*Received 11 March 2025, Revision accepted: 19 August 2025*
*Himalayan Biodiversity 2025. 10: 47- 57* **DOI: https://doi.org/10.3126/hebids.v10i1.85806**
***ISSN: 2382-5200***

# Spatial Distribution of Invasive Alien Plant Species in Baglung and Kushma Municipalities, Central Nepal

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## ABSTRACT

Invasive alien plant species (IAPs) frequently find ideal small-scale habitats in urban settings, where they can grow and spread their seeds throughout the environment around them. In addition to offering possibilities for early identification and elimination of invaders, regular monitoring of IAPs in urban areas produce science-based data for the management of IAPs. In this study, we inventoried IAPs and documented their spatial distribution in Baglung and Kushma municipalities, central Nepal. We evaluated the flora along the sides of the roadways in 80 plots ($5 \times 5m^2$) spaced out across the roads in municipalities at intervals of roughly 500 m using a checklist of the 27 IAPs that have been recorded from Nepal. The IAPs present in each plot were noted together with the location's coordinates. The frequency, and distribution maps of the IAPs were prepared using field data. Arc GIS was used to prepare distribution maps for each IAP and the general distribution patterns for species richness. In Bagiung and Kushma municipalities, we recorded eleven IAPs, i.e. 43% of the total number of IAPs recorded from Nepal. *Bidens pilosa* had the highest frequency whereas *Galinsoga quadriradiata* had the lowest. Two of the recorded IAPs *Chromolaena odorata* and *Lantana camara* were among 100 of the world's worst invasive species. IAPs have been spreading quickly over road networks in Kushma and Baglung. IAPs distribution and periodic inventories are therefore be thoroughly carried out at the national level to establish management methods for preventing biological invasion.

**Keywords:** Biological invasion, Distribution Maps, Roadside vegetation, Urban biodiversity

## INTRODUCTION

An invasive species is an organism that is not indigenous or native to a particular area and cause great economic and environmental harm to the new area (McNeely, 2001). Invasive alien plants (IAPs) frequently find suitable microhabitats in urban environments, where they then disperse their propagules to spread further in the surrounding terrain (Pathak et al., 2021). The expansion and detrimental effects of invasive, non-native plants are putting native ecosystems in threat globally. Plant species, many of which are of foreign origin, can be found in a wide variety of habitats created by urban surroundings. Understanding the spatial distribution of invasive alien species is crucial for future urban planning and management of the city's natural spaces (Štajerová et al., 2017).

A significant environmental issue in Nepal is a biological invasion from invasive alien species. Along central Nepal's transportation networks, IAPs have been quickly disseminated. The road networks serve as plant invasion source areas and distribution pathways (Adhikari et al., 2024). IAPs distribution and implications must therefore be thoroughly studied at the national

level to establish management methods for managing IAPs (Paudel, 2015). There are 30 plant species particularly troublesome invasive alien plant species in Nepal (Shrestha et al., 2024), six of these are included in an international list of 100 of the world's worst invasive alien species (Lowe et al., 2000).

A lot of work is needed to reduce the spread of IAPs, which pose a severe environmental hazard. One of the most serious detrimental impact to the conservation of natural biodiversity is the unchecked spread of species from one geographic location to another that have been unintentionally or intentionally introduced by humans. This has important socioeconomic, health, and ecological ramifications (Vitousek et al., 1996). Due to open border traffic and a heavy reliance on the import of food and other goods, various IAPs are infiltrating our country from neighboring nations, primarily from India. By suppressing or eliminating native species, either directly by out-competing them for resources or indirectly by altering the way nutrients are cycled through the systems, such invasive alien plant species can change the structure and species composition of ecosystems. Because of this, it is important to reduce the negative effects of IAPs introduction and expansion into new areas. Additionally, specific data about the pattern of species distribution is required for the management of IAPs. Roads serve as source locations for invasive species since they are directly linked to disturbance. The distribution of IAPs along road networks can be studied to learn more about how they are distributed. As a result, this kind of research could help develop techniques for tracking the further spread of IAPs into new geographic areas and managing their effects.

