Assessment of the perceived effects and management challenges of *Mikania micrantha* invasion in Chitwan National Park buffer zone community forest, Nepal

Akriti Khadka*
Kathmandu Forestry College, Kathmandu, Nepal

* Corresponding author.
E-mail address: khadkaakriti@gmail.com (A. Khadka).

Abstract

The effects of invasion by *Mikania micrantha* in the buffer zone of Chitwan National Park (CNP) of Nepal are well documented; however the studies were confined to appraising the perception of household and did not assess the changes in livelihood activities after the invasion. This study presents the effects of invasion of *M. micrantha* on the livelihood of buffer zone of the Chitwan National Park; hence addressing the gap in information and shows the complex effect of *M. micrantha* on rural livelihood. The study used a questionnaire survey to 170 households in the CNP of Nepal. The results indicate that the invasion of *M. micrantha* have negative effects on the community livelihood in the study area. Basic forest products such as fodder and fuel wood have become scarce as a result of reduction in the native plants. Also the spread of *M. micrantha* is creating impassable copse that destroy wildlife abode and jungle paths resulting into animals to shift their habitat to core area thereby reducing tourism revenues. Therefore, the study concludes that invasion of *M. micrantha* directly or indirectly is modifying the rural household livelihoods and a quick action is stipulated. Hence, a higher level body like the Ministry of Forestry or Department of National...
Park and Wildlife Conservation needs to take care of issues related to alien species. Correspondingly, it is also very important that people are aware and educated about alien species and their effects.

Keywords: Environmental science

1. Introduction

Any species, such as microorganisms, plants and or animals, native to a specific area, which establishes itself in another ecosystem, may be defined as alien species (Piemental, 2011). However, not all exotic species are invasive. To be invasive, a species has to be naturalized and spread beyond its range. It is estimated that only one percent of the total introduced species becomes invasive (Keam et al., 2009). Invasive species may become a greater threat to native ecosystem and species richness when the habitat into which it invades become fragmented (D’Antonio and Kark, 2002; Moore, 2000; Wilcove et al., 1998). In general, when a new species enters into an ecosystem, it influences the structure and function of, and eventually the goods and services provided by the ecosystem (Wilcove et al., 1998).

Invasive alien species (IAS) may also cause social instability and economic hardship placing curbs on substantial development, economic growth and food security (GISP, 2009). This is particularly serious in the developing world, where they are compounding a multitude of problems affecting livelihoods (Sapkota, 2007). The government’s priority to promote tourism in order to increase the volume of trade makes Nepal likely to host many exotic species. Furthermore, the absence of a clear policy on introduction and prevention of invasive species, quarantine facilities, and studies on IAS is a recipe for more establishments of exotic species.

The effect of invasive plants on rural communities is much more complex than that of the negative ecological repercussion. More than two-thirds of the population live in rural areas and practice subsistence farming. Forest resources are very important for their survival and daily livelihoods (Adhikari et al., 2004; Pandit and Bevilacqua, 2011). The abundance of invasive plants usually outcompete the native ones thereby affecting the delivery of the quantity of native forest products. Forest products are a major input in the farm household production input in Nepal. The effect of failing to provide quality timber and forest products can cause rural farmers to change their livelihood strategies. This is due to the convoluted linkages between community livelihood and forest; a change in the state of one variable can be expected to have an impact on other (Shackleton et al., 2007).

However, in many cases, the effects of invasive species on livelihoods are contentious (Rai et al., 2012a, b). The plant species studied to examine the
livelihood effects of invasive species is *Mikania micrantha*. The fast growing perennial creeping vine, *Mikania micrantha*, which originates from Central and South America, colonizes agricultural lands and vandalizes crops and multipurpose trees in moist tropical forest zones of Asia, particularly South East Asia (Choudhary, 1972; Holmes et al., 2009; Parker, 1972). It is one of the worst weeds in the world (Tiwari et al., 2005), has been recorded as one of the 100 worst invasive alien species in the world (Lowe et al., 2001), and second most serious weed in South Pacific (Waterhouse and Norris, 1987).

