An Ecological Assessment of Invasive Alien Plant Species in Jokhar Lake Area of Kailali District, Nepal

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Article History : Received Date : 2079/04/15; Accepted Date : 2079/08/10

Abstract

Invasive alien plant species (IAPS) have been creating adverse impacts on native diversity. Diversity of Nepal's wetland ecosystems are also threatened by several IAPS but the related studies are very scarce. This study has assessed the status of IAPS found in Jokhar Lake of Kailali district, Nepal. The IAPS survey was carried out by sampling 30 plots of $(1\times1)m^2$ each in and around the lake area. A total of 17 species of IAPS were reported from the study site. Most of the IAPS were the members of the family Asteraceae. The diversity of IAPS in the lake represents about 65% of the total IAPS in Nepal. Around the lake periphery, *Ageratum houstonianum* and *Argemone mexicana* and inside the lake *Eichornia crassipes* and *Pistia stratiotes* were major IAPS. The natural beauty of the lake has been ruined by these IAPS. A detailed study on the impacts and ecology of these IAPS in the lake and lake periphery is still lacking. Hence, it is recommended that the IAPS in the lake area should be controlled to conserve the native diversity and the natural beauty of the lake.

Keywords: Jokhar Lake, alien plants, invasion, native diversity, conservation

Introduction

Some of the plant species native to one area or region after introduction into the novel area outside their normal distribution might become problematic for native diversity, ecosystem functioning, and for the livelihood of community people. Such species are termed as the invasive alien plant species (CBD 2009). Generally, the species which show such characteristics display strong vegetative growth, grow in even adverse soil and climatic conditions, and can produce a large number of minute or long-lived seeds (Lee et al. 2018; Mathakutha et al. 2019). They also have a high seed germination rate, rapid maturation of a sexually reproductive stage, and high ability to establish over large areas (Forman and Kesseli 2003; Whitney et al. 2008).

The IAPS may be herbs, shrubs, trees, and vines that can grow rapidly, form dense thickets, and negatively impact native species and natural communities (Walker and Smith 1997; Zenni and Ziller 2011; Barney et al. 2015). Anthropogenic disturbances, increasing human movement, global trade, and climate change have increased the intensity of biological invasion worldwide (Lin et al. 2007; Masters and Norgrove 2010; Beauséjour et al. 2015).

A wide variation of climate and geography of Nepal has favored the introduction of several alien plant species in the country. There are 26 alien plant species categorized as invasive members in Nepal (Shrestha et al. 2016). Among these, *Lantana camara*, *Mikania micrantha*, *Chromolaena odorata,* and *Eichhornia crassipes* are among the 100 of the world's worst invasive alien species (Lowe et al. 2000). They have been widely distributed throughout the country. Mainly the degraded lands, roadsides, forest margins, and other degraded habitats are the main target of invasion where the IAPS has been creating adverse impacts on native diversity (Tiwari et al. 2005; Shrestha 2016; Thapa et al. 2015, 2016a, 2016b, 2017). Besides, Nepal is also rich in wetlands and wetland diversity but alien plant invasion in such ecosystems has also threatened several native flora and fauna (Shrestha et al. 2020; Thapa et al. 2020a, 2020b). In this situation, activities regarding the regular monitoring of IAPS, assessing their impacts on native diversity, and control or management of IAPS is an urgent need. The main of the study is to assess some of the basic ecological parameters of IAPS found in Jokhar Lake of Kailali district.

