurrence and life-forms are generally associated with specific climatic regimes. In present investigation it was found that species class A (species rarity) was prevailing in different direction of urban landscape. The subsequent classes were decreasing in terms of number of species presence and even nil or negligible in higher frequency class. These findings were also supported by Oraon and Jhariya (2018). They also found the similar trend of species distribution as per the frequency class.

Table 2. Species rarity or commonness in an urban setup of Sarguja

Species	Sites	Rare (A)	Low frequency (B)	Intermediate (C)	Moderately high (D)	High frequency (E)
Tree	East	10	0	0	0	0
	West	7	2	0	0	0
	North	11	1	0	0	0
	South	10	1	0	0	0
Sapling	East	0	0	0	0	0
	West	2	0	0	0	0
	North	2	0	0	0	0
	South	2	0	0	0	0
Seedling	East	3	0	0	0	0
	West	1	3	0	0	0
	North	6	2	0	0	0
	South	2	0	0	0	0
Shrub	East	4	1	0	2	0
	West	4	1	1	0	0
	North	4	2	0	1	0
	South	3	2	0	0	0
Herb (Rainy season)	East	0	3	2	0	0
	West	4	3	0	0	0
	North	5	1	3	0	0
	South	3	2	0	0	0
Herb (Winter season)	East	1	2	0	0	0
	West	3	3	0	0	0
	North	5	2	0	0	0
	South	3	1	0	0	0
Herb (Summer season)	East	4	1	0	0	0
	West	12	0	0	0	0
	North	6	3	0	0	0
	South	3	1	0	0	0

Relationship of density to GBH

Tree species density-GBH distribution followed a linear model [Y = lin. (a − bx)] on all the direction of the Ambikapur. The sites thus exhibited a small structure as 15-67.74% individuals had ≤10 cm girth, and only 6.45–24.14% were in girth classes exceeding 10 cm GBH (Figure1), while 28.13–70% individuals were exceeding >50 cm GBH. When data were pooled, the woody species density was related to GBH according to:

(1) East direction: Y = lin. [5.714x+5.714]
(2) West direction: Y =lin. [-33.57x+225.7]
(3) North direction: Y = lin. [-35.71x+231.4]
(4) South direction: Y = lin. [-1.071x+45.71]

Linear relationship between density and GBH reflected structure vegetation where only 28.13 70% individuals were in classes >50 cm GBH. Jhariya and Yadav (2018) reported that the sites possessed small structure (≤10 cm girth) as 72.66% and 73.87% individuals, respectively in natural and teak stand. Further the relationship between density and girth class revealed 1.27-6.22% individuals were distributed in girth class ＞50 cm. This may be because of higher biotic pressure and faster turnover in the study sites (Jhariya and Yadav, 2018). Similarly, Oraon (2012) mentioned up to 1.5–3.7% of individual species was in girth classes exceeding 50 cm GBH and nearly 89-94% individuals had girth class of ≤10 cm. Jhariya (2014) reported that 86.37–91.71% individuals had ≤10 cm girth, 8.29–13.63% in girth of more than10 cm, while 1.58–2.18% individuals were represented with exceeding girth class of>50 cm in an forest stand.