This study primarily focused on the effect of invasion of *Mikania micrantha* on the livelihood of buffer zone households in Chitwan National Park (CNP), Nepal. The vine was first noticed in Buffer Zone of the Chitwan National Park after flood in the Rapti River in 1992. It is believed that the Rapti River, which flows from the south to west, brought the species to their community forest. Previous works into the invasion of *M. micrantha* have studied the effects of the vine on the Buffer zone ecosystem; and consider it to have degraded the biodiversity and household livelihood in the communities (see for example Rai et al., 2012b). The current study builds on previous studies but in contrast to, for example, studies by Rai et al. (2012b) which evaluated the perception of household on the invasion, it analyzes livelihood activities that have been altered after, and how the communities are adapting to the infestation. The study also intended to study the perception of local people on the use of *M. micrantha* and suggests management options to contain this and or stop more invasive species from invading and threatening forest biodiversity.

2. Material and methods

2.1. Study area

Chitwan National Park is located in the South Central lowland of Nepal, between 84°20′ East and 27°30′ North, and covers an area of 932 km². It is a renowned biodiversity hotspot and a UNESCO World Heritage Site. To enhance the conservation of the core zone, an additional 750 km² area, including settlements around the park was declared as a buffer zone in 1996 (GoN, 1996).

The study was conducted in Kumroj Buffer Zone Community Forest, which has a total area of 21.22 km² (see Table 1). The Kumroj Buffer zone Community Forest is harbored by Kathar Village Development Committee (VDC) in the East, Bachhauil VDC in the West, and Khairahani VDC and CNP in the North and South respectively. The community forest is highly infested by *Mikania micrantha* and the species colonization was negatively affecting the local people. The economic activities and the pristine landscape have been severely affected by the invasion (Sapkota 2007; Rai and Scarborough, Forthcoming). Kumroj VDC lies in Dun valley of Chitwan District within CNP. There are 1750 households in the VDC and
8082 people of various castes and ethnicity composed of indigenous Tharu and Darai communities with hill migrants.

*Mikania micrantha* commonly known as Mile-a-minute is overspreading forest patches and grassland in buffer zone of CNP (Poudel et al., 2005; Sapkota, 2007). The effect of colonization of *Mikania micrantha* on the native plant species in Buffer zone of CNP of Nepal are well registered (Rai et al., 2012a; Sapkota 2007).

### 2.2. Sampling design

The data was collected to understand the perception of the local people on the invasion of *Mikania micrantha* and the perceived post infestation changes encountered by the communities. Respondents were asked to analogize the current situation to that of five years ago.

Household interviews were carried out in December 2015 using a questionnaire (see Supplementary Material, S1). A systematic random sampling was used to select the household, that is, the first household was selected randomly and then every tenth household considering their location on both sides of the street was interviewed along with scattered houses as well. The households were stratified into four strata based on the time taken to reach the forest—that is 5, 15, 30 and 45 min thereby unveiling the relationship between household dependencies on forest products and distance to forest (Sapkota and Oden, 2008). Interview was taken considering the local cultural diversity and the gender issues. Household heads of any gender was interviewed based on their availability during the visit. A total of 170 households were surveyed which is 10% of the total household in forest user group.

### 2.3. Data analysis

The perception of the local people on *Mikania micrantha* invasion was analyzed using descriptive statistics such as percentage, mean, standard deviation, frequency

| Attribute       | Area (km²) |
|-----------------|------------|
| Forest          | 3.10       |
| Agriculture     | 12.98      |
| Grassland       | 3.66       |
| Water bodies    | 0.94       |
| Others          | 0.54       |

| Table 1. Bio-geographical attributes of Kumroj Buffer zone Community Forest (Source: NTNC, 2013). |
distribution and use of graphics. Cross tabulation was used to generate the descriptive statistics. All the statistical analyses were done using the Statistical Package for Social Science (SPSS) software (IBM SPSS, version 20).

