



Diversity and Phytosociological studies of Invasive Alien Plant Species and their effects on vegetation in District Jaunpur

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ABSTRACT

Biological invasions represent a critical dimension of anthropogenically driven global environmental change, exerting profound influences on community assembly mechanisms, vegetation structure, ecosystem functioning, and landscape-level ecological resilience. Stratified systematic vegetation sampling was conducted across heterogeneous habitat matrices encompassing croplands, fallow fields, wastelands, transportation corridors, riparian zones, wetlands, and peri-urban landscapes. Quadrat-based sampling protocols were employed to ensure spatial representativeness and statistical robustness of vegetation estimates. Species-level ecological amplitude and dominance patterns were quantified using core species frequency, population density, numerical abundance, basal area cover, and the Importance Value Index (IVI). The study documents extensive taxonomic representation of invasive alien flora spanning multiple angiosperm families and functional life-form spectra, with therophytic and ruderal herbaceous taxa exhibiting marked numerical and spatial dominance within high-disturbance regimes. By integrating floristic inventories with quantitative vegetation analytics, this investigation establishes a robust ecological baseline for invasion monitoring within intensively managed tropical agro-landscapes. The findings provide critical empirical inputs for predictive invasion modelling, invasive species prioritisation, and development of evidence-based invasive species management frameworks across the Indo-Gangetic biogeographic region.

KEYWORDS

Biological invasions, species frequency, invasive species, ecosystem functioning, vegetation structure.

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1. Introduction

From the IPBES assessment, the importance of the biodiversity loss at a global scale can be explained by the presence of the invasive alien species as one of the important direct drivers. Another finding of the IPBES assessment is that the biological invasions coexist alongside other drivers of environmental change and their effect will vary depending on the properties of the invaded ecosystem and the degree of human interference in the ecosystem (IPBES, 2023). India is distinguished as globally significant megabiodiverse countries due to its highly varied thermal regimes, altitudinal gradients, and alongwith habitat diversity. In recent decades, biodiversity loss has accelerated at unprecedented rates, driven largely by human actions like habitat conversion, deforestation, agricultural intensification, urbanization, pollution, and exotic introductions (Sala *et al.*, 2000; IPBES, 2019). The biological invasion phenomenon has become one of the most widespread and difficult challenges facing native plant diversity and ecosystem health. Invasive alien plant species (IAPS) take over disturbed environments and displace native plants that play vital roles in the function of the ecosystem (Vilà *et al.*, 2011).

In a similar vein, the data collected from India revealed that the distribution of the aliens is dependent on the taxonomic, biogeographic, and ecological features of these organisms. According to the national

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database of alien plants gathered by Khuroo et al., (2012), There are 1,599 alien plant species that exist in India. Such an ecosystem promotes the growth of plants with fast growth rate and efficient seed dispersal. However, this change occurs not only due to the negative impact of the disturbance but as a result of the disturbance of the balance of resource filters, plant competition, and seed production (Davis et al., 2000; Lockwood et al., 2005). In agricultural landscapes, repeated tillage, irrigation, fertilizer application, and pesticide use create highly disturbed environments that favor fast-growing, opportunistic plant species. Native species adapted to relatively stable ecological conditions are often unable to compete under such regimes, leading to declining species diversity and homogenization of vegetation (Tilman et al., 2001). Transport systems, commerce, and human movement have increased the production of propagules across biogeographical boundaries, leading to an increase in the number of alien plants globally (Hulme, 2009). In tropical and subtropical zones, which include India, the effect of anthropogenic disturbances on plant diversity is most pronounced. Favorable climatic conditions, long growing seasons, and fertile soils facilitate rapid growth and reproduction of invasive plants once introduced. Disturbance-driven invasion often gives rise to competitive exclusion of indigenous species, disruption of successional pathways, and long-term alteration of vegetation structure (Didham et al., 2005). The socio-economic consequences of plant biodiversity loss further exacerbate the problem. Declining availability of native fodder species, medicinal plants, and ecosystem services disproportionately affects rural communities relying on natural resources for their subsistence (Pimentel et al., 2005). Phytosociology is the scientific study of plant communities, focusing on their composition, structure, distribution, and relationships with environmental factors. Originating from early vegetation studies in Europe, phytosociology has evolved into a quantitative and analytical discipline that provides essential tools for understanding vegetation dynamics (Braun 1932; Curtis & McIntosh, 1951)

