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Structural (Physical) Attributes of Invasive Plant Species on Agricultural Land of Mangalpur, Chandrapur-01, Rautahat, Nepal.

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Abstract

Biological invasions are increasingly recognized as significant drivers of economic and environmental harm, largely due to their negative impacts on biodiversity and ecosystem processes. Understanding and quantifying the effects of Invasive Plant Species (IPS) on agricultural land has therefore become a key research priority to inform effective policy and management strategies. In this study, I surveyed agricultural land in Mangalpur village, Chandrapur Municipality-01, Rautahat district, Nepal, to assess the structural (physical) attributes of IPS and conducted a socio-economic survey to evaluate their impacts. Thirty 1×1 m² plots were established, and eight IPS belonging to four plant families were identified through cluster analysis. Key metrics such as density, frequency, abundance, cover, Relative Population Density (RPD), Relative Frequency (RF), Relative Abundance (RA), and Relative Cover (RC) were measured. Additionally, species richness, species diversity, and Importance Value Index (IVI) were calculated. The results revealed that three species Ageratum conyzoides, Argemone mexicana, and Erigeron karvinskianus were the most dominant IPS, with Ageratum conyzoides exhibiting the highest density. While local farmers are aware of the IPS problem, management practices such as manual removal, burning, chemical application, and ploughing are only occasionally implemented. This highlights an urgent need for more systematic and effective control measures, as the current level of invasion suggests the situation could worsen in the future if left unaddressed.

Keywords: *Agricultural land, Biological Invasion, IPS*

Introduction

Invasive Plant Species (IPS) are the species, native to one area or origin, that have been introduced into an area outside their natural distribution, either by accident or on purpose, and which have colonized or invaded their near habitat, threatening biological diversity, ecosystem, habitats and human well-being (CBD, 2002).

Biological invasions are continuously increasing in their spatial extent with a greater severity of impacts on the environment, agriculture, and livelihoods (Pejchar & Mooney, 2009; Simberloû et al. 2013; Paini et al. 2016). The number of invasive species continues to increase worldwide, and progress toward achieving the Convention on Biological Diversity's Aichi Target 9 remains unsatisfactory. Key gaps in current management efforts include insufficient early detection and rapid response systems, limited coordination among stakeholders, inadequate resources, and weak policy enforcement. Addressing these challenges is crucial for improving invasive species management and meeting global biodiversity goals (CBD, 2014; Seebens et al., 2017). Furthermore, Climate change exacerbates biological invasions by altering environmental conditions that favor the establishment and spread of invasive species, such as increased temperatures, altered precipitation patterns, and more frequent extreme weather events, which create new opportunities for invasions and reduce ecosystem resilience (IUCN, 2017; Bellard et al., 2013). Additionally, global trade accelerates the introduction and dispersal of invasive species by increasing the movement of goods and people across regions, often bypassing natural barriers and facilitating the transport of alien species to new habitats (Bellard et al., 2013; Tittensor et al., 2014). Together, climate change and trade act synergistically to intensify the scale and impact of biological invasions worldwide (Levine and D'antonio, 2003). Therefore, the management of invasive alien species, which is an essential component of biodiversity conservation and environmental management, has become a major challenge globally.

Nepal is ranked third out of 124 countries as one of the most threatened nations by biological invasions in the agriculture sector (Paini et al. 2016). Located in the center of the Himalayan biodiversity hotspot, Nepal has a steep elevation gradient, resulting in significant variations in topography and climate along its length. Extreme climatic variations refer to the wide range of temperature and precipitation conditions found across Nepal, from tropical lowlands to alpine highlands, creating diverse ecological niches (Shrestha et al., 2012). Invasive plant species, due to their high adaptability and phenotypic plasticity, can adjust their growth and reproductive strategies to thrive in these varied environments, allowing species from different bioclimatic regions to establish successfully (Bellard et al., 2013; Davidson et al., 2011). This adaptability makes Nepal's diverse climate particularly vulnerable to biological invasions. Furthermore, the probability of introduction of alien plant species to Nepal appears high due to 1) increasing tourism activities particularly in mountain regions, 2) growing amount and diversity of imported agricultural products, 3) increasing quantity of imported crop seeds and other commodities, and 4) ineûective bio-security eûorts including quarantine at international border points and airports. Recent studies indicate that the number of naturalized flowering plant species in Nepal has increased, with over 200 species now documented, and approximately 35 of these are recognized as invasive due to their significant ecological and economic impacts (Adhikari et al., 2021; Karki et al., 2023). Although the overall impact of biological invasions in Nepal has not been evaluated, the estimated annual cost of invasion to Nepal's agriculture sector alone is nearly US$ 22.7 million (Paini et al. 2016). Biological invasions in Nepal are increasingly threatening biodiversity and ecosystem services, with their severity and spread

