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RESEARCH ARTICLE

Peoples' Perception on Invasive Alien Plant Species of Ramdhuni Municipality, Sunsari District, Eastern Nepal

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Highlights

- Nine invasive alien plant species (IAPs) were prevalent in Ramdhuni Municipality, Sunsari District, eastern Nepal.
- Knowledge on the identity of IAPs was poor in the rural areas.
- Including detrimental effects, IAPs also had some beneficial aspects for local community.

Abstract

The purpose of this study was to record existing information and perception of local people on invasive alien plant species IAPs in the rural areas of lowland, eastern Nepal (Ramdhuni Municipality, Sunsari District). A semi-structured questionnaire survey and interview were carried out to document whether the people were known or unknown to the IAPs followed by harmful or beneficial effects of IAPs and control measures to minimize the spread of IAPs. We found that only 6.25% of respondents knew about the IAPs and there was significant difference between the percentage of respondents who were known or unknown to IAPs. There was a significant positive correlation between the respondents' ages and the number of plants they described. Local people have been using IAPs for food, medicine, and fodder for a long time. However, some IAPs also have detrimental effects in forest and agriculture.

Keywords: *awareness programme, community perception, ecosystem services, management efforts*

Introduction

Invasive alien plant species (IAPs) are defined as the plants that enter a non-native area and trigger environmental, economic, and ecological harm [1]. Globally, the numbers of IAPs are found to be increasing irrespective of local ecosystems and landscapes [2]. Consequently, IAPs have exerted detrimental effects on native ecosystems e.g., loss of native biodiversity, ecological imbalance and habitat loss [3]. Convention on Biological Diversity also highlighted the detrimental effects of IAPs in multiple ways in native habitats of other species [4]. One of the largest contributors to the spread in IAPs is anthropogenic factors e.g., urbanization, tourism, trade, and transportation [5]. For instance, many invasive plants appear to spread most effectively in metropolitan and urban periphery settings where extensive histories of human disturbance have produced unoccupied niches and plenty of bare ground. [3]. Despite several interventions and strategies for the control of IAPs, they are vigorously spreading in native habitats. Hence, the issue of rapid increase in the invasiveness of IAPs is one of the biggest challenges to the modern world.

To date, 27 species of IAPs have been reported in Nepal [6]. These IAPs are invading native ecosystems of lowland and midhills areas of the country [7]. The most notorious IAPs of the lowlands are *Mikania micrantha, Chromolaena odorata,* while in the

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midhills *Ageratina adenophora, Lantana camara* are prevalent. These IAPs have created several negative impacts on local people who rely on forests and agricultural products for food, firewood, wood, medicinal plants and livestock foraging [8]. From an ecological point of view, it is obvious that the invasion of IAPs is destructive. However, some invasive plant species are also explored for their beneficial aspects. Many of the IAPs are very attractive and are used as ornamental plants as well as for other beneficial purposes. Hanley and Roberts [9] have reported many possible advantages could be available through invasive species management. Thus, the general perception of communities and people towards IAPs depends on the types of IAPs and the local context. Consequently, this study will explore the perception of people towards IAPs in the Ramdhuni municipality, eastern Nepal. Here, we aimed to find out the proportion of people who are aware of IAPs, their possible negative and positive impacts and management strategies.

Materials and Methods

Study Area

The study was carried out in four villages (Sivnagar, Dhamaura, Singiya, and Kumyahi) of the Ramdhuni Municipality, Sunsari district (87˚10' E and 26˚42' N) (Figure 1). It is situated at an altitude ranging from 85 m – 185 m above sea level. The average annual rainfall and temperature is 1954 mm and 24°C respectively (average data between 2000 and 2019 AD) (Department of Hydrology and Meteorology, Kathmandu). Mostly the Tharu people (20,250 individuals) have inhabited the Municipality [10]. The population of Tharu has been followed by Chhetri (6,671 individuals), Brahmin (5,875 individuals), Musahar (2,385 individuals) and Rai (1,674 individuals) [10].