Unlike purely floristic surveys that document species presence, phytosociological studies emphasize the relative importance and dominance of species within communities. Primary vegetation metrics such as species abundance, frequency, stem density, basal coverage, and Importance Value Index (IVI) allow researchers to quantify how plant species are distributed across space and how strongly they influence community structure. These metrics are particularly valuable in invasion ecology, where dominance rather than mere presence determines ecological impact.

Quantitative vegetation analysis enables comparison of invasion intensity across these habitats and identification of invasion hotspots (Ellenberg & Mueller, 1974). In the case of exotic plants, the role of phytosociology is that of a bridge between floristics and ecology. With the help of quantification of structural dominance and pattern, any modification brought about by invaders to the plant community in the ecosystem can be objectively evaluated. This study has taken the above framework into consideration while analyzing the species richness, dominance and impact of exotic plants in Jaunpur District. The migration of plant species apart from their native biogeographical boundaries has become a defining ecological phenomenon of the modern era. Species that are transported, purposely or non-purposely, beyond their biogeographical boundaries by human activities are termed **alien**, **exotic**, or **non-native species**. Although most alien species do not survive in their new environment, a few do establish populations and then become invasive. (Pyšek et al., 2004).

Establishment occurs when introduced individuals survive and reproduce under local environmental conditions. Naturalization refers to the formation of self-sustaining populations without continued human assistance. Finally, invasion is characterized by rapid population growth, spatial spread, and significant ecological impact (Blackburn et al., 2011). Invasions by biota have been recognized as an environmental problem worldwide on par with climate change, habitat destruction, and pollution. Invasive alien plants are introduced into almost all continents except Antarctica, in different ecosystems (Pyšek & Richardson,

2007). The ecological impacts of alien plant species in India are numerous. In the forest, invasive shrubs and climbers suppress native tree regeneration and alter habitat structure. In grasslands and open habitats, invasive herbs displace native grasses, affecting grazing systems and livestock productivity. Aquatic invasive clog waterways, reduce water quality, and disrupt freshwater biodiversity (**Rai & Singh, 2021**). It is essential to distinguish between the description of invasion status and the proof of its effects for this study. Invasion status is defined by presence, density, and IVI of IAPS, while comparing richness, abundance, diversity, or community structure of natives in more invaded vs. less invaded communities will be a better indication of the effect on vegetation. This combined method is in accordance with invasion ecology research in general, which uses comparisons of more and less invaded communities (Vilà et al., 2011). The present study addresses this gap by conducting a comprehensive phytosociological and diversity-based assessment of non-indigenous species in Jaunpur district. By analyzing habitat-wise variation in invasion intensity, identifying dominant invaders, and evaluating impacts on native vegetation, the study provides regionally relevant insights essential for evidence-based management and conservation planning.

In accordance with Convention on Biodiversity, exotic invasive plants refer to those plants that have been brought to the region from outside their geographical region and threaten the ecosystem, habitat, or any other living organism due to their invasion. The threat of invasion of plants in India has increased due to globalization and urbanization (Singh, 2005; Sekar, 2012).

RESEARCH METHODOLOGY

Study Site Profile

Coordinates of site: Present investigation was done in Jaunpur District, Uttar Pradesh, India, located in the Middle Gangetic Plain, a region recognized for its high agricultural productivity and intense anthropogenic land use (**Singh et al., 2013**). **Jaunpur district** shares its borders with Azamgarh to the north, Ghazipur to the east, Varanasi to the south, and Prayagraj to the west, according to the [District Census Handbook 2011](#).

Climate

Jaunpur District experiences a tropical monsoonal climate typical of the Middle Gangetic region (**Kant et al., 2025**). The hot season is April through June, rainy season June through September, and winter season December through February. During the summer, the temperature rises above 45°C, but during winter, the climate is extremely cold and the temperature drops to 7-8°C. The average rainfall annually is 950-1100 mm.