Parbat and Baglung area have forests, marshes, and agricultural farmlands that are invaded by several IAPs that may be the focus of the further inventory. Therefore, the present study on 1) inventory of IAPs, and 2) spatial distribution of IAPs in Baglung and Kushma municipalities will aid the concerned authority for science-based management in protecting the rivers, forests, street edges, and agricultural fields from their negative effects. This study might be able to give information for limiting their distribution to other areas.

## MATERIALS AND METHODS

### Study Area

The plain area of Kushma municipality including Maldhunga in the west and Dobilla in the east is the study area for this study. Kushma falls under Gandaki province at an altitude of 722 meters to 911.84 meters. The study site in Kushma Municipality accounts for 93.18 $km^2$ area. Kushma municipality lies in longitude between 83.6200604˚ to 83.706073˚ east and latitude between 28.223998˚ to 28.2566752˚ north. It is nestled amongst the tall mountain ranges, aligned with the cliffs, gushing rivers, and a lush-green environment. The Kali Gandaki River lies to the west and the Modi River to the east.

Baglung municipality is situated on a plateau overlooking the Kali Gandaki Gorge directly south of the Dhaulagiri Himalayan range. City limits are roughly determined by the Theule Khola to the south, Kali Gandaki to the east, and Dhodeni Khola to the north. Baglung Municipality lies at an altitude of 751 meters to 1119.23 meters. The study site in Baglung municipality accounts for 98.01 $km^2$. Baglung municipality lies in longitude between 83.5627034˚ to 83.615587˚east and latitude between 28.2566752˚ to 28.2653766˚ north.

Pokhara is the nearest city to both Kushma and Baglung. So, the climate is nearly as like to that of Pokhara. There was average rainfall of 473

mm in the pre-monsoon season, 3336 mm in the monsoon season, 171 mm in the post-monsoon season, and 82 mm in the winter over the period of 25 years in Pokhara (1985- 2010) (DHM, 2016).

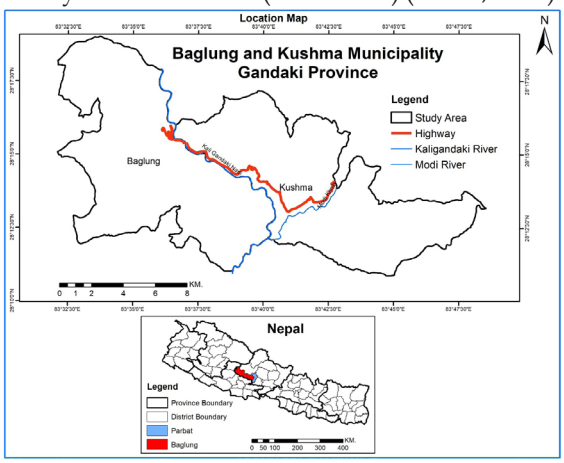



**Figure 1:** Map of Baglung and Kushma Municipality in Nepal

Both Kushma municipality and Baglung municipality are connected to Pokhara via Baglung highway. The highway and the roads that are connected to the highway are the main study site of the study.

## Survey of IAPs

The list of the most troublesome invasive alien plant species created by Shrestha et al., (2022) was used for the survey's purposes. Between December and January 2022/23, an ecological survey of these invasive alien species was conducted along the road network between Kushma and Baglung. The road network was used as a study site during our assessment since IAPs abundance would be higher in vegetation along roads. The survey of IAPs used a systematic sampling technique that involved placing sample plots systematically along the route at intervals of 500m. A 5x5m$^2$ area was defined along the roadside at each predetermined distance. Along the main road networks in Kushma and Baglung, 80 roadside plots, in total, were sampled. To the best of our ability, all municipal main roads, secondary roads, and accessible highways were surveyed. IAPs were enumerated to obtain frequency and cover. The visual estimate was used to determine the cover of IAPs. With the help of the GPS (First used in the field during 2022, December), latitude, longitude, and elevation were recorded for each plot. Depending on the location and accessibility, the plots' distances from the road varied from 1 to 5 meters. We conducted a field survey and gathered herbarium samples of the IAPs from the municipalities of Kushma and Baglung and compared them to those that were reported from Nepal (Adhikari et al., 2022).