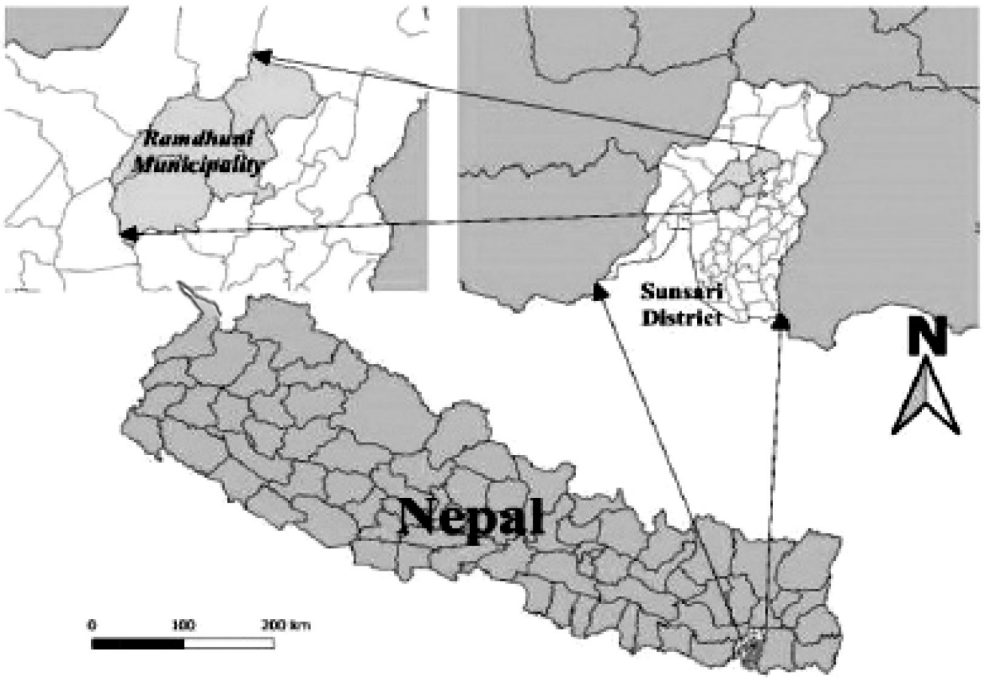

Fig 1. Map of the study area showing the Ramdhuni municipality, Sunsari District, Nepal.

Data Collection

The data was collected in July 2020 and August 2021. A total of 64 respondents were interviewed. Prior to this, field observation was also carried out to find out the richness of invasive species in the study areas. A random sampling method was used for the interview of the respondents (farmers, housewives, students, job holders and businessmen). Demographic information of the respondents was also recorded. The methodology of the present research followed the procedure of Shrestha *et al.* [11]. The photographs of all IAPs species recorded in Nepal were shown to the respondent and their responses were recorded. A semi-structured questionnaire was used to collect the information on the names of IAPs with their details such as, whether they were known or unknown to the term IAPs, harmful or beneficial effects, and management activities to control spread of corresponding IAPs, if any. The respondents were interviewed in their own local language. Mostly "Tharu" language was used in questionnaire survey. The Nepali term "Bahiya Michaha Banaspati" and its translation in Tharu language were used in place of "Invasive Alien Plant Species" with the respondents for their convenience. Respondents were also encouraged to give their response in their own

language. Respondents were classified as "Respondents known to IAPs" only if they knew about the meaning of invasiveness, its' definition, and basics or concept of IAPs. If not, they were kept under the category called "Respondent unknown to IAPs". All of the respondents provided verbal approval for the research paper's future publication. The International Society of Ethnobiology's code of ethics, principles, and directives were adhered to in the current study [12].

Data Analysis

Most of the data obtained in the study was descriptive. All descriptive analysis was performed in MS Excel 2007. A Chi-square test was performed to observe the significant difference between the knowledge of the respondents, who were known or unknown to IAPs and also to analyze the significant difference between the positive and negative impacts reported by the respondents. A simple linear regression and a Pearson correlation test were used to study the relationship between the age group and the IAPs described by them. R version 4.0.3 was used to conduct all statistical analyses (R Core Team 2019).

Results and Discussion

Demographic Information

Altogether, 64 respondents were interviewed in the present study, which comprises 53% of men and 47% of women (Table 1). Based on age group, 46% of the respondents were over 50 years old, 40% between 30 and 50 years old and 12% below 30 years old. The higher percentage of respondents were farmers than others and more than half of the respondents were literate (Table 1).

Table 1. Demographic information of respondent

Categories	Demographic variables	Percentage
Gender	Male	53.1%
	Female	46.8%
Age group	Below 30	12.5%
	30-50	40.6%
	Above 50	46.8%
Occupation	Farmer	43.7%
	Housewife	28.1%
	Job	9.3%
	Business	9.3%
	Student	9.6%
Education	Literate	59.3%
	Illiterate	40.6%

Richness of IAPs and Proportion of Respondents who have Information About Identity of IAPs

Nine different IAPs were reported from the study area under six families (Table 2). Among six families, IAPs belonging to Asteraceae was high (3 species).