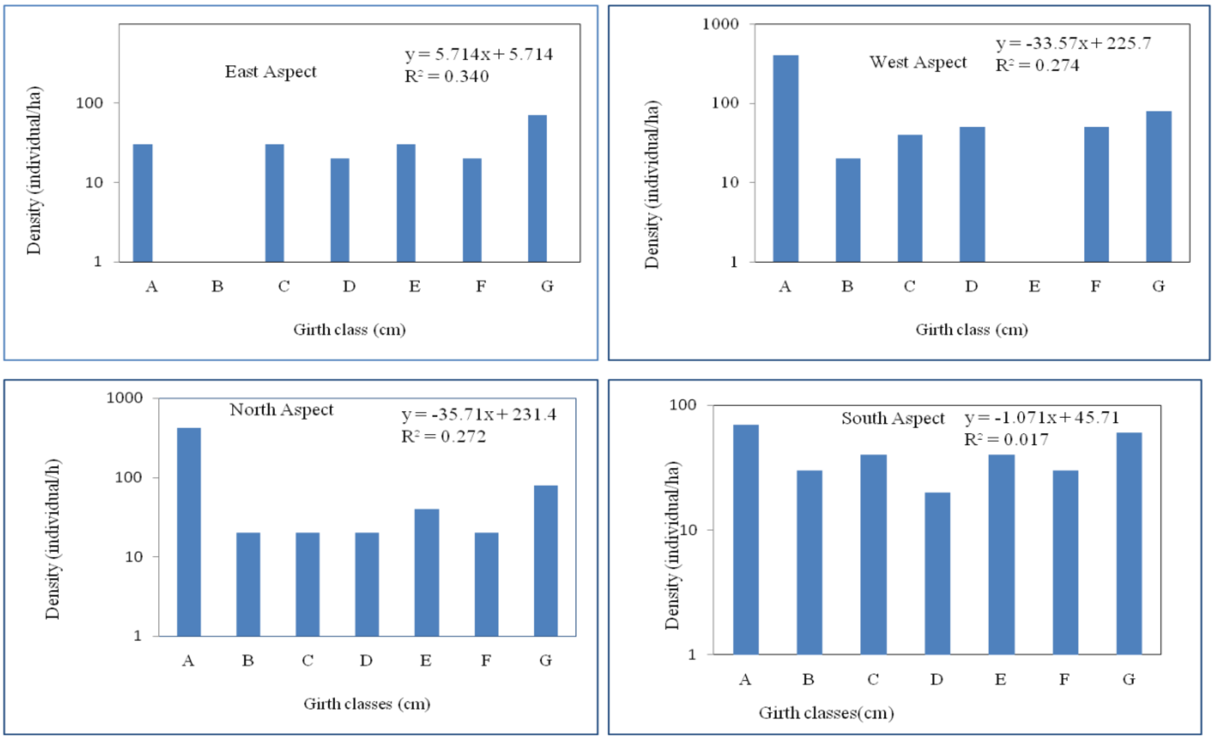
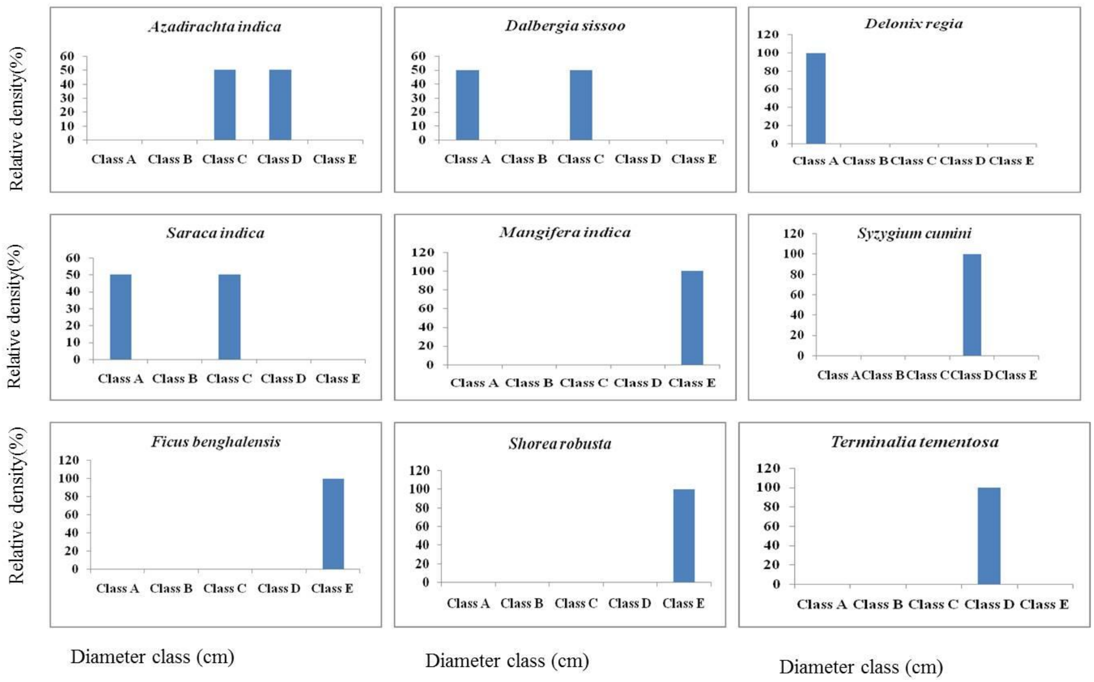