IAPs and geographic coordinates (latitude, longitude) were all noted for each plot. With the help of ArcGIS, data were utilized to create distribution maps of all IAPs in the Kushma and Baglung municipalities.

## Spatial distribution mapping

The spatial distribution map of each IAPs was created using Arc GIS version 10 and the GPS readings that were collected from the field study. As stated earlier, with the help of geographical coordinates and ArcGIS software distribution maps were obtained for each species encountered in the field survey.

## Data Analysis

The frequency of each IAPs was computed from our survey data following the method of Kent (2012) using the relation:

$$\text{Frequency (\%)} = \frac{\text{No of sample plots with individual IAPs}}{\text{Total no of plots sampled}} \times 100$$

Further, the calculation of percentage occurrence in different road networks for each IAPs was also done.

## Results

A total of eleven IAPs were recorded in the study area (Table 1).

**Table 1:** Name of Species found in the present research

| S.N. | Name of IAPs | Family | Common name | Local/ vernacular name | Native range |
|---|---|---|---|---|---|
| 1 | *Mimosa pudica* L. | Fabaceae | Sensitive plant | Lajjawoti jhar | Tropical America |
| 2 | *Bidens pilosa* L. | Asteraceae | Beggar's stick | Kalo kuro | Tropical America |
| 3 | *Chromolaena odorata* (L.) R. King & H. Rob. | Asteraceae | Siam weed | Seto banmara | Jamaica, West Indies |
| 4 | *Ageratum houstonianum* Mill. | Asteraceae | Blue Billy Goat weed | Nilo gandhe | South America |
| 5 | *Ageratum conyzoides* L. | Asteraceae | Billy goat weed | Seto gandhe | South America |
| 6 | *Ageratina Adenophora* (Spreng.) R. King & H. Rob. | Asteraceae | Crofton weed | Kalo banmara | Central America |
| 7 | *Amaranthus spinosus* L. | Amaranthaceae | Spiny pigweed | Kandelunde | Tropical America |
| 8 | *Xanthium strumarium* L. | Asteraceae | Rough Cackle-Bur | Bhende kuro | America |
| 9 | *Lantana camara* L. | Verbenaceae | Lantana | Banphanda | West Indies |
| 10 | *Parthenium hysterophorus* L | Asteraceae | Bitterweed | Patijhar | Mexico, West Indies, Central and South America |
| 11 | *Galinsoga quadriradiata* Ruiz & Pav. | Asteraceae | Hairy galinsoga. | Jhuse chitlange | America |

## Frequency of Invasive Alien Plant Species

A road network inventory in Kushma and Baglung municipalities enlisted 11 different Invasive Alien Plant species (IAPs). *Bidens pilosa* was present in 85% of the sample plots (Table 2). It was the species that had been dispersed across practically every sample plot and was the most frequent. *Ageratum houstonianum* was present in 65% of the sample plots (Table 2). It was the second most frequent.It was followed by *Ageratina adenophora* (53.75%).