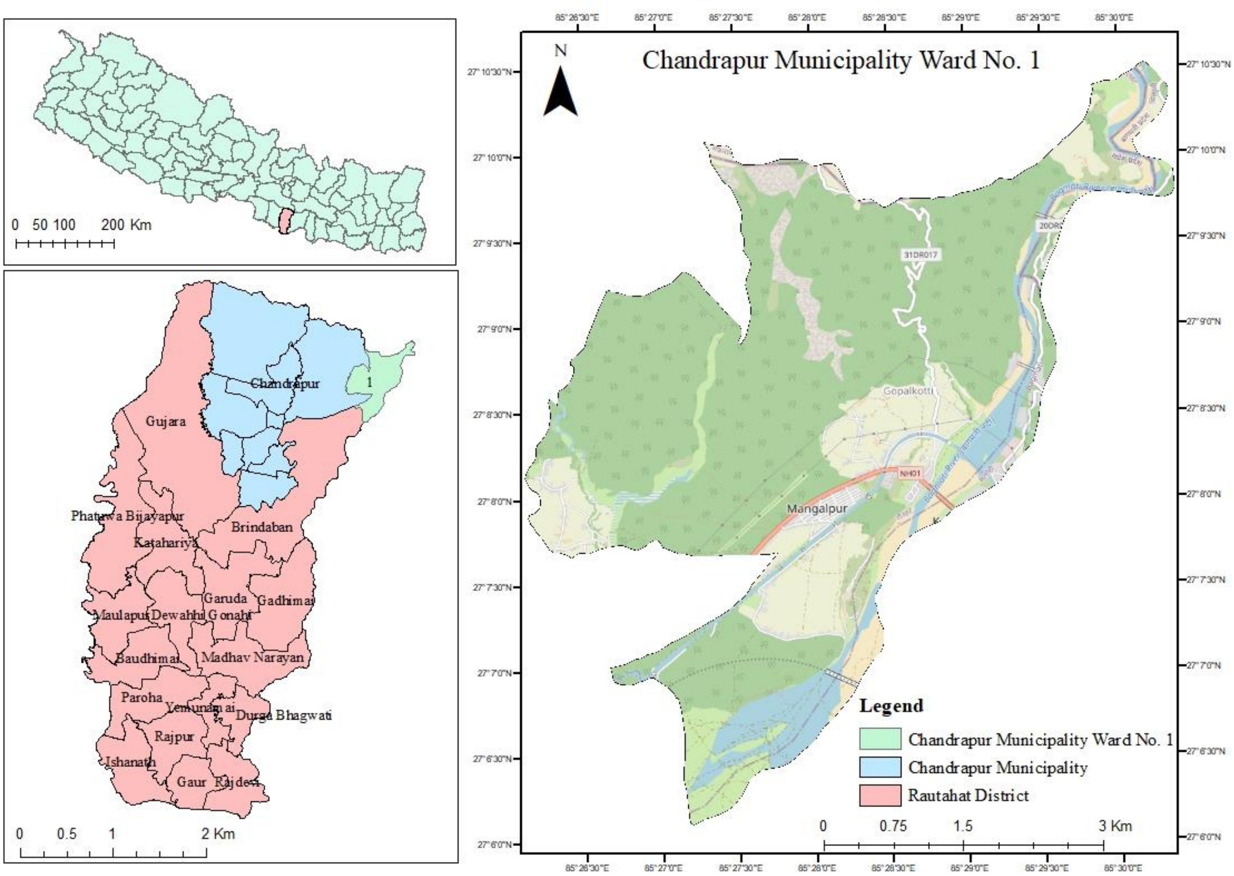

Figure 1: Map of the study area

continuing to grow (Bhatt et al., 2024; Shrestha et al., 2020). Invasive alien plant species degrade habitats, reduce native species diversity, and disrupt ecosystem functions, especially in protected areas and wetlands, driven largely by human activities such as agriculture and trade (Bhatt et al., 2024; Pant, Thapa, & Bist, 2023).

This study focused on assessing the structural attributes of Invasive Plant Species (IPS) in agricultural land of Chandrapur-1 (Mangalpur), Rautahat, Nepal. It aimed to measure population parameters such as density, frequency, abundance, cover, and Importance Value Index (IVI), evaluate the socio-economic impacts on local farmers, and develop management strategies based on the invasion mechanisms.