Figure 1. Tree species density and GBH relationship of urban vegetation in Sarguja

Population Structure of Urban Vegetation

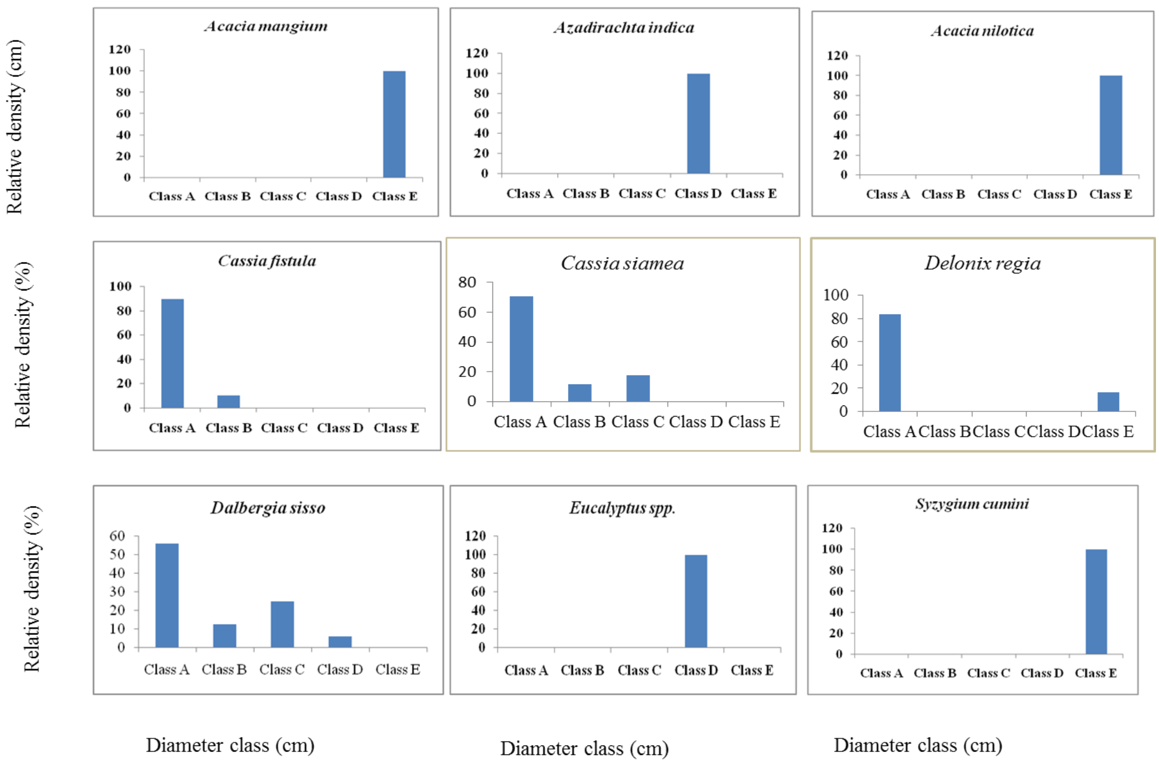
Population structure of tree species towards east site reflected class A was represented by *Dalbergia sissoo, Delonix regia,Saraca indica*, no species found in class B, class C was represented by *Azadirachta indica,Dalbergia sissoo, Saraca indica*, class D was represented by *Azadirachta indica, Syzygiumcumini, Terminalia tomentosa*, class E was represented by *Mangifera indica, Ficus benghalensis,Shorea robusta, Terminalia bellerica, Terminalia chebula*. In east aspect class E was represented also represented by few species but have poor regeneration (Figure 2).