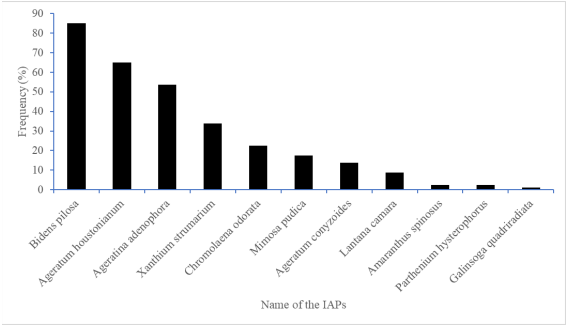



**Figure 2:** Frequency of IAPs in the study area

Of these IAPs, five exhibited frequency levels above 20% which are *Bidens pilosa, Chromolaena odorata, Ageratum houstonianum, Ageratina adenophora, Xanthium strumarium,* etc (Table 2). The IAPs along with their presence plots and frequencies is tabulated below:

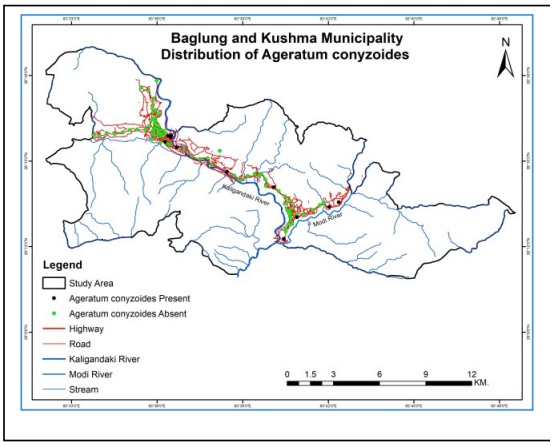
**Table 2:** IAPs with their Presence Plots and Frequency

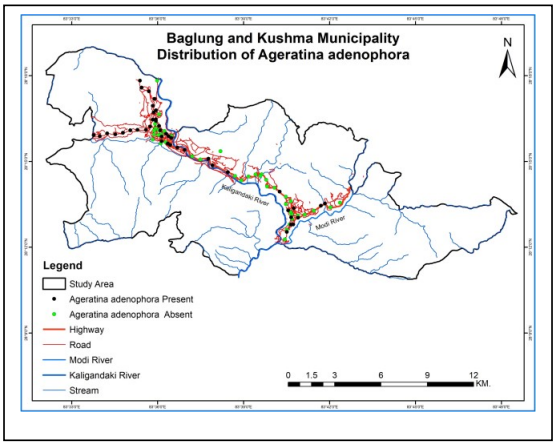
| S.N. | Name of the Species | Total No of Presence Plots | Frequency (%) |
|---|---|---|---|
| 1 | *Bidens pilosa* | 68 | 85 |
| 2 | *Ageratum houstonianum* | 52 | 65 |
| 3 | *Ageratina adenophora* | 43 | 53.75 |
| 4 | *Xanthium strumarium* | 27 | 33.75 |
| 5 | *Chromolaena odorata* | 18 | 22.5 |
| 6 | *Mimosa pudica* | 14 | 17.5 |

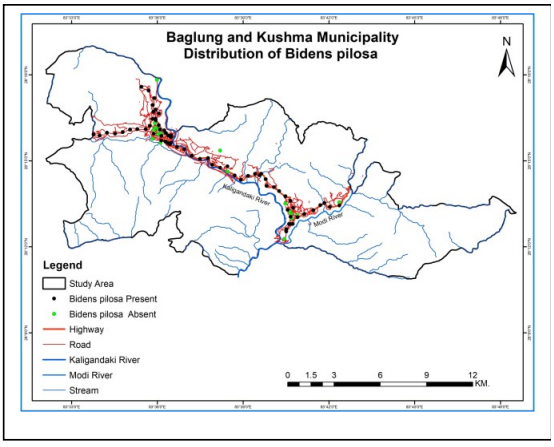
| | | | |
|---|---|---|---|
| 7 | *Ageratum conyzoides* | 11 | 13.75 |
| 8 | *Lantana camara* | 7 | 8.75 |
| 9 | *Amaranthus spinosus* | 2 | 2.5 |
| 10 | *Parthenium hysterophorus* | 2 | 2.5 |
| 11 | *Galinsoga quadriradiata* | 1 | 1.25 |