Soil Characteristics

Jaunpur is dominated by recent alluvial soils formed through continuous deposition by the Gomti River and associated floodplains (**Anil et al., 2020**). Soil texture ranges from sandy loam in upland agricultural areas to clay loam and silty clay in low-lying wetlands. Presence of organic matter and fertility makes soil of this area perfect for cultivation. (**Rai & Singh, 2021**).

Vegetation analysis: The foliage of Jaunpur District is chiefly anthropogenic and fragmented, shaped by intensive agriculture and expanding settlements (**Rai et al., 2012**). Natural vegetation has been largely replaced by croplands interspersed with roadside vegetation, wetlands, wastelands, degraded scrub

patches, forest edges, and urban open lands (Singh *et al.*, 2013).

Exploratory survey

Reconnaissance surveys are broadly acknowledged in invasion ecology as an essential initial step for identifying invasion-prone habitats and designing systematic sampling frameworks (Richardson *et al.*, 2000; Pyšek & Richardson, 2007). During this phase, special emphasis was placed on areas subjected to frequent anthropogenic disturbances, as disturbed habitats are known to be highly susceptible to biological invasions (Hobbs & Huenneke, 1992; Davis *et al.*, 2000).

Site Selection and Sampling framework

A Proportional random sampling design was established to assure systematic and representative coverage of diverse habitat types within Jaunpur District. Stratified sampling is widely recommended in ecological and invasion studies as it minimizes sampling bias and allows accurate comparison across heterogeneous landscapes (Kent, 2012; Ellenberg & Mueller, 1974).

Florida Sampling Method

Greenery sampling was carried out using the quadrat method, a standardised and widely accepted approach for quantitative assessment of plant communities (Curtis & McIntosh, 1951; Misra, 1968). The method provides accurate assessments of species composition, density, frequency, and abundance, which are essential for phytosociological analysis in invasion ecology (Ellenberg & Mueller, 1974).

Vegetation Type	Quadrat Size
Herbs	1 × 1 m
Shrubs	5 × 5 m
Trees	10 × 10 m

Data Collection : Data collection done systematically within each quadrat laid across different sampling sites and habitat types to obtain reliable quantitative information on species composition and invasion intensity. Quadrat-based data collection is widely recognized as a robust method for ecological and phytosociological studies (Curtis & McIntosh, 1951; Ellenberg & Mueller, 1974).

Identification of Plant Species

Field identification was carried out using morphological features such as habit, leaf structure, inflorescence type, floral characters, and fruit morphology with the help of regional floras (Singh *et al.*, 2013; Reddy, 2008). Uncertain plant specimens were gathered for rigorous laboratory scrutiny. Identification was confirmed using authoritative taxonomic literature such as *Flora of India* and regional botanical references (Reddy, 2008; Singh *et al.*, 2013). Botanical nomenclature was updated according to internationally accepted standards.

Phytosociological Parameters

Frequency (%) :

$$\text{Frequency (\%)} = (\text{Number of quadrats in which the species occurs} / \text{Total number of quadrats studied}) \times 100$$

Density

$$\text{Density} = \text{Total number of individuals of a species} / \text{Total number of quadrats studied}$$

Abundance

$$\text{Abundance} = \text{Total number of individuals of a species} / \text{Number of quadrats in which the species occurs}$$

Relative Phytosociological Values

To evaluate the comparative ecological importance of each species within plant communities, relative values were computed. Relative Density (RD %), Relative Abundance (RA %).

Importance Value Index (IVI)

$$\text{IVI} = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Abundance}$$

Community Diversity Indices

Plant community diversity and structural characteristics were assessed using widely accepted ecological diversity indices to quantify species diversity, dominance, and composition across the study sites. The **Shannon–Wiener Diversity Index (H')** was employed to evaluate species diversity by integrating both species richness and evenness within plant communities (**Shannon & Weaver, 1998**).