Table 2. List of the IAPs included in the present study.

Scientific Name	Family	Tharu Name	Nepali name
Ipomoea carnea Jacq.	Convolvulaceae	"Karmi"	Besaram
Lantana camara L.	Verbenaceae	"Ganki"	Kirne kanda
Mikania micrantha Kunth.	Asteraceae	"Lati"	Lahare banmara
Parthenium hysterophorus L.	Asteraceae	"Mokra"	Pati jhar
Ageratum conyzoides L.	Asteraceae	"Bokra"	Gandhe
Amaranthus spinosus L.	Amaranthaceae	"Genhari"	Kande lunde
Argemone mexicana L.	Papaveraceae	"Suruj kant"	Thakal
Senna occidentalis (L.) Link	Fabaceae	"Jhunjhuni jhar"	Panwar
Mimosa pudica L.	Fabaceae	"Lajauni"	Lajjawati

Only 6.25% of the respondents were recorded under the category called "Respondents known to IAPs". The percentage of the respondents who were unknown to IAPs was significantly higher than the respondents with information ($\chi^2 = 94.53$, p-value <

0.001, Figure 2). The age of the respondents had a significant positive correlation with the number of plants described by them ($r = 0.686$, p-value < 0.001, Figure 3). The description of the plants included negative impacts and positive use of IAPs. This could be due to the dependency of old people on plant species for their primary needs and primary health care since a time immemorial. Modernization, allopathic medicines, and fast access to various daily materials from the market might be the possible reasons for adult and younger generations to be less fascinated by plants and their use. The present result was also supported by the previous studies [13,14,15].

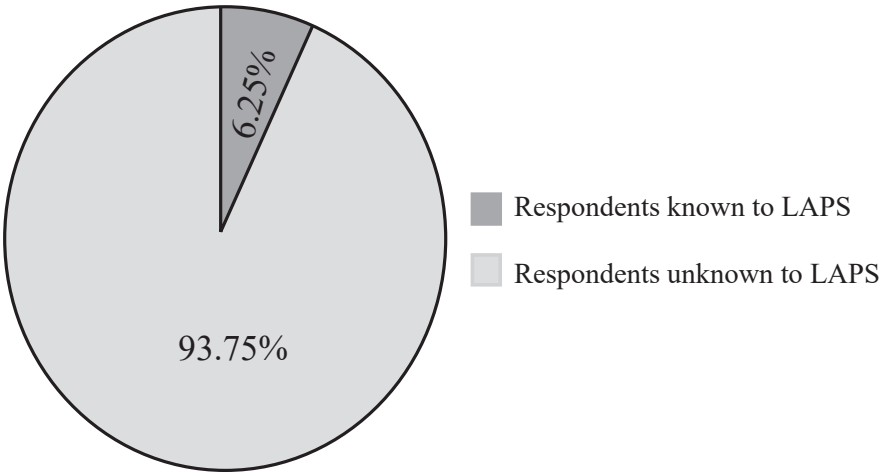

Fig 2. Number of respondents who are known or unknown to IAPs

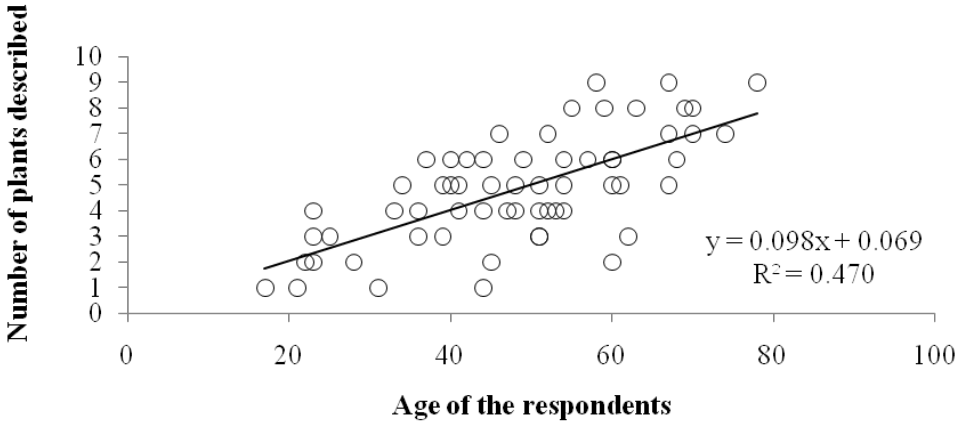

Fig 3. A simple linear regression between the age of the respondents and number of plants described

