International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Impact of Biological Invasion on Floristic Composition in An Indian Dry Tropical Urban Region of India

Anjali Anjali[1], Rup Narayan[2]

[1] Research Scholar, Ecology Research Lab, Department of Botany, Chaudhary Charan Singh University, Meerut, 250004

[2] Professor, Ecology Research Lab, Department of Botany, Chaudhary Charan Singh University, Meerut, 250004

Abstract: ***Biological invasions are key contributor to global environmental change, leading to the depletion of native biodiversity and functional changes in ecosystem. Anthropogenic activities add to the aggravation caused by these intrusions. This study was aimed to investigate the invasion trends of alien flora within a dry tropical region of India i. e. region across Meerut University Campus and surrounding area, which is a well intruded area located amidst the rapidly urbanizing districts of Uttar Pradesh, India. Extensive site surveys were conducted in the study region from 2019 to 2022, resulting in the compilation of a species list which was derived from recorded flora and existing literature. Each species was classified based on its nativity, life form and habit. Out of 111 plant species spread across 37 families, 84.49% were identified as alien, while only 15.51% were found native. The highest proportion of alien flora originated from American biogeographic regions (36.06%), followed by Asian (10.81%), European (9.91%), African (5.41%), Australian (3.61%) and 21% of mixed origins. Dominant families included Poaceae, Fabaceae, Asteraceae, Malvaceae, Cyperaceae, and Amaranthaceae; collectively constituting to 58.31% of the total flora. Herbaceous species were most prevalent, accounting for 85.58%, followed by shrubs (9.01%), climbers (3.61%) and trees (1.81%). Further annual life form was more dominant (65.76%), followed by perennial (26.12%) and biennial (1.81%). Increase in perennial invaders shows the progressing threat to native species. The findings highlight an increasing trend in the intrusion of alien flora, predominantly from American, Asian and European biogeographic origins, into the studied region. These results underscore the need for effective management strategies to mitigate the naturalization, colonization, and invasion of alien weeds in urban areas where native species are already under threat and undergone many alterations, particularly within rapidly urbanizing anthropo - ecosystems in Indian dry tropics.***

Keywords: Biological invasion, Alien Flora, Native Species, Anthropogenic Activities, Dry – Tropics

1. Introduction

It has been recorded that, the tropical ecosystems, which are known for their dynamic nature and rich biodiversity, have become increasingly vulnerable due to the impact of extensive developmental activities in these areas. This makes these ecosystems fragile to the changes and external stress, which is particularly evident in urban and peri - urban areas (Gupta and Narayan, 2011). These natural ecosystems are transforming into anthropogenic environments at rapid rates, which leads to altered vegetation and soil structures in these dry tropical regions (Gupta and Narayan, 2006, 2010; Agrawal and Narayan, 2017). Various recent research highlights the impact of human interventions on tropical ecosystems, thus highlighting the potential challenges which comes along with it, such as habitat fragmentation, altered pollution levels, and climate change, which eventually poses threat to the biodiversity and other ecosystem services (Allen et al., 2024).

Generally, the introduction of any invasive species may occur either accidentally, through an escape after being imported for a specific purpose or it may occur deliberately on a large scale. For it to be called invasive, an introduced species must have the ability to establish itself, get naturalized and spread in an ecosystem beyond its native range (Williamson, 1996). Various factors like globalization and rapid alteration of natural habitats due to non - natural interventions have especially increased the pace of invasion over the past century (Schei, 1996). It was also recorded that, many individuals introduce these non - native species into entirely new habitats for the purpose of economic gain, and maximum cases of invasiveness can be traced back chiefly to the intended or unintended consequences of economic activities. Across the continental and global scales, these species invasions have reduced the regional and native distinctiveness of flora and fauna (Vitousek et al., 1997; Pyšek et al., 2008). Gradually, a stage has come where in many continental regions, more than 20% of the plant species are now reportedly have reached to the status of “non - native”, and the severity of condition can be estimated by the records itself, that in many islands, the proportion of non - native plant species has reached a stark high of 50% or even higher (Vilà et al., 2011).

Invasive weeds have the tendency to grow and produce biomass more extensively than native species. They exhibit a high competitiveness and efficient reproductive ability which helps them to produce numerous seeds. Besides this, they have efficient dispersal mechanisms, vegetative reproduction and quick establishment strategies which aid them in their adaptation to new environments (Sharma et al., 2005; Simberloff et al., 2017; Seebens et al., 2017). It has been recorded that, in determining the success of an invasion, the biotic and abiotic characteristics of the target habitat are equally significant as the autecological characteristics of the invasive species (Higgins and Richardson, 1996). Besides this, many of these species are very tolerant around various newer abiotic environments and have the potential to be allelopathic to the native flora of that ecosystem (Huang et al., 2009; Sharma et al., 2005). Once they become established, certain alien species have the potential to disrupt the patterns of plant succession, altering the fire and nutrient cycles, and displace or completely replace the native plant and animal species of the place they invade. (Vilà et al., 2011). In addition to this, encroaching on these natural habitats leads to severe consequences for native biodiversity patterns worldwide (IPBES, 2023).

So, in accordance with the above mentioned perspective, to effectively monitor the spread and impact of these invasive species across different regions of study and to develop appropriate management strategies, it is crucial and necessary to establish a comprehensive regional and national database on alien flora. Such databases would help in providing valuable insights; especially in anthropogenicaly intervened areas where the native floras have seen a major transformation or better say loss in past few decades. Implementing and conducting these studies is of paramount importance to make ensure the protection and conservation of natural ecosystems along with the study of changed dynamics of the functionality of native flora. So, to look into the impact of biological invasions on the floristic composition of native flora, region of Chaudhary Charan Singh University campus and surrounding area was taken for studying the dynamics around it.