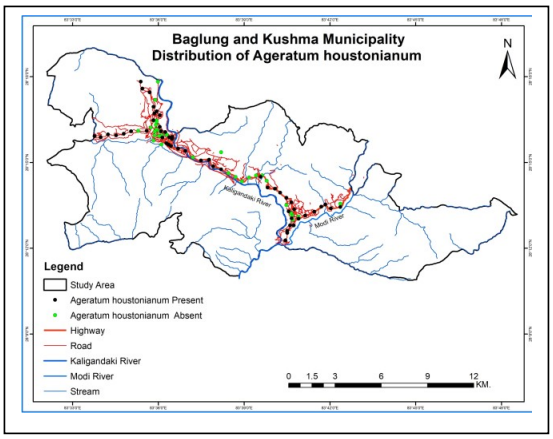
## Distribution of IAPs

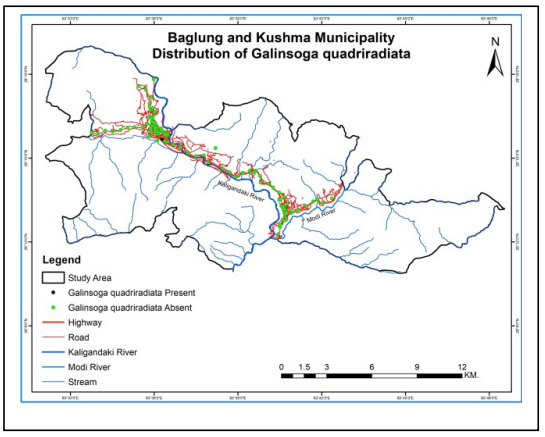
*Bidens pilosa* was widespread throughout the research area, according to maps of eleven IAPs in the Kushma and Baglung municipalities.*Ageratina adenophora* was also found everywhere. There have been reports of *Ageratum conyzoides* in areas where roadways cross agricultural land. The research area was overflowing with *Ageratum houstonianum*. There was no *Amaranthus spinosus* in other areas, but it was in Badagau, Kushma. Instead of an urban environment, a free roadway was where *Chromolaena odorata* was reported. There was only one location at Baglung Bazaar where *Galinsoga quadriradiata* was found. *Lantana camara* was found along Kaligandaki riverside, along the road from Kushma to Baglung. *Mimosa pudica* was frequently observed outside of urban areas. In Baglung Bazaar, *Parthenium hysterophorus* was found only at two locations. *Bidens pilosa* was found in all different types of land use, including highways, urban areas, farmland, and bare areas along the road networks in the municipalities of Kushma and Baglung. It was found in all different types of land use, including highways, urban areas, farmland, and bare areas along the road networks in the municipalities of Kushma and Baglung.