Based on individual IAPs, a higher percentage of respondents noticed the invasion of *P. hysterophorus* (28.12%) (Figure 4)*, followed by L. camara* (21.87%)*, A. spinosus* (18.75%)*, M. micrantha* (15.62%), and *A. conyzoides* (12.5%) (Table 3). In the study area, *P. hysterophorus* and *L. camara* were highly invaded in roadside and around the river banks, *A. spinosus* and *A. conyzoides* in agricultural field and *M. micrantha* was invaded in forest area. Tiwari *et al.* [16] have also reported that *P. hysterophorus*, *A. conyzoides,* and *M. micrantha* were frequently occurring species in the Sunsari district and supported our study. Their extensive fruit production, quick vegetative expansion, and effective seed dissemination are the causes of their invasion [17]. It has been reported that the invasion of *P. hysterophorus* is not recent but was already present in the study areas since 7-8 years ago [18,19], which was also mentioned by six respondents from Sivnagar. *M. micrantha* was found vigorously invading in forest areas and in some crop fields.

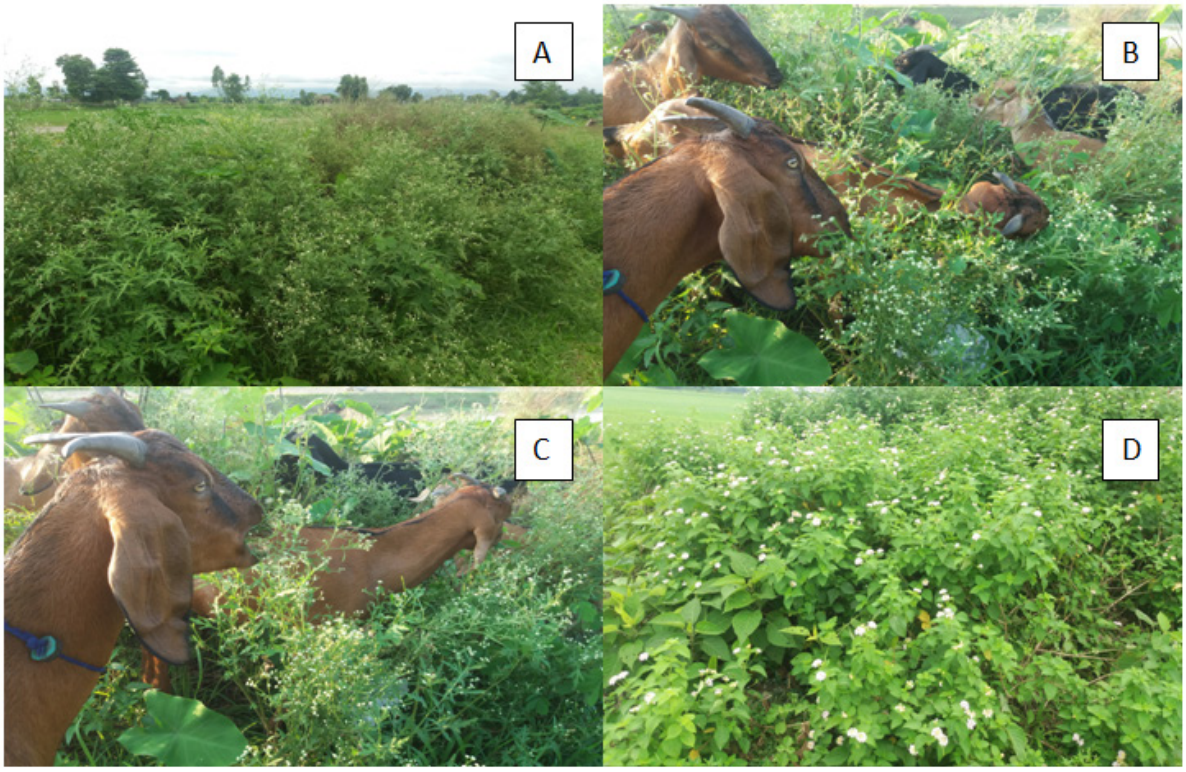

Fig 4. (A) P*arthenium hysterophorus* (B, C) Livestock grazing in the *Parthenium hysterophorus* (D) *Lantana camara*