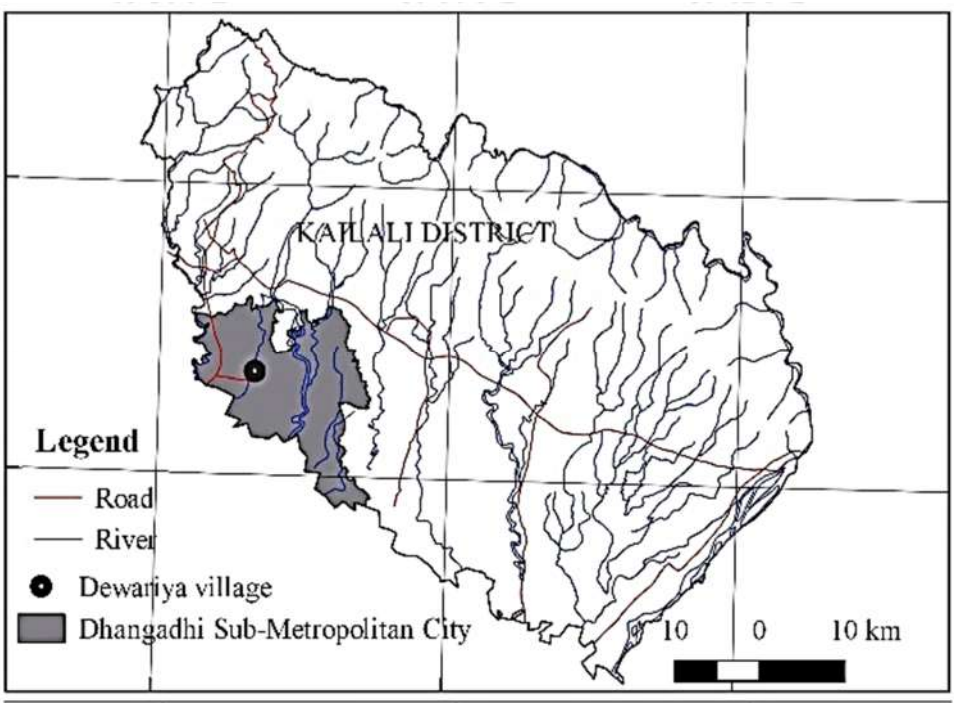
ISSN 2661-6114

Material and Methods

Study site

This study was carried out in Jokhar Lake area (28°42'24.23" N and 80°37'21.02"E) near the Dewariya village located in Dhangadhi Sub-Metropolitan City – 7 (Fig. 1). The lake is a famous wetland of Sudurpaschim Province, Nepal which is situated about 5km far from the main city Dhangadhi. The lake area covers about 120 ha. It also has religious significance in the Tharu community. The vegetation around the Jokhar Tal is dominated by mainly Sal tree (*Shorea robusta*), *Bombax ceiba, Acacia catechu, Terminalia alata, Syzygium cumini, and Dalbergia sissoo.* The climatic of the study site is hot in the summer season (above 38°C) and cold in winter (7.5°C). The rainfall is maximum in July (693.4mm) and minimum in November (2.5mm). The relative humidity remains fairly throughout the year except in dry months. The lake was severely colonized by aquatic invasive *Eichhornia crassipes.* The surrounding of the lake was also invaded by a number of IAPS.

Fig. 2. Map of study site showing Dewariya village and Dhangadhi Sub-Metropolitan City in Kailali District



Survey on IAPS

The IAPS survey was carried out during September-October 2018. The IAPS richness, density, frequency, and abundance were measured around the lake by sampling plots of size 1×1 m^2 (as most of the species were herbaceous). A total of 30 quadrats were sampled along the margin of the lake and among them alternately 15 were sampled in water and 15 were out of the water (Fig. 2). In these quadrats the IAPS encountered were recorded. Their density, frequency, abundance, and IVI were calculated. Voucher specimens were collected, identified and herbaria have been deposited at Department of Botany, Kailali Multiple Campus, Dhangadhi, Kailali. Copies of voucher specimens are preserved at Tribhuvan University Central Herbarium (TUCH), Kirtipur, Kathmandu, Nepal.

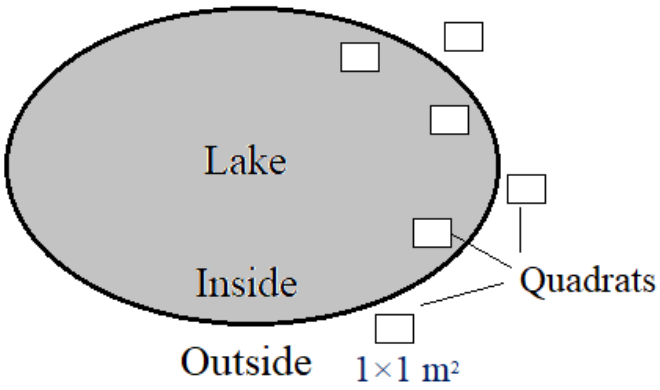


Fig. 2 Arrangement of quadrats in the study site

The density, relative density, frequency, relative frequency, abundance, relative abundance, and important value index (IVI) of the IAPS were calculated using the following formulae:

$$\text{Density} = \frac{\textit{Total number of individuals of a species in all quadrats}}{\textit{Total number of quadrats studied}}$$

$$\text{Relative Density} = \frac{\textit{Number of individuals of one species}}{\textit{Total number of all individuals counted}} \; X\ 100$$

$$\text{Frequency} = \frac{\textit{Number of quadrats in which the species occures}}{\textit{Total number of quadrats sampled}}$$

$$\text{Relative Frequency} = \frac{\textit{Frequency of one species}}{\textit{Total frequency of all species}} \; X\ 100$$

$$\text{Abundance} = \frac{\textit{Total Number of individuals of a species in all quadrats}}{\textit{Total number of quadrats in which the species occured}}$$

$$\text{Relative Abundance} = \frac{\textit{The abundance of one species}}{\textit{Total all species counted}} \; X\ 100$$

Importance Value Index (IVI) = Relative Frequency + Relative Density + Relative Abundance

Results

IAPS in the Jokhar Lake area

The study reported a total of 17 species in and around the Jokhar Lake area (**Table 1**). Most of the species (6 species) were the members of the family Asteraceae. They were *Ageratum houstonianum, A. conyzoides, Bidens pilosa, Xanthium stramonium, Parthenium hysterophorus*, and *A. adenophora.* Two species *Alternanthera philoxeroides* and *Amaranthus spinosus* were the members of the family Amaranthaceae. The rest of the species represented a single-family. They were *Pistia stratiotes* (Araceae), *Senna tora* (Fabaceae), *Ipomoea carnea* (Convolvulaceae), *Hyptis suaveolens* (Lamiaceae), *Mimosa pudica* (Mimosaceae), *Oxalis latifolia* (Oxalidaceae), *Argemone mexicana* (Papaveracea), *Eichhornia crassipes* (Pontederiaceae), and *Lantana camara* (Verbenaceae). Among them, *E. crassipes* (Pontederiaceae) and *P. stratiotes* (Araceae) were aquatic species found in the water body.

ISSN 2661-6114

Table 1. List of IAPS found in Jokhar Lake, Kailali

SN	Family	No of species	Name of species
1	Asteraceae	6	*Ageratum houstonianum , A. conyzoides, Bidens pilosa, Xanthium strumarium, Parthenium hysterophorus*, and *A. adenophora*
2	Amranthaceae	2	*Alternanthera philoxeroides* and *Amaranthus spinosus*
3	Araceae	1	*Pistia stratiotes*
4	Fabaceae	1	*Senna tora*
5	Convolvulaceae	1	*Ipomoea carnea*
6	Lamiaceae	1	*Hyptis suaveolens*
7	Mimosaceae	1	*Mimosa pudica*
8	Oxalidaceae	1	*Oxalis latifolia*
9	Papaveracea	1	*Argemone mexicana*
10	Pontederiaceae	1	*Eichhornia crassipes*
11	Verbenaceae	1	*Lantana camara*
Total species		**17**	

Density, Frequency, Abundance, and IVI of IAPS

Among the 17 IAPS reported from Jokhar Lake, the most dominant two species were *A. houstonianum* and *A. mexicana.* Relative density (RD), relative frequency (RF), and relative abundance (RA) of *A. houstonianum* were 45.30, 14.14, and 1.74, respectively followed by *A. mexicana* (RD = 16.05, RF = 9.24 and RA = 0.94). The highest IVI was calculated in *A. houstonianum* i.e. 61.18 followed by 26.23 in *A. mexicana. Ageratina adenophora* has the lowest RD (0.35) and IVI (2.10). The lowest frequency was found in *Pistia stratiotes* (1.63) and *A. adenophora* (1.63). RD, RF, RA, and IVI of all the 17 species have been given in **Table 2**.