Materials and Method

Study Area

The study was conducted on Agricultural land of Mangalpur, Chandrapur-1 of Rautahat district, Madhesh Province, Nepal. The Agricultural land is located in 85.465965E and 27.123978N. The elevation of the study area is 136m from sea level. The Agricultural Land was selected because it is near to the human settlement and East-West Mahendra Highway. The study area is the source of the food grains, vegetables, fruits, lentils and other cash crops for farmers of the village. The area of the agricultural land is 50ha.

Field Survey

A Field Survey was carried out in January 2020. A preliminary assessment was carried out for rapport building with farmers of the village to get preliminary understanding about the status of the selected Agricultural land. A general approach of the preliminary survey was to get the field information from farmers of the Mangalpur village.

Plot Sampling and IPS

In the Agricultural land (mixed crops land), 5 transect were made and in each transect 6 plots of size 1×1m^2 were sampled to measure selected IPS density, frequency, abundance and cover. The length of transect was about 100m and distance between them was about 50m. The distance between two plots was 10m. Sample size 1×1m^2 was made in Agricultural land. The Geographic location (latitude, longitude and elevation) was noted by the Global Positioning System (GPS). Invasive Plant Species cover was estimated visual estimation in percentage cover (1%, 2%, 5% and increments up to 100%) in each plot. The Invasive Plant Species reported were collected and counted by separating their individual root. The IPS were identified using Final Manual on Invasive Plant Species in Kailash Sacred Landscape-Nepal (2016), comparing herbaria of Tribhuvan University Central Herbarium, (TUCH), Kirtipur, Kathmandu, Nepal.

Density, Frequency, Abundance and Cover of IPS

After recognizing plant communities by using Final Manual on Invasive Plant Species in Kailash Sacred Landscape-Nepal (2016), comparing herbaria of Tribhuvan University Central Herbarium, (TUCH), Kirtipur, Kathmandu, Nepal and IPS cover, density and frequency of all the IPS found on Agricultural land of Mangalpur village were measured. Population density, frequency, abundance, and cover of Invasive Plant Species (IPS) were measured.

Population density, Frequency, Abundance, and Cover were calculated by the following formulas,

$$PD = \frac{\text{Mean no. of individual of each species}}{\text{Area of Quadrate in m}^2}$$

$$\text{Frequency (\%)} = \left(\frac{\text{No. of quadrats in which a species occurs}}{\text{Total no. of quadrats of occurrence}}\right) \times 100\%$$

$$\text{Abundance} = \frac{\text{Total no. of individuals of a species}}{\text{Total no. of quadrats of occurrence}}$$

$$\text{Cover (\%)} = \left(\frac{\text{Sum of cover of IPS from all quadrate}}{\text{Total no. of plot sampled}}\right) \times 100\%$$

(Source: Zhigila et al. 2015)

Socio-economic Survey

A set of structured questionnaires was prepared to gather qualitative information on invasive plant species (IPS) in the study area. Key Informant

Interviews were conducted in Mangalpur and Dovantol villages of Chandrapur-01 Municipality, Rautahat district, involving both elderly and younger farmers. A total of 10 farmers were interviewed as key informants using a judgmental sampling method, while an additional 60 farmers were surveyed to collect broader information about IPS. The questionnaire focused on farmers' awareness of IPS, the common invasive species present, their impact on crop productivity, control methods employed, and challenges faced in managing these species. The purpose was to understand local knowledge and perceptions, assess the ecological and economic effects of IPS, and identify effective management practices within the community.

Results

Plant Species Richness

In the study area, the species richness of invasive plant species (IPS) increased annually, indicating rapid growth and a negative impact on agricultural land and crop production. A total of eight IPS belonging to four families were recorded (Table 1), with Asteraceae being the richest family containing four species. Among them, *Ageratum conyzoides*, *Argemone mexicana*, and *Erigeron karvinskianus* were the most dominant and problematic species affecting the crop fields.