Table 3. Availability of the IAPs in the study areas reported by the respondents

Availability/Occurrence	Name of species	Respondents (Number, %)
Frequently occurred species	*Parthenium hysterophorus*	18, 28.1%
	Lantana camara	14, 21.8%
	Amaranthus spinosus	12, 18.7%
	Mikania micrantha	10, 15.6%
	Ageratum conyzoides	8, 12.5%
	Mimosa pudica	2, 3.1%
Less observed species (since 10-15 years)	Argemone Mexicana	28, 43.7%
	Senna occidentalis	14, 21.8%
	Ipomoea carnea	12, 18.7%

Locals have also reported that the occurrence of some of the IAPs was declining. For instance, 43.75% of the respondents mentioned that the occurrence of *A. Mexicana* has declined in the last 15 years, followed by *S. occidentalis* (21.87%) and *I. carnea* (18.75%) (Table 3).

Ranges of Impact from IAPs

Both positive and negative impacts of IAPs from the present investigation were recorded (Table 4). In total, 93.7% and 35.9% of the respondents reported the positive and negative impacts of IAPs, respectively. The number of respondents who reported positive impacts is significantly higher than the negative impacts ($\chi^2 = 44.41$, p-value < 0.001). The percentage of respondents who reported the positive impacts ranged from 3.12 to 93.7% and negative impacts from 6.2 to 28.1%, respectively. Interestingly, the percentage of respondents reporting positive impacts of IAPs was high. This could be because the direct negative effect of IAPs is less pronounced in daily life of local people [8], but positive impacts are seen directly as they use it directly as forage, medicine, food, etc. (Table 4 and 5).

Table 4. Positive and Negativ Impact of IAPs based on respondents perception

Impacts of IAPs	Impact category of IAPs	Name of species	Respondent (count, %)
Positive impact	Medicine	*Ageratum conyzoides*	32, 50%
		Amaranthus spinosus	24, 37.5%
		Mimosa pudica	12, 18.7%
	Food	*Argemone Mexicana*	4, 6.2%
		Amaranthus spinosus	60, 93.7%
		Ipomoea carnea	22, 34.4%
		Mimosa pudica	38, 59.3%
	Forage for livestock	*Ageratum conyzoids*	22, 34.4%
		Mikania micrantha	18, 28.1%
		Ipomoea carnea	14, 21.8%
		Parthenium hysterophorus	4, 6.2%
	Insect repellant	*Lantana camara*	2, 3.12%
Negative impact	Harmful to livestock	Ipomoea carnea	6, 9.3%
		Lantana camara	4, 6.2%
		Parthenium hysterophorus	8, 12.5%
	Problem with the collection of aquatic products	*Ipomoea carnea*	16, 25%
		Mikania micrantha	8, 12.5%
	Problem while collecting forest products	*Lantana camara*	4, 6.2%
		Mimosa pudica	8, 12.5%
	Disturbance in the agriculture	*Argemone Mexicana*	18, 28.1%

Table 5. Medicinal uses of four invasive alien plant species in different diseases reported by the respondents

Plant species	Ailments used	References
Ageratum conyzoides	Paste or juice of the plants was used in cuts and wounds to check bleeding.	[11,20]
Amaranthus spinosus	Young shoots were used to treat menstrual disorder, continuous bleeding, and flatulence.	[21]
Mimosa pudica	Decoction of roots and leaves were used in piles, diarrhea and stomach pain.	[21,22]
Argemone Mexicana	Paste of stems or seeds was used to treat skin infections and rashes	[22]

Positive Impacts

Four species have been used for a medicine, two species for food, five species as fodder for livestock, and one species as a insect repellant (Table 4 and 5). 50% respondents reported the use of *A. conyzoides* for cuts, wounds, and to check bleeding. The use of *A. conyzoides* in cuts and wounds has also been reported by the previous studies [11,14,20,23]. Furthermore, 6% of respondents