Figure 2 Population structure of tree species in east direction of urban setup



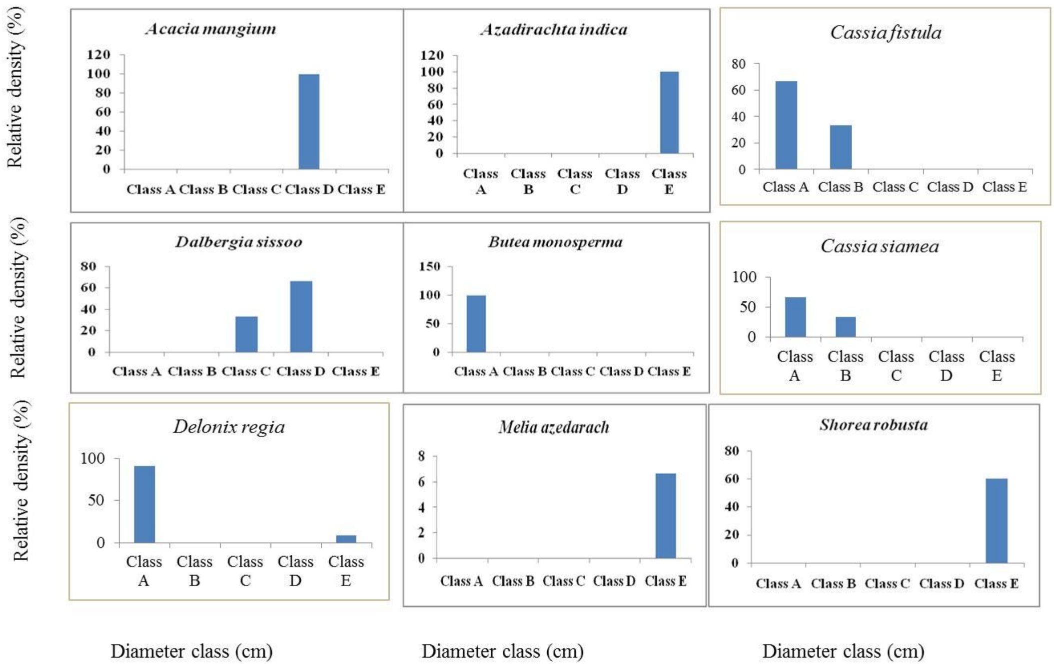
Towards west direction class A was represented by *Cassia siamea*, *Cassia fistula*, *Dalbergia sissoo*, *Delonixregia*, class B was represented by *Cassia siamea*, *Cassia fistula*, *Dalbergia sissoo*, class C wasrepresented by *Cassia siamea*, *Dalbergia sissoo*, *Zizyphus mauritiana*, class D was representedby *Azadirachta indica*, *Dalbergia sissoo*, *Eucalyptus spp.*,andclass E was represented by *Acacianilotica, Acacia mangium*, *Delonix regia*, *Syzygium cumini*. In Class E *Acacia nilotica*, *A. mangium*,*Delonix regia*, *Syzygium cumini* found which is higher than other classes. *Cassia siamea*, *Cassiafistula*, *Dalbergia sissoo*, *Delonix regia* shows good regeneration in this site (Figure 3).