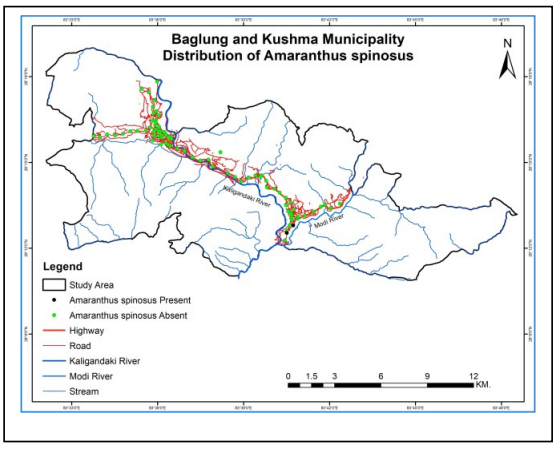


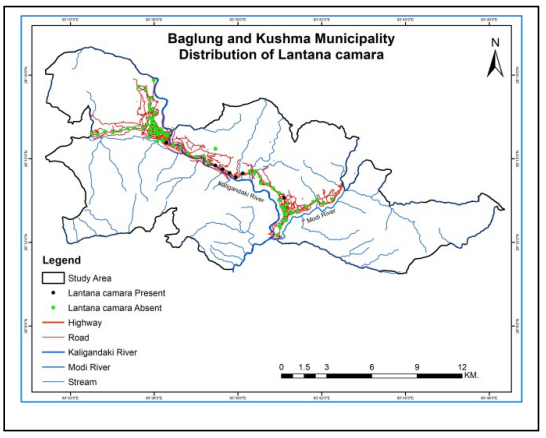



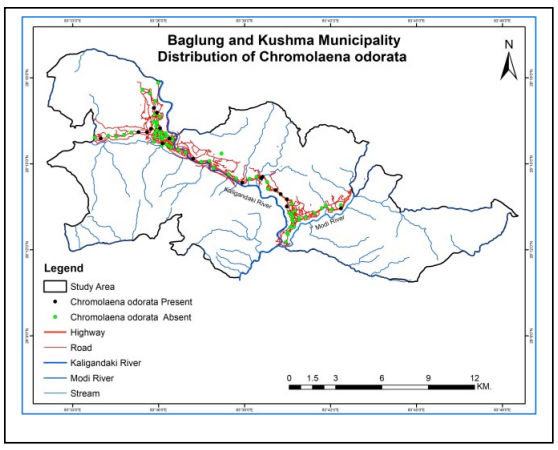



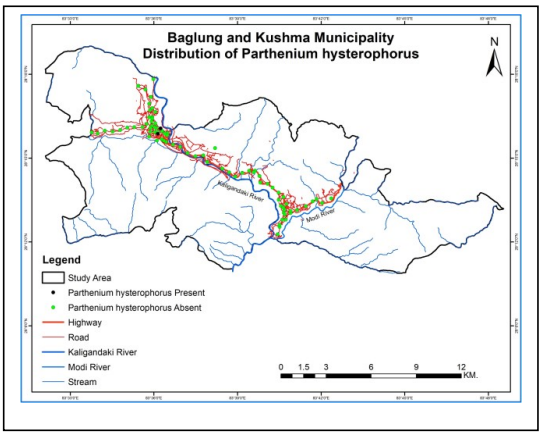

Baglung and Kushma Municipality
Distribution of Ageratum houstonianum
N
Legend
Study Area
Ageratum houstonianum Present
Ageratum houstonianum Absent
Highway
Road
Kaligandaki River
Modi River
Stream
0 1.5 3 6 9 12
KM.

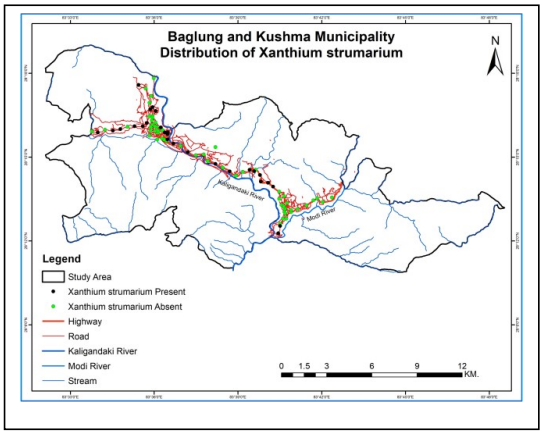

Baglung and Kushma Municipality
Distribution of Galinsoga quadriradiata
N
Legend
Study Area
Galinsoga quadriradiata Present
Galinsoga quadriradiata Absent
Highway
Road
Kaligandaki River
Modi River
Stream
0 1.5 3 6 9 12
KM.


Baglung and Kushma Municipality
Distribution of Amaranthus spinosus
N
Legend
Study Area
Amaranthus spinosus Present
Amaranthus spinosus Absent
Highway
Road
Kaligandaki River
Modi River
Stream
0 1.5 3 6 9 12
KM.