The objective of the present research study was to evaluate the impact of biological invasions on the floristic composition of vegetation across the study site at region across Meerut University Campus and surrounding area, in Delhi NCR, which is a part of Indian dry tropical urban region. This place has experienced severe anthropogenic pressure for the past four to five decades due to many city development projects. The main aim of this study was to determine the nativity of plant species within the study area to assess the severity of impact of alien species, and the alteration which native flora has undergone across the timeline.

2. Materials and Methods

Study Area

The study area was a region across University Campus and surrounding area, in Delhi NCR (which has a spread over a full area of 221.1 acre campus with a built - up area of about 37.40 acres). The study was conducted over a period from April 2019 to June 2022 in a dry tropical urban region of India. Only those patches of study site were considered for study where vegetation was still in natural form and surrounded by anthropogenic intrusions**.** It is situated within Upper Ganges - Yamuna Doab region, precisely at latitude and longitude 28.9692° N and longitude 77.7405° E 77°40' E in the Meerut district of Uttar Pradesh, India. The district's rectangular land area is bordered by Muzaffarnagar in north, Ghaziabad and Hapur in south, Bijnor and Amroha in east, and Baghpat in west side. Being strategically connected to major cities like New Delhi, Muzaffarnagar, Ghaziabad, Noida, Aligarh, Haridwar, and Faridabad, Meerut is traversed and well commuted by three national highways (NH 58, NH - 119, and NH - 235). The city has witnessed extensive development over the past four to five decades, which has significantly impacted its ecology due to industrial growth, transportation, and urbanization (Rani et al., 2022).

Chaudhary Charan Singh University (formerly, Meerut University) was established in 1965. Before the establishment of the campus area, this place had lush green mango orchard arena along with well flourished native flora in open fields around the area. With time, many anthropogenic interventions in form of construction, connectivity projects and other disruptions took place, and in past 5 - 6 decades the native flora has slowly started getting severely affected by these activities. Gradually, more strategically evolved species started making their space into these tampered ecosystems, thus severely altering the structures of ecosystems and soil dynamics. So, the study of these impacts on floristic composition of the studied site became important.

Floristic Data Collection

From 2019 to 2022, survey visits were conducted to the study area, resulting in a detailed inventory of its flora getting compiled in a place. This compilation of flora data relied on extensive scientific literature, such as Agarwal (2009). Each plant's habit was meticulously documented referring to these reliable sources. The plants were then listed alphabetically according to their continent of origin, with author citations mentioned along and family names included. The identified plant species were further categorized into four habit groups: trees, shrubs, herbs and climbers to peep more into their habit. The scientific names of these species were updated using online taxonomic databases, including Plants of the World Online (http: //www.powo. science. kew. org) and E - Floras (http: //www.efloras. org). Plant samples were also identified or confirmed with already available regional floras (Haines, 1925, Saxena & Brahmam, 1996).

Nativity Analysis

The biogeographic origins of the found species were determined by using resources such as Plants of the World Online (POWO), specialized internet pages like E - Floras, and various published research papers chiefly including those by Khuroo et al. (2012, 2021), Agrawal and Narayan (2017), Singh et al. (2010) to name some. A biogeographic origin finding methodology was employed to assign native ranges to each species. Alien species origins were classified on a continental scale, encompassing Asia (excluding the Indian subcontinent), Europe, Africa, North America, South America, and Oceania/Australia. Plant species with multiple biogeographic origins that included the Indian subcontinent as one of their origins were considered as native. Species identified as originating from anywhere from tropical America, South America, or North America were categorized as native to America only.

Data Analysis

For making charts and tables, SPSS 2.0, MS Excel and MS Word software has been used.

Figures and Tables

Table - 1: Table 1. Family, habit and nativity of plant species of Studied Region in an Indian dry tropical region of India. (Codes: IS – Indian sub - continents, AS – Asia, AM (inclusive of North America, South America and Tropical America), AF – Africa, EU – Europe, OA – Oceania/

Paper ID: SR241205220823 DOI: https://dx.doi.org/10.21275/SR241205220823

Australia), H - Herb, S - Shrub, C - Climber, T - Tree, A - Annual, B - Biennial, P - Perennial)