Statistical Analysis

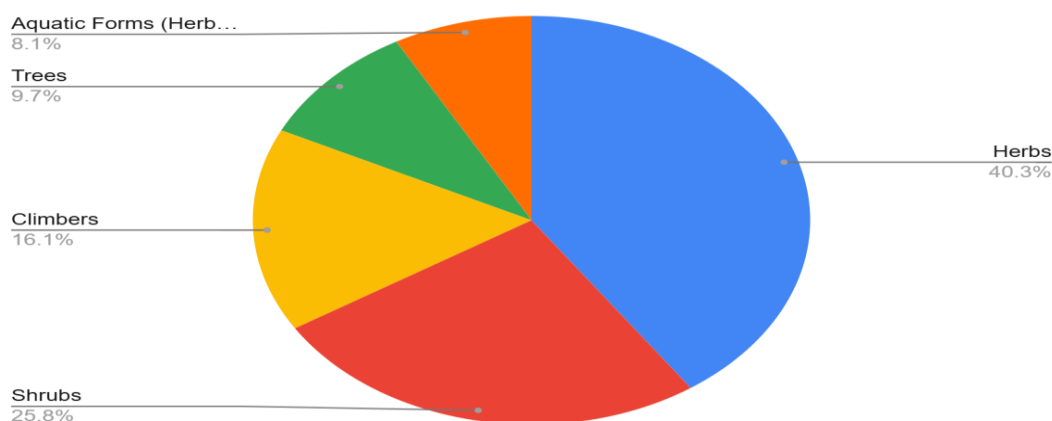
All quantitative data obtained from vegetation sampling and diversity assessment were statistically analyzed to ensure accuracy, reliability, and scientific validity. Phytosociological parameters including frequency, density, abundance, relative values, IVI, percent cover, and diversity indices were compiled habitat-wise and subjected to statistical evaluation.

Result

Life-Form Spectrum and Growth Habit of Invasive Alien Plants

S. No.	Life-Form Category	Number of Species (n)	Percentage (%)	Representative Species Observed
1	Herbs	25	40.3	<i>Ageratum conyzoides</i> , <i>Parthenium hysterophorus</i> , <i>Tridax procumbens</i> , <i>Amaranthus spinosus</i>
2	Shrubs	16	25.8	<i>Lantana camara</i> , <i>Chromolaena odorata</i> , <i>Calotropis gigantea</i> , <i>Croton bonplandianus</i>
3	Climbers	10	16.1	<i>Mikania micrantha</i> , <i>Ipomoea purpurea</i> , <i>Merremia dissecta</i> , <i>Passiflora foetida</i>
4	Trees	6	9.7	<i>Prosopis juliflora</i> , <i>Leucaena leucocephala</i> , <i>Eucalyptus tereticornis</i> , <i>Grevillea robusta</i>
5	Aquatic Forms (Herbs + Ferns)	5	8.1	<i>Eichhornia crassipes</i> , <i>Pistia stratiotes</i> , <i>Salvinia molesta</i> , <i>Lemna minor</i>