Invasive Plant Species (IPS)

In the Agricultural land, following IPS were found:

Table 1: List of IPS found in the Agricultural land

S.N.	Scientific name of IPS	Common name	Local name	Family
1	*Ageratum conyzoides*	Billygoat weed	Gandhe Jhar	Asteraceae
2	*Erigeron karvinkianus*	Karwinsky's Fleabane	Phule Jhar	Asteraceae
3	*Amaranthus spinosus*	Spiny pigweed	Kandlude	Amaranthaceae
4	*Oxalis latiofola*	Purple wood sorel	Chari Amilo	Oxalidaceae
5	*Parthenium hysterophorus*	Parthenium	Pati Jhar	Asteraceae
6	*Alternanthera philoxeroides*	Alligator weed	Jala jambhu	Amaranthaceae
7	*Agremone mexicana*	Mexican poppy	Thakal	Papaveraceae
8	*Bidens pilosa*	Cobbelers pegs	Suere Kuro	Asteraceae

Cover of IPS in the Agricultural land

A total of eight invasive plant species (IPS) were identified in the agricultural land during the study. Among these species, *Ageratum conyzoides* exhibited the highest cover, indicating its widespread dominance in the area. This was followed by *Argemone mexicana*, *Bidens pilosa*, and *Erigeron karvinskianus*, which also showed significant coverage but to a lesser extent. In contrast, *Alternanthera philoxeroides* was recorded with the lowest cover among the IPS, suggesting a relatively limited presence in the agricultural fields. The cover measurements were obtained through systematic sampling using quadrats, providing quantitative data on the spatial extent of each species within the study site.

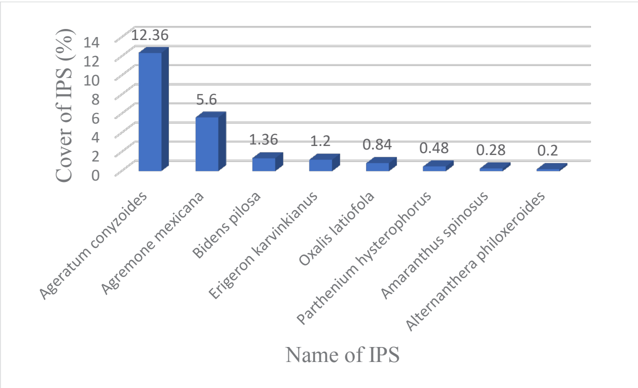

Figure 2: Cover of IPS

Population density, Frequency, Abundance, RPD, RF, RA, RC, and IVI of IPS

Table 2: Calculation of population density, frequency, abundance, cover, RPD, RF, RA, RC, and IVI of IPS

S.N.	Name of species	Total no. of individuals of each species on Agricultural land	Mean no. of individuals of each species	Total no. of Quadrats of occurrence	No. of Quadrats occurrence	Population density of each species (Ind./m²)
1	*Ageratum conyzoides*	309	0.554	30	22	0.554
2	*Erigeron karvinkianus*	30	0.054	30	11	0.054
3	*Amaranthus spinosus*	7	0.013	30	6	0.013
4	*Oxalis latiofola*	21	0.038	30	2	0.038
5	*Parthenium hysterophorus*	12	0.022	30	1	0.022
6	*Alternanthera philoxeroides*	5	0.009	30	3	0.009
7	*Agremone mexicana*	140	0.251	30	18	0.251
8	*Bidens pilosa*	34	0.061	30	8	0.061
	Total	**558**				**ΣPD=1**

Abundance of each species (A)	Frequency of each species (F) (%)	Cover of each species (C) (%)	Relative Population Density (RPD) (%)	Relative Abundance (RA) (%)	Relative Frequency (RF) (%)	Relative Cover (RC) (%)	IVI (%)
14.05	73.33	12.36	55.38	25.95	30.98	55.38	112.31
2.73	36.67	1.2	5.38	5.04	15.49	5.38	25.91
1.17	20	0.28	1.25	2.16	8.45	1.25	11.86
10.5	6.67	0.84	3.76	19.39	2.82	3.76	25.28
12	3.33	0.48	2.15	22.17	1.41	2.15	25.73
1.67	10	0.2	0.89	3.08	4.23	0.89	8.20
7.78	60	5.6	25.09	14.37	25.35	25.09	64.81
4.25	26.67	1.36	6.09	7.85	11.27	6.09	25.21
ΣA=54.13	**ΣF=236.67**	**ΣC=22.32**					

Socio-economic Impact of IPS

Key informants identified several invasive plant species (IPS) as major problems in agricultural lands, notably *Oxalis latifolia*, *Argemone mexicana*, and *Ageratum conyzoides*. These species have been observed to negatively impact native plants and reduce the productivity of food grains, vegetables, lentils, spices, and fruits. The invasion of IPS has become increasingly severe, leading to a decline in crop yields and threatening the livelihoods of farmers and villagers who depend on these lands for food and income. Specifically, *Ageratum conyzoides* reduces plant diversity and biomass, while *Argemone mexicana* releases allelochemicals that inhibit the germination and growth of important crops like beans and maize.