S. No	Name of plant	Family	Habit	LifeForm	Nativity
1	*Abutilon indicum* (L.) Sweet	Malvaceae	S	A	IS
2	*Acalypha indica* L.	Euphorbiaceae	H	A	IS
3	*Achyranthes aspera* L.	Amaranthaceae	H	A	AM
4	*Aerva javanica* (Burm. f.) Schult.	Amaranthaceae	H	P	AF, AS
5	*Ageratum conyzoides* L.	Asteraceae	H	A	AM
6	*Alhagi maurorum* Medik.	Fabaceae	S	P	EU, AS
7	*Alternanthera pungens* Kunth.	Amaranthaceae	H	P	AM
8	*Alternanthera sessilis (L.) R. Br. exDC.*	Amaranthaceae	H	P	AF, AS, AM
9	*Amaranthus viridis* L.	Amaranthaceae	H	B	AM
10	*Anagalis arvensis* L.	Primulaceae	H	A	EU
11	*Anisomeles indica* (L.) Kuntze (pink tulasi)	Lamiaceae	S	P	IS
12	*Bidens pilosa* L.	Asteraceae	H	A	AM
13	*Boerhavia diffusa* L.	Nyctaginaceae	H	A	IS
14	*Bracharia ramosa* (L.)	Poaceae	H	A	AS, AF
15	*Calatropis procera* L.	Apocynaceae	S	P	AF
16	*Cannabis sativa* L.	Cannabaceae	H	A	AS
17	*Cyathocline purpurea* Kuntze	Asteraceae	H	A	AS
18	*Cayratia trifolia* L. Mabb. &J. Wen	Vitaceae	C	P	OA
19	*Chenopodium album* L.	Amaranthaceae	H	A	EU
20	*Chenopodium murale* L.	Amaranthaceae	H	A	EU
21	*Chorchorus tridens* L.	Malvaceae	H	A	AF
22	*Cissampelos pareira* L.	Menispermaceae	S	P	AM, AS
23	*Cleome gynandra* L.	Cleomaceae	H	A	AM
24	*Cleome viscosa* L.	Cleomaceae	H	A	AM
25	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	C	P	AF, AS
26	*Cocculus carolinus* (L.) DC	Menispermaceae	H	A	AM
27	*Commelina Benghalensis* L.	Commelinaceae	H	A	AS
28	*Corchorus olitori* L.	Malvaceae	H	A	AF
29	*Cortaderia selloana* (Schultz. & Schultz. F)	Poaceae	H	P	AM
30	*Croton bonplandianus* Baill.	Euphorbiaceae	H	A	AM
31	*Cyanthilium cinereum* (L.) H. Rob.	Asteraceae	H	A	AF
32	*Cyathocline purpurea* Kuntze	Asteraceae	H	A	AS
33	*Cynodon dactylon* (L.) Pers.	Poaceae	H	B	IS
34	*Cucumis maderaspatanus* L.	Cucurbitaceae	H	A	IS
35	*Cucumis melo* L.	Cucurbitaceae	H	A	IS
36	*Cyperus brevifolius* (Rottb.) Hassk.	Cyperaceae	H	P	OA
37	*Cyperus compactus* Retz.	Cyperaceae	H	A	AS
38	*Cyperus difformis* L.	Cyperaceae	H	A	AM
39	Cyperus iria L.	Cyperaceae	H	A	AM
40	*Cyperus mindorensi* (Steud.) Huygh	Cyperaceae	H	A	EU
41	*Cyperus rotundus* L.	Cyperaceae	H	P	OA
42	*Cyperus surinamensis* Rottb.	Cyperaceae	H	P	AM
43	*Cyprus longus* L.	Cyperaceae	H	P	AF, AS, EU
44	*Dactyloctenium aegypticum* (L.) P. Beauv	Poaceae	H	A	AF, AS
45	*Datura metel* L.	Solanaceae	S	A	AF, AS
46	*Digitaria violascens* Link	Poaceae	H	A	AS
47	*Dicliptera paniculata* (Forssk.) Darbysh.	Acanthaceae	H	A	AF
48	*Digera muricata* Mart.	Amaranthaceae	H	A	AM
49	*Digitaria ciliaris* (Retz.) Koeler	Poaceae	H	A	AS
50	*Digitaria violascens* Link	Poaceae	H	A	IS
51	*Digitaria sanguinalis* (L.) Scop.	Poaceae	H	A	AM
52	*Dysphania ambrosiodes* (L.) Mosyakin & Clements	Amaranthaceae	H	A	AM
53	*Echinocloa crus - galli* (L.) P. Beauv.	Poaceae	H	A	IS
54	*Echinocystis lobata* (Michx.) Torr. & A. Gray	Cucurbitaceae	C	A	AM
55	*Erigeron bonariensis* (L.)	Asteraceae	H	A	AM
56	*Erigeron canadensis* L.	Asteraceae	H	A	AM
57	*Euphorbia hirta* L.	Euphorbiaceae	H	A	AM
58	*Ficus carica* L.	Moraceae	T	P	AS
59	*Fimbristylis ferruginea* (L.) Vahl	Cyperaceae	H	P	AS
60	*Foeniculum vulgare* L.	Apiaceae	H	A	EU
61	*Galium aparine* L.	Rubiaceae	H	A	EU, AS
62	*Gnaphalium pensylvanicum* Willd.	Asteraceae	H	A	AM
63	*Gomphrena celosioides* Mart.	Amaranthaceae	H	P	AM

64	*Heliotropium supinum* L.	Boraginaceae	C	A	EU
65	*Indigofera glandulosa* Wendl.	Fabaceae	H/S	A/P	IS
66	*Ipomoea obscura* (L.) Ker. Gawl	Convolvulaceae.	H	A/P	AF
67	*Lantana camara* L.	Verbenaceae	S	P	AM
68	*Lepidum didymum* L.	Brassicaceae	H	A	AM
69	*Malvastrum coromandelianum (L.) Garcke*	Malvaceae	H	A	AM
70	*Mellilotus indicus* L.	Fabaceae	H	A	EU, AS, AF
71	*Nerium indica* L.	Apocynaceae	S	P	AS
72	*Oplismenus burmanni (Retz.) P. Beauv.*	Poaceae	H	P	AS, AF
73	*Oxalis corniculata* L.	Oxalidaceae	H	A	EU
74	*Panicum dichotimoflorum* Michx.	Poaceae	H	A	AM
75	*Parthenium hysterophorus* L.	Asteraceae	H	A	AM
76	*Paspalum distichum* (L.)	Poaceae	H	A	AM
77	*Paspalum scrobiculatum* (L.)	Poaceae	H	A	IS
78	*Pergularia daemia (Forssk) Chiov. vine heart shaped*	Apocynaceae	H	P	IS
79	*Persicaria lapathifolia* L.	Polygonaceae	H	A	EU, AS
80	*Phyllanthus niruri* L.	Phyllanthaceae	H	A/P	AM
81	*Physalis minima* L.	Solanaceae	H	A	AM
82	*Physalis perivuana* L.	Solanaceae	H	A	AM
83	*Plumbago zeylanica* L.	Plumbaginaceae	S	P	AS, AF
84	*Poa annua* L.	Poaceae	H	A	EU, AS, AF
85	*Portulaca halimoides* L.	Portulacaceae	H	A	AM
86	*Portulaca oleracea* L.	Portulaceae	H	A	AM
87	*Rumex crispus* L.	Polygonaceae	H	A/B	EU
88	*Rumex dentatus* L.	Polyonaceae	H	A/B	EU, AS, AF
89	*Scorpia dulcis* L.	Plantaginaceae	H	A	AM
90	*Senna occidentalis* (L.) Link.	Fabaceae	H	A	AM
91	*Setaria pumila* (Poir.) Roem. & Schultz	Poaceae	H	A	EU
92	*Setaria verticillata* (L). P. Beauv.	Poaceae	H	A	EU
93	*Sida acuta Burm*. F.	Malvaceae	H	P	AM
94	*Sida cordifolia* L.	Malvaceae	H	P	IS
95	*Sida rhombifolia* L.	Malvaceae	H	P	IS
96	*Solanum nigrum* L.	Solanaceae	H	A	AM
97	*Solanum virginianum* L.	Solanaceae	H	A/P	IS
98	*Sonchus arvensis* L.	Asteraceae	H	A	EU, AS
99	*Stellaria media* Vill.	caryophyllaceae	H	A	EU
100	*Tephrosia purpurea* L. Pers.	Fabaceae	H	A/P	AF, IS
101	*Trianthema portulacastrum* L.	Aizoaceae	H	A	AM
102	*Tribulus terrestris* L.	Zygophylaceae	H	A	AS, AF
103	*Tridax procumbens* L.	Asteraceae	H	A/P	AM
104	*Trifolium resupinatum* L.	Fabaceae	H	A	AM
105	*Urena lobata* L.	Malvaceae	H	P	AS
106	*Veronica agrestis* L.	Plantaginaceae	H	A	EU, AS, AF
107	*Vicia hirsuta* (L.)	Fabaceae	H	P	AS, AF
108	*Vicia sativa* L.	Fabaceae	H	A	EU
109	*Withania somnifera* (L.) Dunal	Solanaceae	S	P	AS, AF
110	*Xanthium strumarium* L.	Asteraceae	H	A	AM
111	*Zizyphus jujuba* Mill.	Rhamnaceae	T	P	AF, EU, AS