Table 2. Ecological parameters of IAPS in Jokhar Lake, Kailali

SN	Scientific Name	Relative Density (RD)	Relative frequency (RF)	Relative abundance (RA)	Important value index (IVI)
1	*Ageratum houstonianum*	45.30	14.14	1.74	61.18
2	*Argemone Mexicana*	16.05	9.24	0.94	26.23
3	*Lantana camara*	4.79	3.26	0.80	8.85
4	*Alternathera philoxeroides*	4.70	5.98	0.43	11.11
5	*Senna tora*	4.43	4.89	0.49	9.82
6	*Oxalis latifolia*	3.46	8.16	0.23	11.84
7	*Bidens pilosa*	2.30	8.16	0.15	10.62

SN	Scientific Name	Relative Density (RD)	Relative frequency (RF)	Relative abundance (RA)	Important value index (IVI)
8	*Xanthium strumarium*	2.75	8.16	0.18	11.09
9	*Eichhornia crassipes*	3.46	4.89	0.38	8.74
10	*Ipomoea carnea*	3.72	6.53	0.31	10.56
11	*Parthenium hysterophorus*	2.04	2.72	0.41	5.17
12	*Ageratum conyzoides*	2.22	5.98	0.20	8.40
13	*Hyptis suaveolens*	0.53	8.16	0.04	8.72
14	*Pistia stratiotes*	1.68	1.63	0.56	3.88
15	*Amaranthus spinosus*	1.68	3.26	0.28	5.23
16	*Mimosa pudica*	0.53	3.26	0.09	3.88
17	*Ageratina adenophora*	0.35	1.63	0.12	2.10

Discussion

Jokhar Lake is one of the important wetlands of Far Western Province, Nepal situated in Dhangadhi Sub-Metropolitan City –7, Kailali. It is categorized as a freshwater/natural; lacustrine and permanent wetland (DoF 2017). The lake is the habitat of several plants and animals. Major aquatic plants found in the lake include *Ludwigia adscendens, Utricularia Australia, Oryza rufipogon, Sphagnum nepalensis* and the major plant species found around the lake are *Shorea robusta, Syzygium cumini, Adina cordifolia, Acacia catechu, Dalbergia sisoo, Ctenopharyngodon idella,* etc. (DoF 2017). The lake has also a religious significance among the Tharu community. It is also one of the visiting destinations of tourists and provides spots for picnic. Therefore, invasion of alien plant species in and around the lake has been taken place but regular monitoring of IAPS and ecological assessments on them was lacking.

This study has documented a total of 17 IAPS in and around the Jokhar Lake area (Table 1). Six species were the members of family Asteraceae (*Ageratum houstonianum, A. conyzoides, Bidens pilosa, Xanthium strumarium, Parthenium hysterophorus*, and *A. adenophora*), two species (*Alternanthera philoxeroides* and *Amaranthus spinosus*) were Amaranthaceae. The families Araceae, Fabaceae, Convolvulaceae, Lamiaceae, Mimosaceae, Oxalidaceae, Papaveraceae, Pontederiaceae, and Verbenaceae had single members each (Table 1). In Nepal, 26 species were categorized as the problematic IAPS (Shrestha 2016). The number of IAPS in the Jokhar Lake area represents about 65% of total IAPS in Nepal.

Around the lake periphery, *A. houstonianum* and *Argemone mexicana* had high relative density (RD) and relative frequency (RF). The IVI of *A. houstonianum* was also the highest among all IAPS (**Table 2)**. Two aquatic IAPS in the lake were *E. crassipes* and *P. stratiotes.* These two species were highly problematic in the lake as they have covered major parts of the lakes (personal observation). *E. crassipes* is included in the list of the world's 100 worst IAPS (Lowe et al. 2000).

