Status and Diversity of Invasive Alien Plant Species in Rupa Lake, Kaski District, Nepal

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Abstract

Invasion of Alien Plant Species is the major threat to wetland ecosystem and its ecological function. In Nepal, more studies are concentrated on the impact of alien species in protected areas whereas limited studies have targeted wetland. We here attempted to explore the status and distribution of IAPS in the Rupa Lake and provide baseline information. We followed systematic sampling with random start for measuring invasion of alien species in the lake where total 107 plots having 1 m^2 (1m x 1m) quadrant size were laid out. Altogether 6 Invasive Alien Plant Species (IAPS) were observed which have covered 18.5 hectare of lake's water zone. Among 6 species; the importance value index of water hyacinth found to be the highest (67.164) and water chestnut as lowest (27.216). Manual or physical collection and its utilization for alternative products; paper and fertilizer, is suggested to reduce the invasion pressure on lake ecosystem.

Keywords: *Wetlands, Quadrant, Vegetation analysis, Importance Value Index, Water hyacinth*

Introduction

Species introduced in an area where they do not naturally occur are considered as an alien (Tiwari et al., 2005). Invasive Alien Plant Species (IAPS) is now one of the most significant drivers of population declines and species extinctions in island ecosystems worldwide (Donlan et al., 2003; Reaser et al., 2007). The problem of IAPS continues to grow at great socio-economic, health and ecological costs around the world. The increasing volume of global trade and land-use changes enhance the opportunity for the global spreading of IAPS and are likely to become more severe in the future. A rapid increase in temperature creates the water-stressed (Karki et al., 2019), which may help to spread IAPS more rapidly in the future. The large numbers of IAPS adversely affect the native biodiversity; now become an issue of global concern for its management. According to a World

Conservation Union report, the annual global economic loss caused by invasive alien species amounted to over $400 billion. The cost of damage to native species and ecosystems further increases the above figures (Gould, 2004). The rural farmers are willing to pay NRs. 2,382 per year for *Mikania micrantha* management in Nepal (Rai and Scarborough, 2012). Adequate studies about the economic losses have not yet to be done in Nepal. It is difficult to say how many species are getting extinct or threatened due to the invasion of alien plant species. There remains a gap in understanding the invasive weeds in many areas of the world including Nepal (Matthews and Brandt, 2004).

In Nepal, there are limited studies on wetlands of Nepal. Studies are concentrated on major wetlands like Beeshazari, Koshi Tappu, etc. Invasion of water hyacinth (*Eichhornia crassipes*) is a major threat to tropical and sub-tropical wetlands. Many internationally important wetlands, including the Beeshazari Lake in the Barandabhar corridor forest in Chitwan and Phewa Lake, Rupa, etc. Lakes in Pokhara are already severely invaded by water hyacinth (Gautam et al., 2019). The plant grows fast and soon covers the entire water surface. The substantial reduction in light and air (oxygen) reaching below the surface due to its invasion affects aquatic organisms.

The wetland of Rupa Lake is facing a lot of threats including invasive alien plant species, eutrophication, siltation, encroachment, settlement area expansion habitat destruction, depletion of species abundance and diversity, loss of economic integrity, leaching of organic fertilizers and pesticides from farmlands into the water of a wetland. This study was carried out to assess the current status and diversity of IAPS in Rupa Lake, Kaski Districts of Gandaki Province of Nepal.

Materials and Methods

Study area: This study carried out in and around Rupa Lake. It is one of the nine lakes in Lake Cluster of Pokhara valley which is the latest addition to the Ramsar Site of Nepal declared on 2nd February 2016. It is located in Pokhara Metropolitan, Nepal at an altitude of 600m from the sea level. Total catchment area and water body area of Rupa lake are 27.6km^2 and 1.07km^2 respectively (DNPWC, 2016),whose average depth is 6m (Oli, 2000).Rupa Lake and its catchment areas are rich in floral diversity (Gautam, 2011). Local people are undertaking various activities and developing it as source of monetary income (Tamrakar, 2008).The area is an internationally important Ramsar site which is rich in biological diversity, particularly important from the view of wetland species and migratory bird's diversity but has been lacking the research about the proper study and effect of IAPS which are constantly threatening and encroaching the wetland site and deteriorating the natural native biodiversity and quality. Rapid increase in temperature, need to be consider on the impact on growth of IAPS for its effective and sustainable management (Kharal et al, 2019) of the lake.