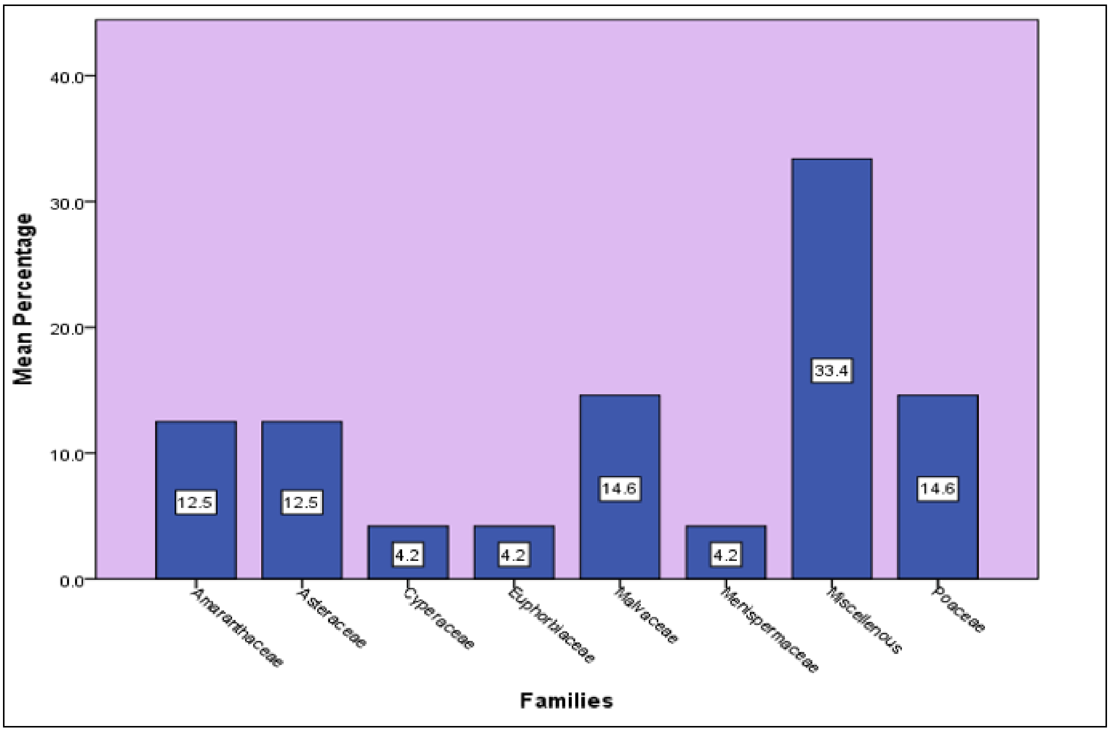

Figure 1.1: Family Distribution Chart for Summer Season

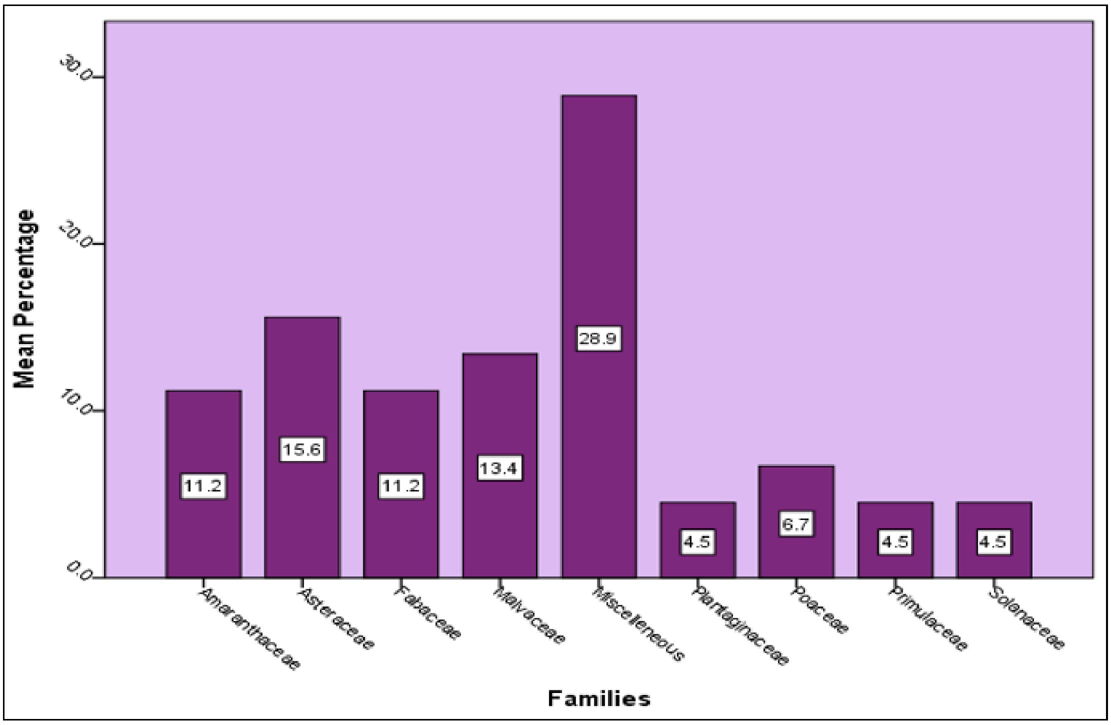

Figure 1.2: Family distribution across Winter Season

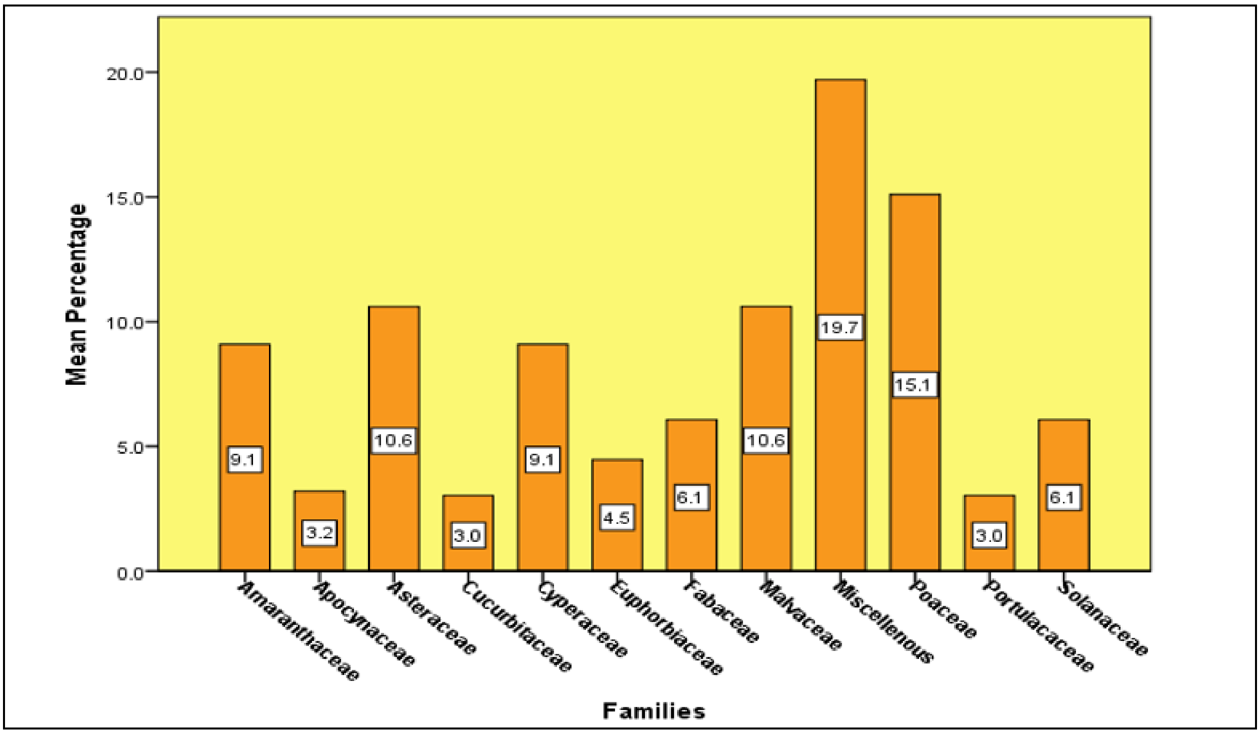

Figure 1.3: Family Distribution across Rainy season

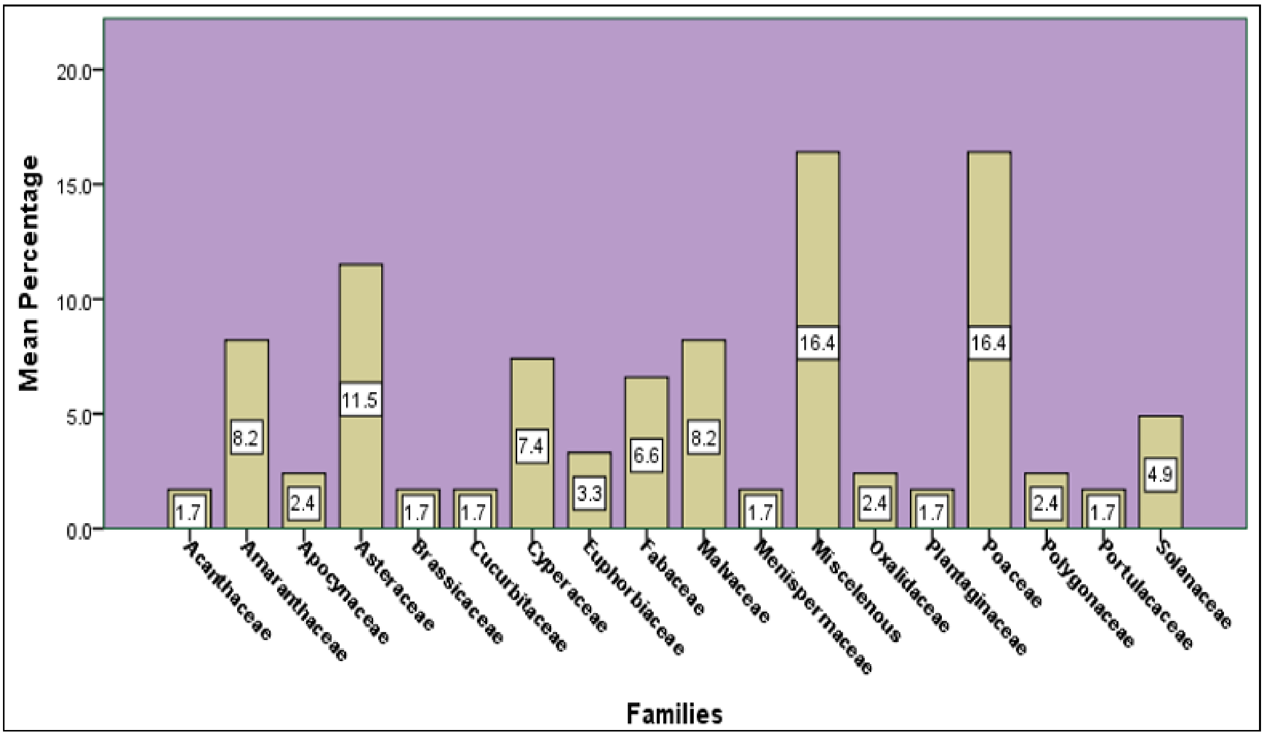

Figure 1.4 Overall Data from all the sites and seasons

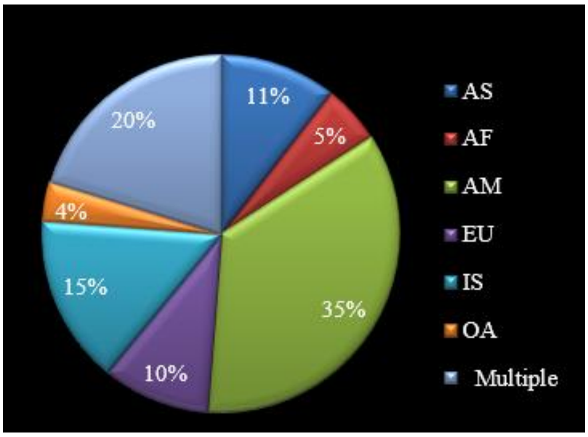

Figure 1.5: Distribution of Flora of Study Region Based on Bio-Geographical Origins

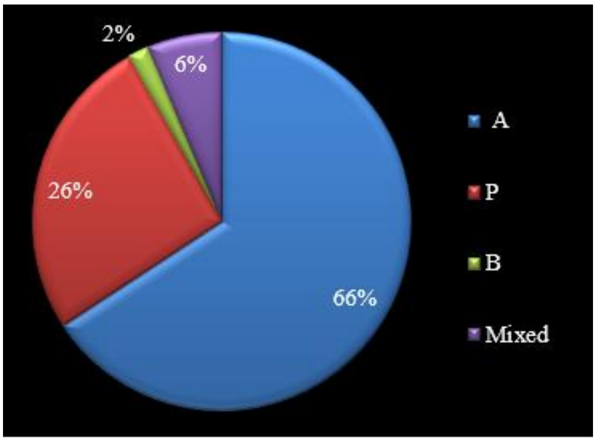

Figure 1.6: Life-Form wise Distribution of Flora of Study Region

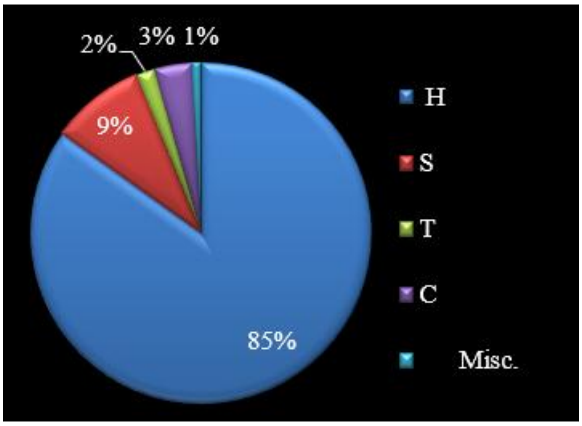

Figure 1.7: Habit-wise Distribution of Flora of Study Region

3. Results

The conducted study documented floristic details for 111 plant species belonging to overall 37 families in Meerut city region focussing around the study area of CCS University Campus. The dominant families identified included Poaceae, Fabaceae, Asteraceae, Malvaceae, Cyperaceae, and Amaranthaceae; collectively constituting 58.31% of the total recorded flora (Fig.1.4). Herbaceous species were the most prevalent ones, comprising 85.58% of the whole flora, followed by shrub species (9.01%), climbing species (3.61%) and tree species (1.81) % (Table 1.1). The data for origin of the plant species indicated that the majority were alien species belonging to American biogeographic regions (36.06%), followed by Asian (10.81%), European (9.91%), African (5.41%), Australian (3.61%) and 21% of mixed origins. Only 15.51% were found native, posing a great challenge for native species to thrive and survive. Out of all studied species, annual life form was more dominant (65.76%), followed by perennial (26.12%) and biennial (1.81%). This increase in perennial invaders shows the progressing threat on native species and the great scope and potential of proliferation of invasive species in urban dry tropical region.