Figure 3 Population structure of tree species in west direction of urban setup



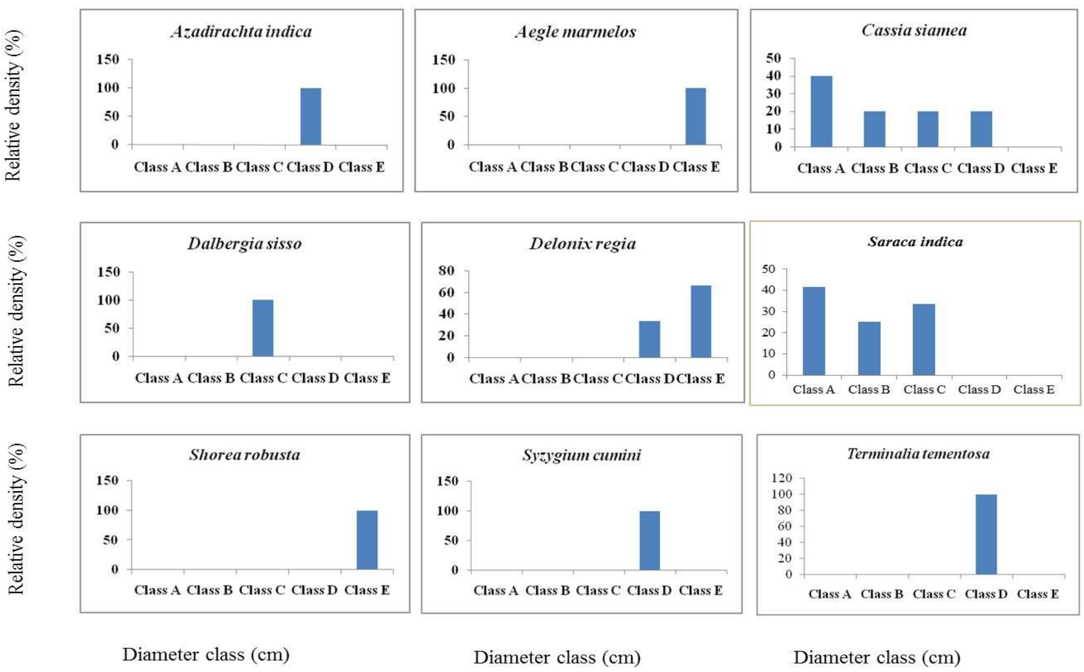
North direction (Figure 4) reflected class A was represented by *Butea monosperma, Cassia siamea, Cassiafistula, Delonix regia, Ficus benghalensis, Pongamia pinnata*, class B wasrepresented by *Cassia siamea, Cassia fistula, Tectona grandis*, class C was represented by *Bauhiniaracemosa, Eucalyptus spp., Dalbergia sissoo, Mangifera indica*, class D was represented by*Acacia mangium, Dalbergia sissoo, Eucalyptus spp., Mangifera indica*, Class E was representedby *Delonix regia, Melia azedarach,Tamarindus indica, Shorea robusta* and *Syzygium cumini*.

Figure 4 Population structure of tree species in north direction of urban setup



At south direction (Figure 5), class A was represented by *Cassia siamea* and *Saraca indica*, class Bwas represented by *Cassia siamea* and *Saraca indica*, class C was represented by *Cassia siamea,Dalbergia sissoo* and *Saraca indica*, class D was represented by *Azadirachta indica, Bombaxceiba, Cassia siamea, Delonix regia, Ficus racemosa, Syzygium cumini* and *Terminaliatomentosa*, Class E was represented by *Aegle marmelos, Delonix regia* and *Shorea robusta.*

Figure 5 Population structure of tree species in south direction of urban setup



During present study species representing single class towards east direction are *Delonix regia*representing class A, *Syzygium cumini* and *Terminalia tomentosa* representing class D, *Ficusbenghalensis, Mangifera indica, Shorea robusta* representing single class E. In west direction*Eucalyptus spp.* and *Azadirachta indica* representing class D while *Acacia mangium, Acacianilotica* and *Syzygium cumini* representing only class E. In north site *Butea monosperma*representing class A, *Acacia mangium* represents class D while *Azadirachta indica, Meliaazedarach, Shorea robusta* represent single class E. In south direction species showing singleclass were *Dalbergia sissoo* represents class C, *Azadirachata indica, Syzygium cumini,Terminalia tomentosa* represent class D while *Aegle marmelos, Shorea robusta* represents class E.Similar findings were also reported by Kittur et al. (2014). They reported that the highlydisturbed sites comprised of seedlings of size class (A) and saplings of size class (B), representedby very few species. Younger andolder trees were more abundant, whereasintermediate-aged trees were distributed sporadically (Jhariya et al. 2012). Similarly, Kumar et al (2017) reported the proportion of seedling size class (A) was found to be dominant while the older size classes (D) and (E) were totally absent in various directions.

Comparative family wise distribution of vegetation layer

A sum of 11 families was recorded for tree stratumamong which the family Fabaceae was found to be dominating followed by Combretaceaefamily (Figure 6). In Sapling layer only single family i.e., Fabaceae was found while in seedling layer 4 families were recorded and the Fabaceae was dominant family. Under shrub species,family Apocynaceae was found as dominant among the 7 families of shrubs. Herb layerreflects total 11familiesand the Asteraceae was the dominating family. Fabaceae family was dominant among the entire stratum in all the direction. Similarly, Pandey and Kumar (2018) also reported Fabaceae is dominant family among the 28 families listed.