All the members of IAPS reported form the lake has several ecological impacts. For example, *A. houstonianum, A. conyzoids, B. pilosa, P. hysterophorus, A. adenophora* replace native plants and alter soil quality (Kohli et al. 2006; Cui and He 2009; Timilsina et al. 2011; Thapa et al. 2017; Shrestha et al. 2018). Another worst aquatic *E. crassipes* and *P. stratiotes* are also known to cause significant ecological and socio-economic effects. They can

ISSN 2661-6114

affect negatively the phytoplanktons, zooplanktons, macroinvertebrates, fishes, birds, etc. (Villamagna and Murphy 2010). Both the species can rapidly form dense mats on the water surface which have serious negative effects on the multifunctional human use of water bodies (Cabi 2019). Both the species also have the ability to change physiochemical and biological characteristics of water bodies (Cabi 2019).

Invasion of IAPS around and inside the lake might have created severe environmental problems such as several native species might have replaced, seedling recruitment of native species might have affected negatively, soil and water quality of the lake, as well as the aquatic flora and fauna, might have changed. Overall, the natural beauty of the lake has been destroying by these IAPS. A detailed study on the impacts of IAPS in the lake and lake periphery is still lacking. Hence, it is recommended that the IAPS in the lake area should be controlled to conserve the natural beauty of the lake.

Conclusion

In conclusion, a total of 17 species of IAPS have invaded in and around the Jokhar Lake of Kailali district, Nepal. Most of the IAPS were the members of the family Asteraceae. The diversity of IAPS in the lake represents about 65% of the total IAPS in Nepal. Around the lake periphery, *A. houstonianum* and *Argemone mexicana* and inside the lake *Eichornia crassipes* and *Pistia stratiotes* were major IAPS. The natural beauty of the lake has been corrupted by these IAPS. A detailed study on the impacts of these IAPS in the lake and lake periphery is still lacking. Hence, it is recommended that the IAPS in the lake area should be controlled to conserve the native biodiversity and the natural beauty of the lake.

Acknowledgement

The authors would like to highly acknowledge the University Grants Commission, Bhaktapur, Nepal. (UGC Nepal) as the study was a part of research funded by UGC. We are thankful to Prof. Emeritus Dr. Pramod Kumar Jha, Prof. Dr. Ram Kailash Prasad Yadav (Head of the Department, Central Department of Botany, Tribhuvan University, Nepal) and Prof. Dr. Padam Raj Joshi (Dean of Far-Western University, Mahendranagar, Kanchanpur, Nepal) for their valuable support to carry out this study.

References

Barney, J. N., Tekiela, D. R., Barrios-Garcia, M. N., (2015). Global Invader Impact Network (GIIN): toward standardized evaluation of the ecological impacts of invasive plants. *Ecology and evolution*, *5*(14), 2878-2889.

Beauséjour, R., Handa, I. T., Lechowicz, M. J., Gilbert, B., & Vellend, M. (2015). Historical anthropogenic disturbances influence patterns of non-native earthworm and plant invasions in a temperate primary forest. *Biological Invasions*, *17*(4), 1267-1281.

Cabi (2019). Invasive Species Compendium (https://www.cabi.org/isc/)

CBD - Convention of Biological Diversity (2009). *What are Invasive Alien Species?* Available at https://www.cbd.int/idb/2009/about/what/ (Assessed on 29 September, 2020)

Cui, Q. G., & He, W. M. (2009). Soil biota, but not soil nutrients, facilitate the invasion of Bidens pilosa relative to a native species Saussurea deltoidea. *Weed Research*, *49*(2), 201-206.

DoF (2017). Wetlands of Western Nepal: A brief profile of Selected Lakes, Department of Forests, Babarmahal, Kathmandu, Nepal

Forman, J., & Kesseli, R. V. (2003). Sexual reproduction in the invasive species Fallopia japonica (Polygonaceae). *American Journal of Botany*, *90*(4), 586-592.

Kohli, R. K., Batish, D. R., Singh, H. P., & Dogra, K. S. (2006). Status, invasiveness and environmental threats of three tropical American invasive weeds (*Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Lantana camara* L.) in India. *Biological Invasions*, *8*(7), 1501-1510.

Lee, J. W., Kim, S. J., An, J. B., Nam, K. B., Shin, H. T., & Jung, S. Y. (2019). Distribution characteristics of invasive alien plants in Jejudo. *Journal of Asia-Pacific Biodiversity*, *11*(2), 276-283.