Farmers are actively trying to control these invasive species through physical methods such as uprooting, pulling, and burning, as well as by applying chemical pesticides like trafajin and 2,4-D. However, these control measures are often labor-intensive and may not provide long-term solutions. Many farmers expressed concern about the future impact of IPS on their agro-ecosystems, fearing further declines in crop yields and increased difficulty in managing their land. The consensus among respondents is that if the invasion continues unchecked, it could severely jeopardize food security and the sustainability of agricultural practices in the region.

Discussion

Plant Species Richness

The increasing species richness of invasive plant species (IPS) in the study area, with eight species from four families—especially the Asteraceae family—reflects similar trends reported in other agricultural regions (Sharma, Singh, & Verma, 2020). Notably, *Ageratum conyzoides*, *Argemone* *mexicana*, and *Erigeron karvinkianus* were the most dominant and problematic species, consistent with findings by Singh and Kumar (2018), who documented their negative effects on crop yields and native biodiversity. The year-by-year growth of IPS and its impact on reducing crop production aligns with Mwangi, Muthuri, and Wanjiru's (2019) observations that invasive plants alter soil nutrients and outcompete crops. Additionally, the allelopathic nature of species like *Ageratum conyzoides* further suppresses crop growth (Kumar & Joshi, 2017), highlighting the urgent need for effective management to protect agricultural productivity.

Impacts of IPS on Species Richness

The increasing invasion of species like *Ageratum conyzoides* and *Argemone mexicana* in agricultural lands reduces native species richness and crop yields, as also reported by Zhang et al. (2023), who found that invasive plants disrupt native plant communities and soil health. High density and dominance of these IPS negatively affect biodiversity and productivity, consistent with findings by Lee and Park (2022) on agroecosystem degradation due to invasive weeds. Farmers' efforts to control IPS through physical and chemical means reflect global challenges in managing invasions that threaten food security and ecosystem stability (Garcia et al., 2021). These impacts highlight the urgent need for integrated management to protect native diversity and sustain agriculture.

Socio-economic Impact of IPS

Agricultural ecosystems in the study area are highly susceptible to invasive plant species (IPS), with key informants and farmers identifying *Ageratum conyzoides*, *Argemone mexicana*, and *Erigeron karvinkianus* as major threats to their livelihoods. Despite awareness of IPS invasion, local management efforts remain limited and sporadic, relying mainly on manual uprooting, burning, chemical application, and ploughing, which have proven insufficient to significantly reduce IPS spread. This situation mirrors findings by Johnson et al. (2022), who reported that inadequate and inconsistent control measures in rural agricultural communities often fail to contain invasive species, exacerbating socio-economic losses. Rejmánek (2005) emphasizes that effective invasive species management requires a comprehensive approach including prevention, early detection, eradication, and integrated control, with prevention being the most cost-effective strategy. These insights highlight the urgent need for coordinated local initiatives and policy support to implement integrated management practices that can mitigate the socio-economic impacts of IPS on farming communities.

Conclusion

Invasive plant species (IPS), notably *Ageratum conyzoides*, *Argemone mexicana*, and *Erigeron karvinkianus*, are increasingly encroaching upon agricultural lands, causing marked declines in native species richness, crop yields, and soil health. This pattern is consistent with extensive research showing that IPS disrupt native plant communities and agroecosystem functions, thereby threatening food security and the livelihoods of farmers (Zhang, Chen, & Wu, 2023; Kumar & Joshi, 2017). Although local farmers employ control measures such as manual removal, burning, and chemical treatments, these efforts have generally been inadequate in effectively managing IPS, mirroring challenges faced in rural agricultural systems worldwide (Johnson, Lee, & Patel, 2022; Mwangi, Muthuri, & Wanjiru, 2019).

The socio-economic consequences of IPS invasion—including reduced agricultural productivity and increased labor demands—highlight the pressing need for integrated and proactive management strategies. Emphasizing prevention, early detection, and coordinated control remains essential to curbing IPS spread, as underscored by Rejmánek (2005). Enhancing local management initiatives through policy support and sustainable practices will be vital to conserving native biodiversity and maintaining agricultural productivity over the long term. Without such comprehensive approaches, continued IPS proliferation is likely to worsen ecological degradation and deepen socio-economic challenges for farming communities.

Recommendations

- Future management of invasive plant species should utilize integrated methods combining mechanical, chemical, biological, and cultural controls tailored to local conditions.
- Prevention efforts must be strengthened through community engagement, early detection, and effective biosecurity measures.
- Supportive policies, sustained funding, and continuous research are vital to empower stakeholders and promote ecosystem restoration and resilience.

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