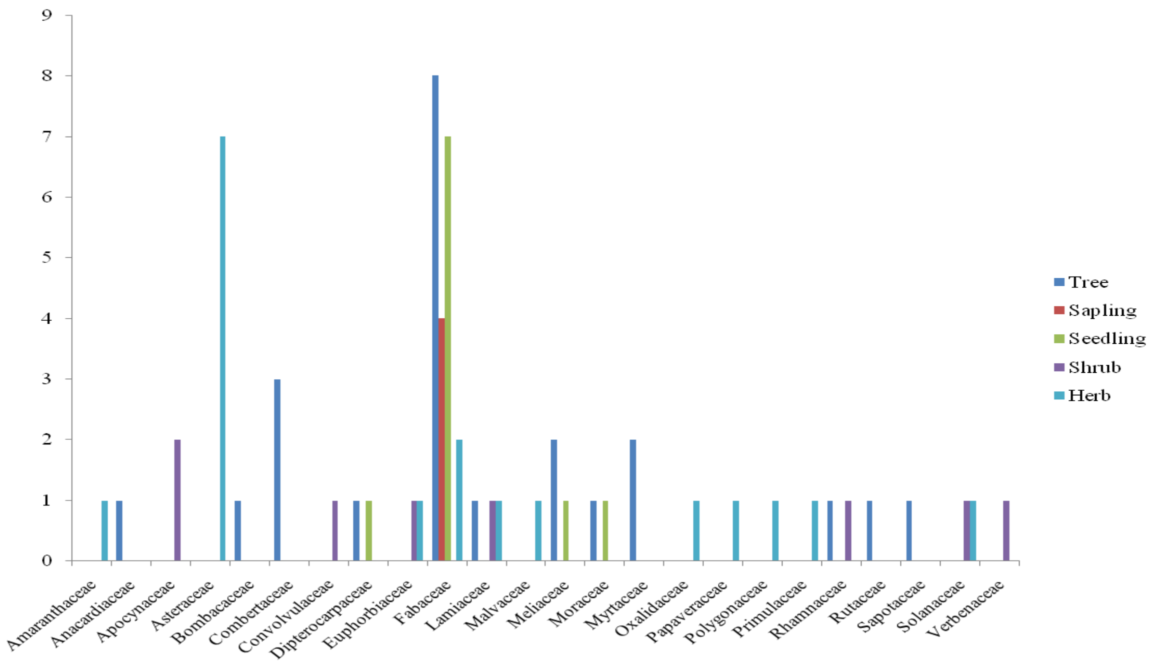


Figure 6. Family-wise distribution of vegetation in an urban setup of Sarguja

Species Regeneration Status

It reflected from the study that towards east direction only single species (*Delonix regia*) showed good regeneration potential among all the species. At west site good regeneration was revealed by *Cassia siamea, Cassia fistula, Delonix regia* and *Dalbergia sissoo.* North direction reflected that *Butea monosperma, Cassia fistula, Cassia siamea, Ficus racemosa* and *Pongamia pinnata* have good regeneration potential over the site. At south direction *Cassia siamea* and *Saraca indica* showed good regeneration potential among all the recorded species. The regeneration potential (in percentage) of various species found in the urban setup of Sarguja is shown in Figure 7. Towards east direction nearly 75% species were not regenerative, in west direction 60% species was not regenerative, in north direction about one third of the species not regenerative while in south the value of not regenerative species was higher (> 80%) than the other direction. The overall good regeneration of urban vegetation was recorded toward west direction followed by north, south and least in east direction. The present findings were corroborates with the earlier findings of Sarkar and

Devi (2014) and Jhariya and Oraon (2012). Similarly,Yadav and Jhariya (2017) reported that in natural forest nearly 11.77% species had good regeneration potential, 29.41% species fair regeneration while 35.29% species were not regenerating. In the plantation site 50% species showed good regeneration and remaining 50% species have fair regeneration status which supports the present findings.