Lin, W., Zhou, G., Cheng, X., & Xu, R. (2007). Fast economic development accelerates biological invasions in China. *PLoS One*, *2*(11), e1208.

Lowe, S., Browne, M., Boudjelas, S., & De Poorter, M. (2000). *100 of the world's worst invasive alien species: a selection from the global invasive species database* (Vol. 12). Auckland: Invasive Species Specialist Group.

Masters, G., & Norgrove, L. (2010). Climate change and invasive alien species. *UK: CABI Working Paper*, *1*.

Mathakutha, R., Steyn, C., le Roux, P. C., Blom, I. J., Chown, S. L., Daru, B. H., Ripley, B.S., Louw, A., & Greve, M., (2019). Invasive species differ in key functional traits from native and non-invasive alien plant species. *Journal of Vegetation Science*, *30*(5), 994-1006.

Shrestha, B.B. (2016) Invasive alien plant species in Nepal. In: Jha, P.K., Siwakoti, M., & Rajbhandary, S. (Eds.) *Frontiers in Botany*. Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, pp 269–284

Shrestha, B., Shrestha, S., Shrestha, A., & Khadka, U. R. (2020). Ramsar sites in Nepal: Conservation, present scenario, biodiversity value and threats. *Journal of Wetlands Ecology*, *2020*, 24782 (https://doi.org/10.3126/jowe.v2020i0.24782)

Shrestha, U. B., Sharma, K. P., Devkota, A., Siwakoti, M., & Shrestha, B. B. (2018). Potential impact of climate change on the distribution of six invasive alien plants in Nepal. *Ecological Indicators*, *95*, 99-107.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A., & Sridith, K. (2016). Impacts of invasive *Chromolaena odorata* on species richness, composition and seedling recruitment of *Shorea robusta* in a tropical Sal forest, Nepal. *Songklanakarin Journal of Science & Technology*, 38, 683–689

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A. T., & Sridith, K. (2016). Plant communities and *Ageratina adenophora* invasion in lower montane vegetation, central Nepal. *International Journal of Ecology and Development*, *31*(2), 35-49.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A., & Sridith, K. (2020). "Soaked in rainwater" effect of *Ageratina adenophora* on seedling growth and development of native tree species in Nepal. *Flora*, *263*, 151554.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A., & Sridith, K. (2020). Airborne and belowground phytotoxicity of invasive *Ageratina adenophora* on native species in Nepal. *Plant Ecology*, *221*(10), 883-892.

Thapa, L. B., Kaewchumnong, K., Sinkkonen, A., & Sridith, K. (2017). Plant invasiveness and target plant density: high densities of native *Schima wallichii* seedlings reduce negative effects of invasive *Ageratina adenophora*. *Weed Research*, *57*(2), 72-80.

Thapa, L. B., Thapa, H., & Magar, B. G. (2015). Perception, trends and impacts of climate change in Kailali District, Far West Nepal. *International Journal of Environment*, *4*(4), 62-76.

Timilsina, B., Shrestha, B. B., Rokaya, M. B., & Münzbergová, Z. (2011). Impact of Parthenium hysterophorus L. invasion on plant species composition and soil properties of grassland communities in Nepal. *Flora-Morphology, Distribution, Functional Ecology of Plants*, *206*(3), 233-240.

ISSN 2661-6114

Villamagna, A. M., & Murphy, B. R. (2010). Ecological and socio-economic impacts of invasive water hyacinth (Eichhornia crassipes): a review. *Freshwater biology*, *55*(2), 282-298.

Walker, L. R., & Smith, S. D. (1997). Impacts of invasive plants on community and ecosystem properties. In: Luken, J. O. & Thieret, J. W. (Eds.) Assessment and Management of Plant Invasions. Springer Series on Environmental Management. Springer, New York, NY, pp. 69-86

Whitney, K. D., & Gabler, C. A. (2008). Rapid evolution in introduced species,'invasive traits' and recipient communities: challenges for predicting invasive potential. *Diversity and Distributions*, *14*(4), 569-580.

Zenni, R. D., & Ziller, S. R. (2011). An overview of invasive plants in Brazil. *Brazilian Journal of Botany*, *34*(3), 431-446.