Baglung and Kushma Municipality
Distribution of Lantana camara
N
Legend
Study Area
Lantana camara Present
Lantana camara Absent
Highway
Road
Kaligandaki River
Modi River
Stream
0 1.5 3 6 9 12
KM.


Baglung and Kushma Municipality
Distribution of Chromolaena odorata
N
Legend
Study Area
Chromolaena odorata Present
Chromolaena odorata Absent
Highway
Road
Kaligandaki River
Modi River
Stream
0 1.5 3 6 9 12
KM.


Baglung and Kushma Municipality
Distribution of Parthenium hysterophorus
N
Legend
Study Area
Parthenium hysterophorus Present
Parthenium hysterophorus Absent
Highway
Road
Kaligandaki River
Modi River
Stream
0 1.5 3 6 9 12
KM.



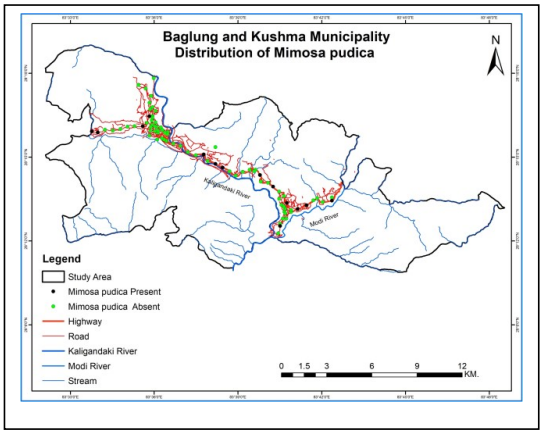




**Figure 3.** Spatial Distribution Maps of all 11 IAPs in the study areas

*Ageratum conyzoides* was present in 13.75% of the sample plots (Table 2). It was the less dominant species in different land use in road networks but was frequent in agricultural land. *Ageratina adenophora* was present in 53.75% of the sample plots (Table 2). According to this species's distribution, it was mainly found in the Baglung municipality but only less frequently in the Kushma municipality. *Chromolaena odorata* was present in 22.5% of the sample plots (Table 2). This species was sparsely dispersed in particular regions of both municipalities *Lantana camara* was present in 8.75% of the sample plots (Table 2). This species was found in one place near the Kalika temple (satellite population) in Baglung and six sites on the roadside in the Kushma municipality. *Xanthium strumarium* was present in 33.75% of the sample plots (Table 2). According to the distribution of this species, it was abundant in various locations of urban areas of both Kushma and Baglung municipalities. *Galinsoga quadriradiata* was present in 1.25% of the sample plots (Table 2). Regarding the distribution of this species, it was found in only one point in Baglung Bazaar of Baglung municipality but was absent in all other waypoints.

17.5% of the sample plots were with *Mimosa pudica* (Table 2). This species had been discovered in 10 waypoints in the Kushma municipality as opposed to merely 4 waypoints in the Baglung municipality. *Parthenium hysterophorus* was present in 2.5% of the sample plots (Table 2). It was found in two locations of Baglung Bazaar of Baglung municipality but was not recorded in any locations of Kushma municipality. Such species with the satellite population stage should be managed with the approach of EDRR (early detection and rapid response). *Amaranthus spinosus* was present in 2.5% of the sample plots (Table 2). According to its distribution, it was not found in any locales of Baglung municipality but found in two waypoints of Badagaun in Kushma municipality.

## DISCUSSION

The current study investigated the distribution patterns of IAPs in the municipalities of Kushma and Baglung, Nepal. Naturalized plant species as well as IAPs were found higher in land use types with high disturbance (Paudel et al., 2021). The road networks are contributing significantly as corridors for the dispersal of IAPs in the middle mountain areas of central

Nepal (Adhikari et al., 2024). IAPs extend into nearby land use types via roads, which act as an essential route for their movement. *Bidens pilosa* had the highest frequency (63%), among the eleven invasive plants in the study sites, which could be due to its high seed production capacity and effective seed dispersal by human and animal vectors (Budumajji & Aluri, 2018).