3. Results

3.1. Sample characteristics

A total of 165 respondents were interviewed from 165 households; out of which 52.9% and 47.1% of the respondents were males and females respectively. While more than one third of all respondents (33.33%) had no formal education, only about one-third of all respondents (29.7%) had primary education (Table 2). The main source of income of people living in the area was solely agriculture (79.4%) while business formed the second most important economic activity (14%) (Table 2).

3.2. Effect of Mikania micrantha on the livelihood activities

All respondents recognized *M. micrantha* by sight and the vine was locally known by different names such as Banmara, Banlude jhar, and Barahmase. A substantial

| Table 2. Socio-economic characteristics of sampled households in the study area. |
|---------------------------------|-----|-----|
| **Respondents**                |     |
| **Gender**                     |     |
| Male                           | 86  | 52.9|
| Female                         | 79  | 47.1|
| **Education**                  |     |
| Primary                        | 49  | 29.70|
| Lower secondary                | 23  | 13.94|
| Secondary                      | 11  | 6.67 |
| Higher secondary               | 19  | 11.52|
| Undergraduate                  | 8   | 4.85 |
| Uneducated                     | 55  | 33.33|
| **Income source**              |     |
| Agriculture                    | 131 | 79.39|
| Business                       | 24  | 14.54|
| Others                         | 10  | 9.06 |
portion of the respondents (55%) believed that *M. micrantha* was introduced via local river flood in 1950, while 19% of them had no idea when it arrived in their community forest (Table 3a). While 53% of the respondents indicated that the vine had negative effects on their livelihoods, the remaining respondents (46%) had mixed perception about its effects; with 28.5% failing to recognize any effect (Table 3b). The majority of respondents also indicated that *Mikania* had significantly decreased the provision of fuel wood and fodders (53%), while 28.5% of the respondents showed that there was no significant effect of the invasive species to the native forest resources (Table 3c). The majority of respondents (85%) believed that *M. micrantha* has increased in the last five years, replacing and hindering regeneration of the native species (Fig. 1).

Similarly, various reasons were given for the increase in abundance of *M. micrantha*. Lack of management in the community forest (CF) was found to be the major reason for the spread (37.6%); followed by restriction of entry into the forest (35.8%), climate adaptation (32.6%) and wind (24.8%) (Fig. 2). However, while a significant number of respondents (35.2%) did not know what caused the proliferation of *M. micrantha* at all, wildlife movement, human intervention and *

| Table 3. Arrival of *Mikania* and its effect on daily life and forest resource. |
|---------------------------------------------------------------|
| **Respondents**                                              |
| **a) Date of arrival of *Mikania***                          |
| After floods in 1992                                        | 93 | 54.7 |
| Few years before                                            | 39 | 22.9 |
| No idea                                                     | 33 | 19.4 |
| **b) Effect of *Mikania* on daily life**                     |
| Negative                                                    | 88 | 53.3 |
| Can’t say                                                   | 47 | 28.5 |
| Nothing                                                     | 30 | 18.2 |
| **c) Effects of *Mikania* on forest resources**             |
| Negative on forest but positive on livelihood               | 2  | 1.21 |
| Increased fuel wood and decreased fodder                     | 24 | 14.5 |
| Decreased fuel wood and fodder                              | 87 | 52.7 |
| Decreased grass, fodder, fuel wood                          | 5  | 3.03 |
| No change                                                   | 47 | 28.5 |
The number of households entering the CF regularly to collect forest products decreased significantly from 99% to 50% after the infestation. The time required to collect forest product per day, measured in hours per trip (h/trip), has more than
tripled after the invasion—increasing from 1.36 ± 0.62 h/trip five years before to 4.62 ± 2.36 h/trip after the invasion, while entry into the forest to collect forest product decreased from 6.84 to 3.39 days per week (Table 4). Similarly, the forest product collected per trip has decreased from 1.63 bharī to 1.38 bharī during the same period (Table 4). However, while the majority of respondent (56.4%) indicated to have collected 2–3 bharī during five years before the invasion, only 1.2% collected the same amount of forest product after the invasion (Fig. 3). Over 52% of respondents indicated that *M. micrantha* caused the decline in the amount of forest products (see Table 3c).