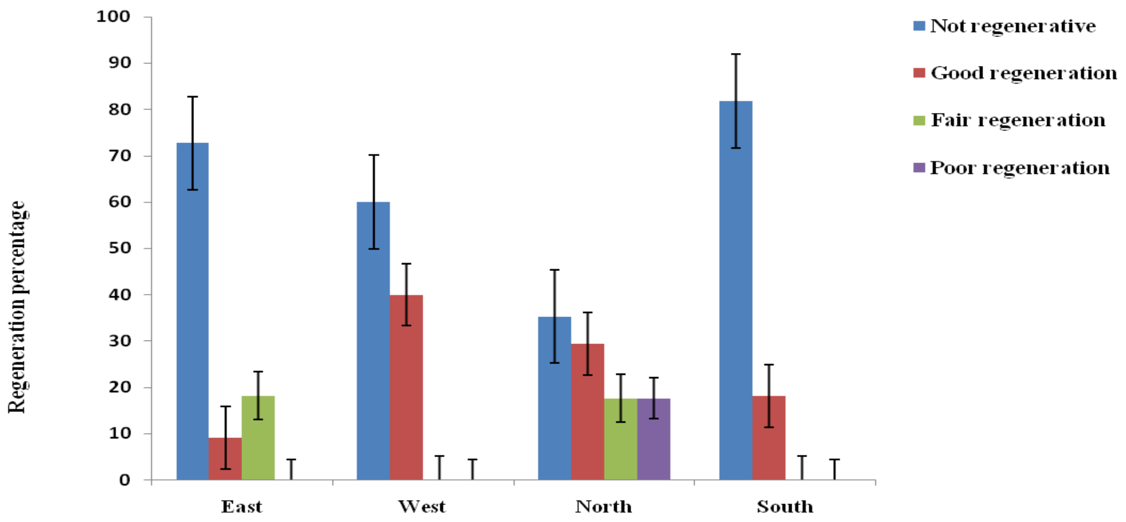


Figure7. Regenerationstatus (%) of urban vegetation in Sarguja

CONCLUSION

The vegetation in the urban setup is important from development, planning and towards sustainable cities. The vegetation in the present investigation shows substantial diversity and distribution across the sites in an urban setup. The species occurrence in terms of frequency revealed that most of the species showed rare category, while other classes were least in occurrence. These call for protection and proper management of rare species for the development of the future stands. The conservation implication should be implied on priority basis to promote the urban greening and urban forestry perspectives. Therefore, efforts should be more for ensuring health and diversity of urban vegetation in order to improve urban environment and to maintained environmental integrity and prosperity.

REFERENCE

Agbelade, A.D., Onyekwelu, J.C. and Oyun, M.B. (2017). Tree Species Richness, Diversity, and Vegetation Index for Federal Capital Territory, Abuja, Nigeria.*International Journal of Forestry Research*.Article ID 4549756, 12 pages, https://doi.org/10.1155/2017/4549756.

Baldauf, R. and Nowak, D. (2014). Vegetation and Other Development Options for Mitigating Urban Air Pollution Impacts.Global Environmental \Change. Pp. 479-485.

Francesco, F. and Alessio, F. (2011). Sustainable management techniques for trees in the urban areas.*Journal of Biodiversity and Ecological Sciences*, 1(1):1-20.

Gavali, R.S. and Shaikh, H.M.Y. (2016). Estimation of Carbon Storage in the Tree Growth Solapur University Campus, Maharashtra, India.*International Journal of Science and Research*,5(4):2319-2367.

Hewit, N. and Kellman, M. (2002). True seed dispersal among forest fragments: dispersal ability and biogeographical controls. *Journal of Biogeography*, 29(3):351–363.

Jim, C.Y. and Chen, W.Y. (2009). Diversity and distribution of landscape trees in the compact Asian city of Taipei.*Applied Geography*, 29:577-587.

Jhariya, M.K., Bargali, S.S., Swamy, S.L. and Kittur, B. (2012). Vegetational structure, diversity and fuel loads in fire affected areas of tropical dry deciduous forests in Chhattisgarh. *Vegetos*, 25(1), 210–224.

Jhariya, M.K. and Oraon, P.R. (2012). Regeneration Status and Species Diversity along the Fire Gradients inTropical Deciduous Forest of Chhattisgarh.*Journal of Plant Development Sciences*, 4(1): 49-54.

Jhariya, M.K. (2014). Effect of forest fire on microbial biomass, storage and sequestration of carbon in a tropical deciduous forest of Chhattisgarh.*PhD thesis*.Indira Gandhi Krishi Vishwavidyalaya, Raipur, India.