Eleven IAPs, or 40.74% of all IAPs reported in Nepal, were recorded in the Bagiung and Kushma municipalities. *Galinsoga quadriradiata* had the lowest frequency *Ageratum houstonianum* (61%) and *Lantana camara* (44%) in similar study at Pokhara, Nepal (Pathak et al., 2021). Among the 100 of the worst invasive species in the world, *Chromolaena odorata* and *Lantana camara* were two of the IAPs that had been documented from the study site whereas four of the IAPs that have been identified *Chromolaena odorata*, *Pontederia crassipes*, *Lantana camara*, and *Mikania micrantha* were among the 100 of the world's worst invasive species in Pokhara (Lowe et al., 2000). In study by Pathak et al. (2021) 20 IAPs were recorded in the Pokhara Valley, or 77% of all IAPs reported from Nepal. We found 11 IAPs with two globally important ones whereas twelve IAPs, including two of the most common species worldwide, *Lantana camara* and *Chromolaena odorata*, were detected in Bardiya National Park (Bhatta et al., 2020). In a study by Paudel (2015) 18 IAPs were reported along road network in central Nepal. *Bidens pilosa* and *Pontederia crassipes* were the two invasive alien plant species with the highest and lowest frequency, respectively, in roadside vegetation (Paudel, 2015). Among others the most prevalent IAPs with the highest cover was found to be *Chromolaena odorata*. In comparison to sites farthest from towns, sites close to settlements exhibited higher IAPs frequency and coverage (Chaudhary et al., 2020). In comparison to these investigations, Kushma and Balgung municipalities showed observable IAPs. These might be a result of Pokhara's proximity, an abundant city where a significant number (20) IAPs were noted. The number of IAPs has been steadily rising in Nepal (Shrestha et al., 2024), and a similar rise can be predicted for the Kushma and Baglung municipalities.

*Ageratum houstonianum*, the IAPs that occurs most frequently in the Kushma and Baglung municipalities, has been categorized as the most problematic IAPs in the central Nepali agroecosystem due to its harmful effects on cattle (Shrestha et al., 2019). *Ageratum conyzoides, Ageratum houstonianum* and *Galinsoga quadriradiata* were reported from farmlands and fallows having negative impacts over there (Shrestha & Shrestha, 2021). Similarly, *Parthenium hysterophorus, Amaranthus spinosus, Xanthium strumarium, Bidens Pilosa*, were urban dwellers and are found by road sites (Pandey et al., 2021). *Lantana camara* was found in various habitats such as forest sides, farm lands, fallows however, *Ageratina adenophora, Chromolaena odorata* are found in almost all terrestrial habitats (Shrestha et al., 2024).

## CONCLUSION

In Kushma and Baglung municipalities, invasive alien plant species (IAPs) are quickly spreading along transport routes. *Bidens pilosa* was the most prevalent species among the eleven species of IAPs identified, and it was followed by *Ageratum houstonianum*, *Ageratina adenophora*, *Xanthium strumarium*, *Chromolaena odorata*. This study highlighted the frequency and the spatial distribution of IAPs. Most of the species are herbs like *Ageratina adenophora, Ageratum conyzoides, Ageratum houstonianum, Amaranthus spinosus, Bidens pilosa, Galinsoga quadriradiata, Parthenium hysterophorus, Xanthium strumarium.* Some of them are shrubs such as *Lantana camara,*

*Chromolaena odorata*, etc. *Mimosa pudica* is a sub-shrub. By managing these IAPs, we can lessen their negative consequences and increase public awareness The information provided in this paper about the distribution of IAPs at the local level may be helpful in creating management plans for preventing biological invasions. To lessen their effects, the rapid spread and establishment of IAPs into new places and ecosystems should be quickly regulated.

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