### 3.3. Change in forest product availability

A total of 127 respondents (77%) indicated that there was a significant change in forest product availability; where the majority (72%) indicated that the forest products were decreasing. A comparison between five years before and after the invasion of *M. micrantha* indicated a significant decrease in forest products availability. While all respondents (100%) said that forest products were enough before the invasion, the majority of them (66.5%) indicated that forest products were scarce after the invasion (Fig. 4).

### 3.4. Coping with the invasion of *Mikania micrantha*

Respondents mentioned many coping strategies, including use of *M. micrantha* to cope with the decrease in availability of natural forest products. Respondents who said they were using *M. micrantha* to cope with the invasion were using the invasive species for making briquettes (65%), as fodders (62%), medicine (53%), and manure (34%) (Fig. 5).

### 4. Discussion

The results of this study indicate that the infestation of *Mikania micrantha* has negatively influenced the livelihoods of the local people in the study area. It is perceived by the local community that the abundance of *M. micrantha* has reduced

| Variables                  | Before             | After              |
|----------------------------|--------------------|--------------------|
| Household enter forest     | 162                | 135                |
| Average FP collection time (h/trip) | 1.36 (0.616) | 4.62 (2.357) |
| Enter to collect the FP (days/week) | 6.84 (1.04) | 3.39 (2.36) |
| FP collection (*Bharī/trip) | 1.63 (0.56)      | 1.38 (0.78)       |

*Bharī is a traditional unit of measurement in rural areas where one Bharī = 25 kg.*

Table 4. Mean (SD) change in the livelihood activities of household. SD = standard deviation; FP = forest product; hrs. = hours.
the local species which resulted into the scarcity of fuel wood, fodder and other forest products. The invasive species is known to overshadow small trees, shrubs and herbs which results in the reduction of native species (Sapkota, 2007). *M. micrantha* was also used as fodder to feed livestock despite the fact that it has been

**Fig. 3.** Change in the amount of forest products collected before and after the invasion of *M. micrantha*.

**Fig. 4.** Comparison of forest product availability 5 years before and after the invasion of *M. micrantha*. 
reported to cause abdominal disorder to livestock (Siwakoti, 2007). This is probably due to the fact that the community has very limited alternatives. The rural community favors native species for firewood and fodder so the infestation directly pressurizes the supply of those products from the buffer zones (Rai et al., 2012b; Sapkota, 2007). The increase in abundance of *M. micrantha* is therefore seen as a diminution of native species produce. With the scarcity of the forest products it can also be assumed that the wildlife may also shift their habitats to the core area as a result of increased human presence in the parks; which may result in fewer visitors, consequently decreasing annual income accrued from tourism by the communities.

However, the community responses on the effects of the invasion were somehow divided depending on their use of the community forest. Some rural people evaluated the effect of *M. micrantha* on their livelihood regarding the supply of forest products after the invasion. For instance, respondents who used the forest as source of firewood indicated that the invasion had negative effect on their livelihood while those who used alternatives like bio-gas and entered less into the community forest indicated no effect on their livelihood due to the invasion.

*Mikania micrantha* is an extremely serious weed with an uncommon growth rate of 8–9 cm per day (Choudhary, 1972) and justifiably has earned the name mile-a-minute (Holmes et al., 2009). It is therefore spreading like wildfire (Paudel, 2011). The respondents of study area have observed an increase in the abundance of *M. micrantha* in last few years. No control measures are practiced which is one of the reasons for its increase. In this context, it is needless to say that *M. micrantha* is...
one of the serious weed of the CNP and need immediate action to control the weed. As the cover of *M. micrantha* increases the livelihood vulnerability increases (Shackleton et al., 2007). However, the viewpoints from two groups of community forest users were divided on the management methods of the invasive species. While the first group of respondents had no issues with the rampant growth of the vine, because they had less reliance on the forest products, did not want to participate in its removal, the second group desperately advocated for the removal of the invasive species.