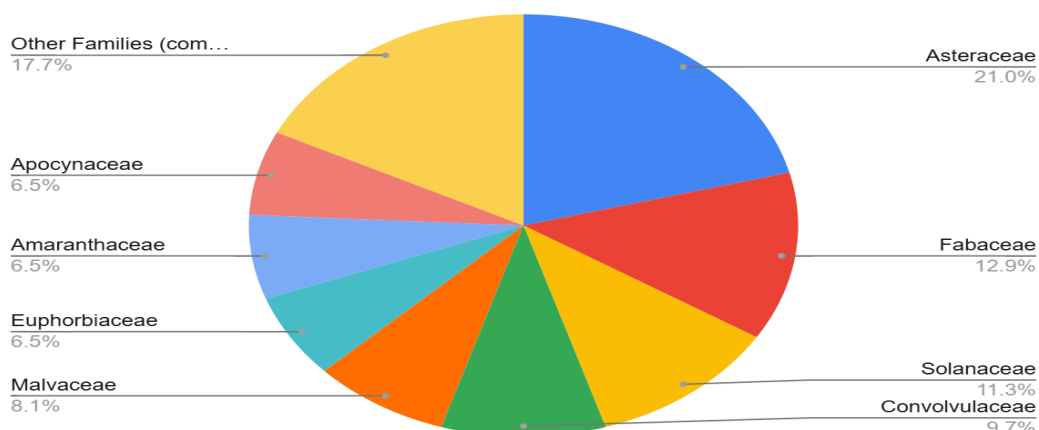
Number of Species



Family-wise Dominance of Invasive Alien Plant Species

S. No.	Plant Family	Number of Species	Percentage (%)
1	Asteraceae	13	20.97
2	Fabaceae	8	12.90
3	Solanaceae	7	11.29
4	Convolvulaceae	6	9.68
5	Malvaceae	5	8.06
6	Euphorbiaceae	4	6.45
7	Amaranthaceae	4	6.45
8	Apocynaceae	4	6.45
9	Other Families (combined)	11	17.74

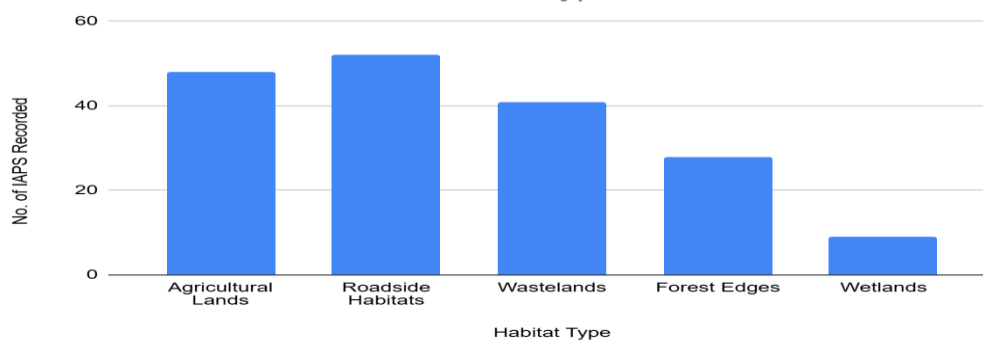
Number of Species



Habitat-wise Distribution Pattern of Invasive Alien Plant Species

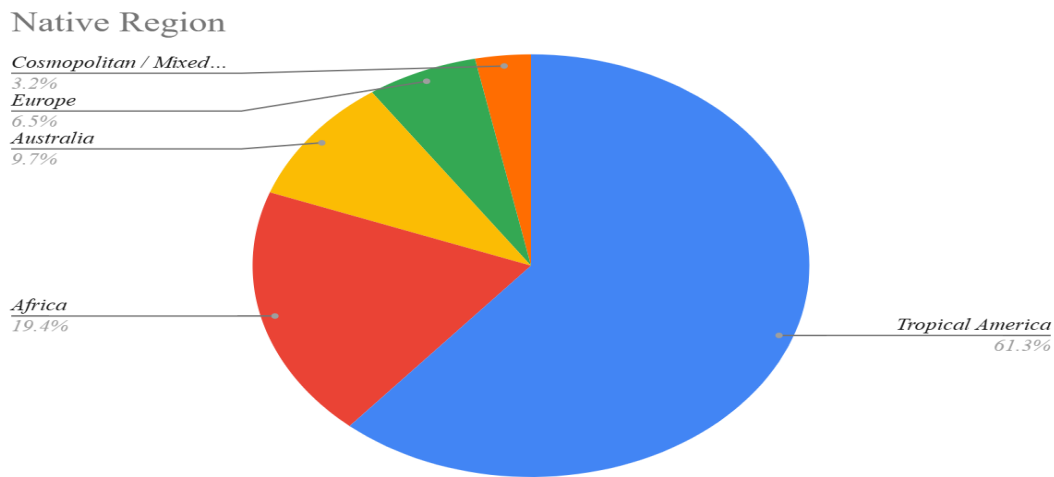
S. No.	Habitat Type	No. of IAPS Recorded	Dominant Species Observed
1	Agricultural Lands	48	<i>Parthenium hysterophorus</i> , <i>Ageratum conyzoides</i> , <i>Amaranthus spinosus</i>
2	Roadside Habitats	52	<i>Tridax procumbens</i> , <i>Croton bonplandianus</i> , <i>Tithonia diversifolia</i>
3	Wastelands	41	<i>Lantana camara</i> , <i>Prosopis juliflora</i> , <i>Chromolaena odorata</i>
4	Forest Edges	28	<i>Lantana camara</i> , <i>Mikania micrantha</i>
5	Wetlands	9	<i>Eichhornia crassipes</i> , <i>Pistia stratiotes</i> , <i>Salvinia molesta</i>