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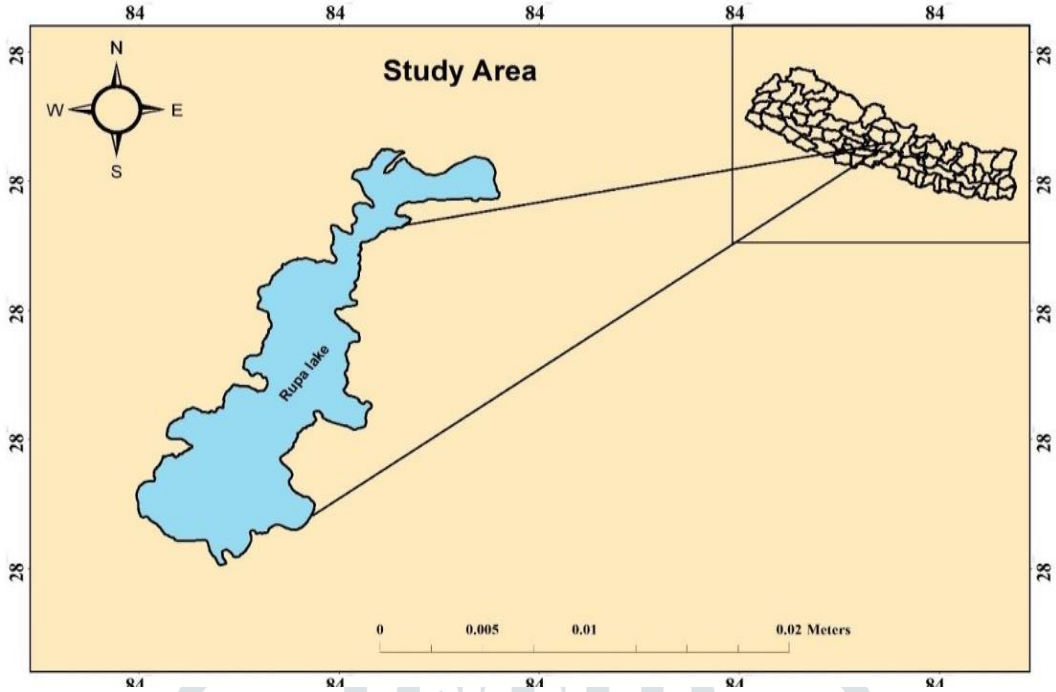

Figure 1. Rupa Lake, Kaski Nepal

Data collection and analysis

A wooden frame of $1m^2$ (1m x 1m) quadrant size was used to collect the data from the Lake by applying systematic sampling with random start for measurement. We also took a reference of the technique suggested by IUCN inventory and assessment guidelines 2005. A total of 107 sample plots were laid out on the lake to collect the samples and to ensure sufficient sampling intensity. The data were analyzed to calculate Density (D), Relative Density (RD), Frequency (F) Relative Frequency (RF), Important Value Index (IVI) for each species (Hussain, 1989 and Barbour et al., 1980).

- $\textbf{Frequency} = \frac{\textbf{Number of sample plots in which species occured}}{\textbf{Total number of sample plots taken}} \times \textbf{100}$
- $\textbf{Relative frequency}(\%) = \frac{\textbf{Frequency of individual species}}{\textbf{Total frquency of all species}} \times \textbf{100}$
- $\textbf{Density/ha} = \frac{\textbf{Total number of plants of any species}}{\textbf{Total number of plots taken} \times \textbf{area of sample plot}} \times \textbf{10000}$
- $\textbf{Relative density}(\%) = \frac{\textbf{Density of individual species}}{\textbf{Total density of all species}} \times \textbf{100}$
- $\textbf{Coverage}(\%) = \frac{\textbf{Area occupied by species A}}{\textbf{Area of sample plot}} \times \textbf{100}$
- $\textbf{Relative coverage}(\%) = \frac{\textbf{Coverage of species A}}{\textbf{Total coverage of all species}} \times \textbf{100}$

$$\textbf{Important Value Index (IVI)} = \textbf{Relative Frequency} + \textbf{Relative Density} + \textbf{Relative Coverage}$$