Jhariya, M.K. and Yadav, D.K. (2018). Biomass and carbon storage pattern in natural and plantation forest ecosystem of Chhattisgarh, India. *Journal of*

Forest and Environmental Science, 34(1):1-11.DOI:10.7747/JFES.2018.34.1.1.

Jhariya, M.K., Banerjee, A., Meena, R.S. and Yadav, D.K. (2019). Sustainable Agriculture, Forest and Environmental Management.Springer Nature Singapore Pte Ltd., 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore**.** eISBN: 978-981-13-6830-1, Hardcover ISBN: 978-981-13-6829-5. DOI: 10.1007/978-981-13-6830-1. Pp. 605.

Khan, M.L., Rai, J.P.N. and Tripathi, R.S. (1987). Population structure of some tree species in disturbed andprotected sub-tropical forests of north-east India.*Acta Oecologia*, 8:247-255.

Kittur, B.H., Swamy, S.L., Bargali, S.S. and Jhariya, M.K. (2014). Wildland Fires and Moist Deciduous Forests of Chhattisgarh, India: Divergent Component Assessment. *Journalof Forestry Research,* DOI:10.1007/s11676-014-0471-0.

Kumar, A., Jhariya, M.K., Yadav, D.K. and Banerjee, A. (2017). Vegetation dynamics in Bishrampur collieries of northern Chhattisgarh, India: eco-restoration and management perspectives. *Environ Monit Assess*, 189:371.

Ogwu, M.C., Osawaru, M.E. and Obayuwana, O.K. (2016). Diversity and Abundance of Tree Species in the University of Benin, Benin City, Nigeria.*Applied Tropical Agriculture,* 21(3):46-54.

Oraon, P.R. (2012). Structure and dry matter dynamics along the disturbance gradient of tropical dry deciduous forest in Bhoramdeo Wildlife Sanctuary, Chhattisgarh. Ph.D. Thesis, I.G.K.V., Raipur (C.G.).

Oraon, P.R. and Jhariya, M.K. (2018). Regeneration and Species Status in Bhoramdeo Wildlife Sanctuary of Chhattisgarh, India under Different Anthropogenic Disturbance Regimes.*Bull. Env.Pharmacol. Life Sci*. 7(5):30-36.

Pandey, R.K. and Kumar, H. (2018). Tree Species Diversity and Composition in Urban Green Spaces of Allahabad City (U.P).*Plant Archives*, 18(2):2687-2692.

Raunkiaer, C. (1934). The Life Form of Plants and Statistical Plant Geography.*Claredon Press* ISBN 9978–40–943-2, Oxford.

Saral, A.M., Selcia, S.S. and Devi, K. (2017). Carbon storage and sequestration by trees in VIT University campus. IOP Conf. Ser.: Mater. *Sci. Eng*. 263 022008 doi:10.1088/1757-899X/263/2/022008.

Sarkar, M. and Devi, A. (2014). Assessment of diversity, population structure and regeneration status of tree species in Hollongapar Gibbon Wildlife Sanctuary, Assam, Northeast India.*International Journal of Society for Tropical Research*, 1(2):26–36.

Saxena, A.K. and Singh, J.S. (1984). Tree population structure of central Himalayan forestassociations and implications concerning their future composition.*Vegetatio,* 54:61–69.

Tripathi, B.C., Rikhari, H.C., Bargali, S.S. and Rawat, Y.S. (1991). Species composition andregeneration in disturbed forest sites in the oak zone in and around Nainital. *Proceedingsof Indian National Science Academy* B, 57:381–390.

Yadav, D.K. and Jhariya, M.K. (2017). Tree community structure, regeneration and patterns of diversity in natural and plantation forest ecosystem.*Res. Environ. Life Sci.,* 10(4):383-389.

Yadav, D.K., Ghosh, L. and Jhariya, M.K. (2017). Forest Fragmentation and Stand Structure in Tropics: Stand Structure, Diversity and Biomass. Lap Lambert Academic Publishing.Heinrich-Bocking-Str. 6-8, 66121, Saarbrucken, Germany.Pp. 116. ISBN: 978-3-330-05287-1.