4. Discussion

The study revealed a significant intrusion of the alien flora in the studied site, which was accounting for 84.49% of the total vegetation pool in the studied area. Among these, American floristic elements were predominant at 36.06%, followed by flora of Asian bio - geographic origin at 10.81%. This intrusion can be largely attributed to the extensive urbanization and city development projects, which has impacted the region's floristic composition. The transfer of plant propagules of species of foreign origin from nearby anthropogenic areas and neighbour cities like Delhi, Ghaziabad etc., driven by increasing inter - state transportation, trade, and other development - related activities, has further aggravated this issue. This global acceleration of alien plant invasion into the novel environments due to the globalization in trade, transport, and tourism has been well - documented (van Kleunen et al.2019). Over the past three decades, India's rapid economic development, its progression and enhanced international trade and treaties have facilitated the establishment and spread of alien flora into the studied region of an Indian dry tropic (Khuroo et al.2012; Inderjit et al.2018). An intrusion of a major portion of 89% alien plant species in the dry tropical region of Bulandshahr in the national capital region of Delhi, with maximum share of American floristic elements at 31% (combined North and South America) has already been reported (Agrawal and Narayan, 2017). In contrast, the present study found increased 36.06% flora of American origin in the studied region of Meerut. However, the investigated area of CCS University in Meerut city is surrounded by other developed and developing areas in Uttar Pradesh, is technically an urban region, recorded a relatively higher number of indigenous plant species (15.51%) compared to only 11% native species previously reported in peri - urban areas of Bulandshahr by Agrawal and Narayan (2017). This higher number of indigenous species could be attributed to the protected nature of the campus area of University, despite it being under immense anthropic pressure.

Alien flora often and easily outcompete the indigenous species in areas which were cleared up for new agricultural or any other developmental activities. Generally, herbaceous species, especially the grasses, are the ecological opportunists that successfully occupy or invade these open spaces (Khuroo et al., 2021). The previous studies found that over 70% of agricultural areas in the nearby regions have more than 70% of the flora as herbaceous (Gupta and Narayan 2006, 2010). The largest floristic representation belongs to the Poaceae family. The second largest family, Fabaceae, underscores the adaptation of leguminous species in dry tropical regions (Prusty, Mishra, & Biswal 2024). The third largest family, Asteraceae, indicates the growing prevalence of weedy elements (van Kleunen et al.2019). In an annotated inventory of alien flora in India by Khuroo et al. (2021), Asteraceae (27 species) and Fabaceae (20 species) were documented as the most dominant families, together comprising 32.4% of the 145 Indian invasive species they reported. A recent study has further reported the occurrence of 591 plant species belonging to genera in 106 families in India, including major portion (62%) of invasive flora in it in protected area of Hastinapur Wildlife Sanctuary, Meerut (Kumar & Narayan 2024).

Although the taxonomic inventory of these alien species represents the first important step in identifying the severity of issue, but more detailed studies on the characterization of alien species, on the basis of their stage of invasion, detection of introduction pathways, identification of potentially encroachable habitats/ecosystems, and vectors of alien species, mapping, assessment, and monitoring of these invasive species using modern geospatial technology such as hyperspectral remote sensing,, containment, impact assessment, control, and restoration are still lacking in India, hence impeding the effective management of plant invasions by these alien species in the country (Khuroo et al.2021; Prusty, et al., 2024).

Certain alien species have emerged as particularly aggressive invaders. *Parthenium hysterophorus* L. is one big example, with its successful proliferation rate across the country, showcasing its broad ecological tolerance and adaptation. *Lantana camara* L, another notable example of invasive species, has rapidly infiltrated the native forested regions of Dehradun at the foothills of India. In addition to this, species like *Chenopodium murale* L. are also becoming invasive within Indian dry tropical ecosystems (Gupta and Narayan, 2012).

These species spread is chiefly due to their high phenotypic plasticity potential, allowing them to adapt to various soil conditions and environments, thus supporting and enhancing their colonization potential in new areas. Taking into consideration, the globally recognized impact of these alien flora on the structuring of native plant communities, particularly in Indian dry tropical regions (Agrawal and Narayan, 2017; Rajasekar and Thangavel, 2024), and their prominent role in reducing biodiversity and ecosystem productivity through mechanisms such as phenotypic plasticity and allelopathic effects (Singh and Sharma, 2023), there is a prime need for active management measures to control their spread dispersion in studied region (Wittenberg and Cock, 2001; Lee, 2002). To formulate and execute an effective management strategy, it is essential to prioritize the analysis of the ecological behaviour and genetic makeup of these alien species, especially the ones that are rapidly colonizing new areas (Wittenberg and Cock, 2001; Lee, 2002). The increasing presence of alien flora in the study region underscores the necessity for such measures (Agrawal and Narayan, 2017)

5. Conclusion

The anthropogenic interventions and associated developmental activities have led to the declination in the count of native flora within the studied region and the same has been displaced by the more strategically advanced alien species, which are showing perennial life form to show severity of threat onto the native species. Further, the studies need to be conducted to look into the detailed strategies and mechanisms of these invasive species and their impact on soil and ecosystem dynamics. Besides this, study about the biogeographic regions of the invasive species or the alien flora can provide the valuable insight around the dynamics and mechanism of these alien flora and their natural survival techniques.

Acknowledgment

The first author sincerely appreciates the support from UGC, Meerut, for providing a fellowship (NFSC) at the time of research and the Botany department, CCSU, Meerut for providing necessary lab facilities for conducting the research work. Additionally, she expresses gratitude towards her supervisor, Prof. Rup Narayan for valuable support and guidance throughout the publication of this paper and related research work.

Conflict of Interest

The author shares no conflict of interest with others on any grounds.

References

[1] Agarwal, S (2009). Angiosperms species diversity and ecological assessment of Hastinapur Wildlife Sanctuary, Uttar Pradesh (India). PhD thesis. Aligarh Muslim University, Aligarh.

[2] Agrawal, S; Narayan, R (2017). Spatio - temporal organization and biomass dynamics of plant communities in a dry tropical peri - urban region: Deterministic role of alien flora in anthropo - ecosystems. *Current Science*, pp 53—62.

[3] Allen, W, et al. (2024). Cyclone Gabrielle's impacts on NZ's ecosystems. *New Zealand Ecological Society Conference Proceedings*, 27 (3), 789 - 800.

[4] Gupta, S & Narayan, R (2006). Species diversity in four contrasting sites in a peri - urban area in Indian dry tropics. *Tropical Ecology* 47 (2): 229—242**.**

[5] Gupta, S & Narayan, R (2010). Brick kiln industry in long - term impacts on biomass and diversity structure of plant communities. *Current Science*, 72—79.