had been using *A. Mexicana* in the study to treat skin diseases. Only 3% of respondents reported the use of *L. camara* as an insect repellant. 93% of the respondents have reported the use of *A. spinosus* for vegetable purposes and it was highly recommended to use as a cooked vegetable. Moreover, the leaves of *I. carnea* were also cooked and used as vegetables. The use of *A. spinosus* as food has been reported by the previous studies [24-26]. On the other hand, 14% of respondents reported using *A. spinosus* to treat menstrual disorders and internal bleeding. The rest of the respondents reported the use of *A. spinosus* to treat flatulence. 36% of the respondents mentioned *I. carnea* for food purposes. However, the same people, including other respondents, have also reported the problem of joint pain after consuming it. In total, 59% and 34% of the respondents claimed the use of *M. pudica* and *A. conyzoides* as fodder respectively. Shrestha *et al.* [11] have also reported the use of *M. pudica* and *A. conyzoides* as fodder for livestock. Some respondents (28.1%) have mentioned the use of *M. micrantha* for fodder purposes, which was supported by Tiwari *et al*. [16]. 28% of respondents have reported the use of *P. hysterophorus* and *I. carnea* as forage for livestock, while others do not. Locals grazing their livestock on the banks of a river full of *P. hysterophorus* are highlighted in figs. 3B and 3C.

Negative Impacts

The respondents have suffered from various problems on agriculture and forest due to IAPs (Table 4). The present study has reported the use of *P. hysterophorus* as fodder by the livestock. However, livestock were found to graze on *P. hysterophorus* only at the time when there was a scarcity of food and forage for livestock. This may had resulted in the poisoning the livestock as 21.8% of respondents had claimed for it. Shrestha *et al.* [11] have reported the poisonous nature of *I. carnea* and *P. hysterophorus* to livestock. Shrestha et al. [2] have reported the same condition regarding *A. haustonianum.* They claim that although animals do not favor the weed as pasture, when let loose in the evening, hungry oxen will run amok and graze on *A. houstonianum* growing on the bund of cropland, which can lead to diarrhoea, various stomach problems, and even animal mortality. Furthermore, the negative impact of *M. micrantha* on society has also been described by Rai and Scarborough [27]. *Due to its thorny morphological structures, A. Mexicana* was found to cause a great disturbance in the agricultural fields of local people.

Management Intervention for the Control of IAPs

Interestingly, locals implemented four different methods for IAPs management (Table 6). Approximately half of the respondents (43.7%) reported that they are using these methods to control IAPs. The "hit-stick" was one of the methods that some locals used to control some IAPs. In this method, a thick stick is taken and struck against those plants until they are destroyed properly. However, the roots were not destroyed completely by this method. The *P. hysterophorous, L. camara,* and *M. micrantha* were reported to be controlled by the "Hit Stick" method. *Hashairi* was one of the common efforts or practice made by locals where farmers remove all the unwanted plant species and waste materials around their agricultural fields and irrigation canals. In the villages, it was mandatory for one member of the family to participate in *Hashairi*; failure to do so resulted in a Rs. 500 fine. In this practice, all the participants should clean the unwanted plants, weeds and wastes from near or around the water sources like irrigation canals, field channels, watercourses, sub irrigation canals, and bank of the canals. Although practice of *Hashairi* was not solely focused on the management of IAPs, it unknowingly contributed to the management of IAPs. *Hashairi* included management activities like manual uprooting and hit stick, that were applied for all IAPs in the study (Table 6). This practice helped to reduce invasion on agricultural and adjoining areas.

Table 6. Management efforts for control of IAPs

Efforts	Name of species	Respondent (Number, %)
Manual uprooting	*Argemone mexicana*	14, 21.8%
	Lantana camara	10, 15.6%
Herbicides	*Mimosa pudica*	6, 9.3%
Stick hit	*Parthenium hysterophorus*	8, 12.5%
	Lantana camara	6, 9.3%
	Mikania micrantha	8, 12.5%
Hashairi (Local)	All IAPs	64, 100%

According to 37% respondents, manual uprooting of *A. mexicana* and *L. camara* is being carried out in the Ramdhuni municipality.

Around 9% of the respondents are using herbicides against *M. pudica.* Manual uprooting is also commonly practiced in other parts of Nepal [2,8]. However, to date, none of the locals and governmental and non-governmental organizations has implemented any specific effort to control and manage these IAPs because they were unaware of their negative effects [2].

Conclusions

The present study has revealed a very little knowledge of IAPs among the locals of the Ramdhuni municipality. They were unable to differentiate native plants and IAPs. However, they have been experiencing both positive and negative impacts. Local people were mostly appreciating the services provided by IAPs compared to harmful effects. Formal and planned management activities for the spread of IAPs is lacking that can be related with the positive impacts experienced locals in their day-to-day life. Consequently, this study highlighted the need of extensive awareness program in rural areas of eastern Nepal that should focus on the identity of IAPs with knowledge regarding detrimental effects of IAPs on native habitat and ecosystem services and control measures to limit the spread of IAPs.

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