No. of IAPS Recorded vs. Habitat Type



Biogeographic Origin of Invasive Alien Plant Species

Native Region	Number of Species	Percentage (%)
Tropical America	38	61.29
Africa	12	19.35
Australia	6	9.68
Europe	4	6.45
Cosmopolitan / Mixed Origin	2	3.23
Total	62	100



Habitat Preference of Different Life Forms of Invasive Alien Plants

Life Form	Habitat Where Most Dominant	Representative Invasive Species
Herbs	Agricultural lands, Roadsides	<i>Parthenium hysterophorus</i> , <i>Ageratum conyzoides</i> , <i>Tridax procumbens</i>
Shrubs	Wastelands, Forest edges	<i>Lantana camara</i> , <i>Chromolaena odorata</i> , <i>Ipomoea carnea</i>
Climbers	Forest margins, Moist habitats	<i>Mikania micrantha</i> , <i>Merremia dissecta</i> , <i>Passiflora foetida</i>
Trees	Wastelands, Roadsides	<i>Prosopis juliflora</i> , <i>Leucaena leucocephala</i>
Aquatic forms	Wetlands, Canals, Ponds	<i>Eichhornia crassipes</i> , <i>Salvinia molesta</i> , <i>Pistia stratiotes</i>

Discussion

The present investigation provides comprehensive evidence of widespread invasion by alien plant species across diverse ecosystems of Jaunpur District, indicating advanced stages of biological invasion and ecosystem transformation. The dominance of herbaceous non-indigenous taxa in the present study aligns with global invasion trends, particularly in agro-ecosystems and human-modified landscapes. Herbaceous invaders such as *Parthenium hysterophorus*, *Ageratum conyzoides*, and *Tridax procumbens* exhibited extensive distribution and high abundance, indicating strong colonization ability. The predominance of Asteraceae, contributing over 20% of invasive species, reflects the evolutionary advantages associated with this family, including high reproductive capacity, efficient wind-mediated seed dispersal, rapid growth rates, and ecological plasticity. Fabaceae emerged as the second most dominant family, highlighting the importance of nitrogen fixation in invasion success. The present study demonstrated a strong positive relationship between disturbance intensity and invasion severity. Highly disturbed habitats supported greater invasive species richness and ecological dominance compared to less disturbed habitats.

Conclusion

The present study provides a comprehensive ecological evaluation of invasive alien plant species (IAPS) in Jaunpur District, Uttar Pradesh, and clearly establishes that biological invasion has emerged as a significant driver of ecological change across terrestrial and aquatic ecosystems of the region. The

invasive flora exhibited strong taxonomic clustering, with Asteraceae emerging as the most dominant family, followed by Fabaceae, Solanaceae, Convolvulaceae, Malvaceae, and Euphorbiaceae. The dominance of herbaceous invaders highlights the strong influence of disturbance-mediated invasion processes, particularly in highly disturbed agro-ecosystems and roadside habitats. In contrast, shrub and woody invasive species such as *Lantana camara*, *Prosopis juliflora*, and *Leucaena leucocephala* demonstrated long-term ecological persistence and structural dominance, indicating advanced stages of invasion and ecosystem transformation.

Diversity analysis revealed a significant reduction in native plant diversity in invaded habitats, as indicated by low Shannon diversity index values and high Simpson dominance. Biogeographic analysis revealed that the majority of invasive species originated from Tropical America, followed by Africa, Australia, and Europe. The study also demonstrated a strong positive relationship between habitat disturbance and invasion intensity. This research establishes a foundation for future ecological monitoring, invasive species management, and biodiversity conservation efforts in the region.

The findings of the present study highlight the urgent need for policy-level intervention to address invasive species threats. Future research should support the development of local invasive species rules, risk assessment frameworks, and management guidelines.

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