Results and Discussion

Species composition: Nepal is a hotspot for many locally and globally significant plants and animals (SUGUN, 2009). Rupa Lake and its catchment areas are rich in floral diversity (Gautam, 2011). It consists 36 species of waterfouls (Kafle et al., 2008), 36 species of herpetofauna (Baral, 2008), 32 species of fishes, in which 13 are native (IUCN, 2004), 34 species of mammals including Ottter (Regmi et al., 2007). Similarly, It consists about 520 plant species, 32 exotic plant species, 80 religious plants and trees, 40 fodders trees and shrubs species, 44 edible wild fruits, 128 tree species, 85 herbaceous plant species, 128 medicinal plants species, 45 threatened plants, 44 algae flora (Regmi et al., 2007), 6 invasive species (Oli,1996). All together 520 plant species were recorded in the area. Trapanatus spp were dominant in the lake, which has high food value for local people (Gautam, 2011). The major lotus species of Rupa lake *Neumbium nuciferum* and *Nymphea alba* have high medicinal value. The major aquatic plants in Rupa Lake are *Azolla carliniana, Ecichorina carassips, Lemana spp. Spirodela oligorhiza, Spirodela poluhyizia* and *Wolfia.* Some submerged rotted aquatic plants in the lake are *Cerlatophyllum spp, Egeria spp. Myriophyllum spp. Potamogaton spp*. (Oli, 1996).

Plants and animals introduced in an area where they do not naturally occur are considered alien (Tiwari et al., 2005). Out of the world, 100 worst invasive aliens include 11 plant species are found in Nepal. The documentation of IAPS in Nepal started in 1958, at present more than 43 studies conducted on IAPS; most of these were unpublished master level thesis (Poudel and Thapa, 2012). Invasive species are the major threats of all types of ecosystems. According to the report of IUCN, 2005 there are 166 alien plants in Nepal. In which, herbs contribute about 76%, followed by shrubs 16%, climbers 6% and trees 2% (Siwakoti, 2012). Among them, 21 species are highly problematic species (Tiwari et al., 2005). *Ageratina adenophora, Chromolaena odorata, Lantana camara, Mikania micrantha, Eichhornia crassipes* and *Ipomoea carnea, fistulosa* are considered as alien species with high threat to native species and ecosystems. Similarly, species like Among these the *Eichhornia crassipes, Ipomoea carnea, fistulosa spp., Mikania micrantha, Alternanthera philoxeroides, Pistia stratiotes, Leersia hexandra, Myrophyllum aquaticum* are major IAPS seriously invaded in wetlands of Nepal (MFSC/CSUWN, 2011). From our research, we found that almost all species have occurred naturally except Water Hyacinth (*Eichhornia crassipes*), Water chestnut (*Trapa natans*), Water Lily (*Nymphoides peltata*), Water Lotus *(Nymphaea nouchali), Azolla spps and Lemna spps.* Gautam et al. (2019) also agreed that water hyacinth (*Eichhornia crassipes*) is the major treats of Rupa lake as it has high IVI (Table1)

Important value index: Altogether 166 alien plants are permanently naturalized in Nepal. The name list of the IAS is prepared as per the standard information (Tiwari et al., 2005). Among total plant species recorded 4 individual plants and 2 associated species were found with invasive character. Water hyacinth has the highest Relative Density (0.285%) followed by others (*Azolla* and *Lemna* species) with a relative density of 0.252%. In a similar way, Water Chestnut has the lowest Relative Density (0.120%). Water hyacinth has the highest relative frequency (29.834%) followed by others (*Azolla* and *Lemna* species) with a relative frequency of 23.757%

whereas Water lily has the lowest relative frequency (12.707%). Water hyacinth has the highest Relative Coverage (37.045%) followed by Water lotus (23.964%). However, others (such as *Azolla spps.* and *Lemna spps*.) have the lowest Relative Coverage (12.123%). The result contradicts the result obtained by Dangi, 2017 where Ipomea carnea (Shrubby morning glory) had the highest coverage in the aquatic land of Beeshazari Lake. Water hyacinth has the highest Important Value Index (67.164) with Water Lotus having the second-highest Important Value Index (42.930%). Water Chestnut has the lowest Important Value Index (27.216) Table: 1.

Table 1: Invasive species in Rupa Lake

SN	Species	Scientific Name	RF%	RD%	RC%	IVI
1	Water Lotus	*Nymphaea nouchali*	18.785	0.182	23.964	42.930
2	Water Chestnut	*Trapa natans*	14.917	0.120	12.179	27.216
3	Water Lily	*Nymphoides peltata*	12.707	0.162	14.698	27.566
4	Water Hyacinth	*Eichhornia crassipes*	29.834	0.285	37.045	67.164
5	Others	(*Azolla,Lemna spp.*)	23.757	0.252	12.123	36.132

Conclusion

The Rupa Lake is invaded with invasive aquatic plant species which seems one of the major threats to lake ecosystem. All together 6 invasive species were recorded where water hyacinth was observed as the most problematic alien species. Despite some cleaning activities, the lake is suffering from proliferation of invasive species continuously, therefore, regular mechanical collection and training for its alternative utilization; paper and fertilizer, are suggested to reduce the invasion pressure on lake ecosystem and regulate the ecological function.

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