[6] Gupta, S & Narayan, R (2011). Plant diversity and dry - matter dynamics of peri - urban plant communities in an Indian dry tropical region. *Ecological Research* 26 (1): 67—78

[7] Haines, H H. "The Botany of Bihar and Orissa. " *Adland and Son, West Newman Ltd., London (*1925).

[8] Higgins, SI & Richardson, DM (1996). Evaluating models of alien plant spread: Evidence from pine invasions. *Ecology*, 77 (5), 1657 - 1666. DOI: 10.2307/2265762

[9] Huang, W., et al (2009). Interactive effects of herbivory and competition on introduced and native

prairie grasses. *Biological Invasions*, 11 (1), 483 - 490. DOI: 10.1007/s10530 - 008 - 9269 - 2

[10] Inderjit, Pergl J & van Kleunen M (2018). Naturalized alien flora of the Indian states: Biogeographic patterns, taxonomic structure and drivers of species richness. *Biological Invasions* 20: 1625–1638. https: //doi. org/10.1007/s10530 - 017 - 1622 - y

[11] Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (2023). Invasive Alien Species Report. UN Environment Programme.

[12] Khuroo, A; Ahmad, A; Hamid, M; Rather, ZA; Malik, AH; & Rashid Rashid (2021). An annotated inventory of invasive alien flora of India invasive alien species: *Observations and Issues from Around the World* 2: 16 - 37. https: //doi. org/10.1002/9781119607045. ch14

[13] Khuroo, AA; Reshi, ZA; Malik, AH; Weber, E; Rashid, I & Dar, GH (2012). Alien flora of India: Taxonomic composition, invasion status and biogeographic affiliations. *Biological Invasions* 14: 99 - 113. https: //doi. org/10.1007/s10530 - 011 - 9981 - 2

[14] Kumar, A. & Narayan, R. (2024). Floristic Composition and Nativity Analysis: Hastinapur Wildlife Sanctuary. *Environment and Ecology*, 42 (3A), 1238 - 1254. DOI: 10.60151/envec/LRBA6690

[15] Lee, CE (2002). Evolutionary genetics of invasive species. *Trends in Ecology and Evolution* 17 (8): 386 - 391. https: //doi. org/10.1016/S0169 - 5347 (02) 02554 - 5

[16] Prusty, S.; Mishra, R. K., & Biswal, A. K. (2024). Uses of invasive alien plant species of Chandaka - Dampada Wildlife Sanctuary: a management implication. *Forestry Research and Engineering: International Journal*, 6 (1), 12 - 17. DOI: 10.15406/freij.2024.06.00111

[17] Pyšek, P; Richardson, DM; Pergl, J; Jarošík, V; Sixtová, Z &Weber, E (2008). Geographical and taxonomic biases in invasion ecology. *Trends in Ecology & Evolution*, 23 (5), 237 - 244. DOI: 10.1016/j. tree.2008.02.002

[18] Rani, P.; Pandey, K.; & Sinha, A. (2022). Urbanization and Its Ecological Impacts in Meerut. *Journal of Environmental Management*, 45 (1), 102 - 119

[19] Saxena, H. O. & M, Brahmam. (1996). "*The Flora of Orissa*. " Orissa Forest Development Corporation, Bhubaneswar. Vol. I - IV.

[20] Schei, P. J. (1996). The Nature of Globalization and Its Impacts. *Ecological Applications*, 6 (3), 825 - 828. DOI: 10.2307/2269488

[21] Seebens, H.; Blackburn, TM; Dyer, EE; Genovesi, P; Hulme, PE; Jeschke, JM; Pagad, S; Pysek, P; Winter, M; Arianoutsou, M; Bacher, S; et al. (2017). No saturation in the accumulation of alien species worldwide. *Nature Communications*, 8, 14435. DOI: 10.1038/ncomms14435

[22] Sharma, G. P.; Raghubanshi, A. S., & Singh, J. S. (2005). Lantana invasion: An overview. *Weed Biology and Management*, 5 (4), 157 - 165. DOI: 10.1111/j.1445 - 6664.2005.00178. x

[23] Simberloff, D; Martin, J L.; Genovesi, P.; Maris, V; Wardle, DA; Aronson, J; Courchamp, F; Galil, B; García - Berthou, E; Pascal, M; Pysek, P; Sousa, R; Tabacchi, E; & Vila, M (2013). Impacts of biological invasions: what's what and the way forward. *Trends in Ecology & Evolution*, 28 (1), 58 - 66. DOI: 10.1016/j. tree.2012.07.012

[24] Singh K. P.; Shukla A. N. & Singh J. S. (2010). State - level inventory of invasive alien plants, their sources regions and use potential. *Current Science* 99 (1): 107 - 114.

[25] Van Kleunen M; Pyšek, P & Dawson, W (2019). The global naturalized alien Flora (GloNAF) database. *Ecology* 100: e02542. https: //doi. org/10.1002/ecy.2542

[26] Vilà, M.; Espinar, JL; Hejda, M; Hulme, PE; Jarošík, V; Maron, JL; Pergl, J; Schaffner, U; Sun, Y; Pyšek, P. (2011). Ecological impacts of invasive alien plants: a meta - analysis of their effects on species, communities and ecosystems. *Ecology Letters*, 14 (7), 702 - 708. DOI: 10.1111/j.1461 - 0248.2011.01628. x

[27] Vitousek, P. M.; D’antonio1, CM; Loope, LL; Rejmánek, M & Westbrooks, R (1997). Introduced species: A significant component of human - caused global change. *New Zealand Journal of Ecology*, 21 (1), 1 - 16. DOI: 10.2307/24054842

[28] Williamson, M. (1996). *Biological Invasions.* Chapman & Hall Co. DOI: 10.1007/978 - 94 - 011 - 4832 - 1

[29] Wittenberg, R & Cock, M J (eds.) (2001). *Invasive alien species: A tool - kit of best prevention and management practices.* CABI Publishing. https: //doi. org/10.1079/9780851995694.0000