Many strategies were used by the household to cope with the scarcity of forest products due to *M. micrantha* invasion in the study area (see Fig. 5). Out of all the strategies the most common strategy was use of alternatives i.e. instead of getting firewood and fodder from the forest, bio-gas and hay was used respectively. With the support of government agencies and NGOs, local farmers have installed bio gas plants as an alternative to fuel wood. While some made use of alternatives, others have reduced the consumption of forest products from the CF, ventured into agroforestry, and went into buying products from the market such as petroleum gas and saw dust.

5. Conclusion

The study illustrates the effects of the invasion of *M. micrantha* on community livelihoods in the Chitwan National Park, Nepal. The effect of invasion of exotic plants on rural livelihoods depends on the availability of native species and the forest product it provides. In this prospect, the abundance of *M. micrantha* lessens the availability of native species. Hence, the invasion of *M. micrantha* negatively affects the human welfare and suggests an instantaneous need to intervene the forest management activities aiming to check the spread of the vine. Accidentally transported *M. micrantha* with a catastrophic growth rate causes a reduction in dependence of local people on their CF and attempt to cope with changes in ecosystem.

An increase in the demand of a product is a result of the strategy that has been employed as an alternative for one product; for example, bio-gas is installed in almost every house. For this the household has to keep livestock for the production of dung which is required to operate bio-gas plants. Again, more livestock equals more fodder. Taking into account the abundance of hay which solves problem of both fodder and fuel, it can be concluded that with eradication of *M. micrantha*, the community forest which at present is in-exploitable to its upmost extent, can be used by people for additional benefits that would help uplift their living standards.

The spread of *M. micrantha* over the last few years leaves to the presumption that the vine may severely undermine the livelihood of Buffer Zone Community Forest BZCF in the future. It has been observed that manual cleaning is a never ending
task because a gap in cleaning means introduction of the weed by seed or the plants part rapidly occur in site from the adjoining areas. Therefore, the impact can be best minimized by proper utilization of the species after a risk assessment has been conducted. For example, the promotion of bio-briquette production in order to give people incentives to remove the vine, based on the fact that manual removal of the vine has failed and the community is not motivated to get involved, taking in account the danger of purposeful introduction of the vine into other forests because of these benefits. And while this may be hard to prevent, a policy must be enacted to limit the vine to the CNP and the one caught spreading the vine intentionally should be severely punished. Furthermore, the utilization of the vine also reduces forest degradation and loss of biodiversity. However the ultimate cost effective approach is preventing the introduction of alien species in new localities. The case of the invasion of *M. micrantha* should provide a case in point that should be used by communities to monitor for new invasive species and handle and control before they become nuisance.

**Declarations**

**Author contribution statement**

Akriti Khadka: Conceived and design ed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

**Funding statement**

This work was supported by the Student Dissertation Grant of National Trust of Nature Conservation (Grant no.: H 6660).

**Competing interest statement**

The authors declare no conflict of interest.

**Additional information**

Supplementary content related to this article has been published online at http://dx.doi.org/10.1016/j.heliyon.2017.e00289.

**Acknowledgements**

I am thankful to Dr. Rajesh Kumar Rai for being such a devoted advisor. He spent his precious time to constantly support me to carry out this study. I would also like to acknowledge Ismael Aaron Kimirei for reviewing and editing the drafts of the manuscript. Finally, I would like to acknowledge two anonymous reviewers for their constructive criticism which has tremendously shaped this work.
References

Adhikari, B., Di Falco, S., Lovett, J.C., 2004. Household characteristics and forest dependency: evidence from common property forest management in Nepal. Ecol. Econ. 48 (2), 245–257.

Choudhary, A.K., 1972. Controversial Mikania (Climber) – a threat to the forests and agriculture. Indian Forister 98, 178–186.

D’Antonio, C.M., Kark, S., 2002. Impacts and extent of biotic invasions in terrestrial ecosystems. Trends Ecol. Evol. 17 (5), 202–204.

GISP, 2009. Invasive Species and Poverty: Exploring the Links, GISP: Cape Town South Africa. (accessed 20.10.11) http://www.gisp.org/.

GoN, 1996. Buffer Zone Management Regulation 2052. Government of Nepal, Kathmandu, Nepal.

Holmes, T.P., Aukema, J.E., Holle, B.V., Liebhold, A., Sills, E., 2009. Economic impacts of invasive species in Forests, past, present and future. Ann. NY Acad. Sci. 1162, 18–38.

Keam, S., McCormick, N., Howard, G., Athanas, A., 2009. Guidelines on Biofuels and Invasive Species. IUCN, Nairobi.

Lowe, S., Browne, M., Boudjelas, S., De Poorter, M., 2001. 100 of the World's Worst Invasive Alien Species: A Selection from Global Invasive Species Database. The Invasive Species Specialist Group (ISSG), pp. 12.

Moore, P.D., 2000. Alien Invaders. Nature 403, 492–493.

Pandit, R., Bevilacqua, E., 2011. Forest users and environmental impacts of community forestry in the hills of Nepal. For. Policy Econ. 13 (5), 345–352.

Parker, C., 1972. The Mikania problem. PANS 18, 312–315.

Biological invasions: economic and environmental costs of alien plant, animal, and microbe species. In: Piemental, D. (Ed.), CRC Press.

Poudel, A., Baral, H.S., Ellison, C., Subedi, K., Thomas, S., Murphy, S., 2005. Mikania micrantha weed invasion in Nepal: A summary report. The first national workshop for stakeholders, Mikania micrantha weed invasion in Nepal: A summary report. The first national workshop for stakeholders. Himalayan Nature, IUCN- Nepal and CAB International, Kathmandu.

Paudel, R.P., 2011. Insight into invasive species (Mikania micrantha): Its control measures and programmes in Nepal. The Initiation 4, 115–119.
Rai, R.K., Sandilya, M., Subedi, R., 2012a. Controlling *Mikania micrantha* HBK: How effective manual cutting is? J. Ecol. Field Biol. 35, 235–242.

Rai, R.K., Scarborough, H., Subedi, N., Lamichhane, B., 2012b. Invasive plants: Do they devastate or diversify rural live- livelihoods? Rural farmers’ perception of three invasive plants in Nepal. Nature Conserv. 20, 170–176.

Sapkota, L., 2007. Ecology and management issues of *Mikania micrantha* in Chitwan National Park. Banko Jankari 17, 27–39.

Sapkota, I., Oden, P.C., 2008. Household characteristics and dependency on community forests in Terai of Nepal. International Journal of Social Forestry 52, 253–282.

Shackleton, C.M., McGarry, D., Fourie, S., Gambiza, J., Shackleton, S.E., Fabricius, C., 2007. Assessing the effects of invasive alien species on rural livelihoods: case examples and a framework from South Africa. Hum. Ecol. 35, 113–127.

Siwakoti, M., 2007. *Mikania* weed: a challenge for conservationists. Our Nature 5, 70–74.

Tiwari, S., Siwakoti, M., Adhikari, B., Subedi, K., 2005. An inventory and assessment of invasive alien plant species of Nepal. IUCN – The World Conservation Union, Nepal, pp. viii+ 114.

Waterhouse, D.F., Norris, K.R., 1987. Biological control Pacific Prospects. -319 Melbourne (Inkata Press). Deutsche Entomologische Zeitschrift 37 (4-5), VIII +360.

Wilcove, D.S., Rothstein, D., Dubow, J., Phillips, A., Losos, E., 1998. Quantifying threats to imperiled species in the United States. BioScience 48, 607–615.