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Research Article

Distribution, effect and utilization of *Mikania micrantha* on livelihood: Case study of Janakauli buffer zone community forest of Chitwan National Park

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ABSTRACT

Forest of lowlands is heavily impacted by invasive plants species, particularly *Mikania micrantha* which is also considered as one of the most invasion species. So, it became essential to understand effects of *Mikania* to user and indigenous vegetation; however the studies were confined to appraising the distribution, effect and utilization of *Mikania micrantha* on the livelihood of buffer zone of the Chitwan National Park. Vegetation survey, key informant interview, focus group discussion, direct observation and stratification were conducted. GPS points were recorded and the distribution map of *Mikania* was made by using ArcView GIS 10.1 and has been found throughout the Community Forest. Regression analysis showed that the number of plant regeneration of native tree species decreases by 0.530 unit with every 1 unit increment in *Mikania* crown cover. The study used a questionnaire survey to 118 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. Only 6.78% of the users utilize *Mikania* for household purpose like briquettes fuel, fodder, medicine and manure. The losses of other plant species have severe effect to biodiversity so control measure with utilization should be taken as the most needed action. Regular assessment and monitoring of *Mikania* effect is necessary to understand the problem and its impact on biodiversity of lowland forest of Nepal.

Keywords: Regeneration, biodiversity, invasion, lowland and regression analysis

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INTRODUCTION

Mikania micrantha is a perennial climber, originally from tropical America. It is a major invasive in several parts of south-east Asia and the Pacific islands. In Nepal, M. micrantha was first reported in 1963 in the eastern part (Tiwari et al., 2005) and spreading towards the western part, which now recorded in 20 Terai districts of Nepal (Rai et al., 2012 a). Likewise, M. micrantha is assessed as one of the six high risk posed invasive alien species in Nepal (Tiwari et al., 2005) and later on, it is considered to be the most problematic in terrestrial ecosystem in eastern and central Nepal (Poudel et al., 2005). Like other weeds, this weed is very tolerant to several biotic and abiotic factors. Higher adoption and competitive ability of this weed are due to its higher seed production ability and longer seed viability (Mertens and Jansen, 2002; Shrestha et al., 2018; Egley and Chandler, 1978). In Chitwan National Park (CNP), M. micrantha was found to be the most serious weed among the eight invasive species in terrestrial ecosystem (Sapkota, 2006).

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 & 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 &Norris, 1987).

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There is urgent to investigate the invasion of *Mikania* and formulate the strategy to overcome the problem of habitat degradation (Bhatta, 2006). Due to the lack of invasive species management provision, exist in Chitwan, *Mikania* eradication is still the topic of experiment. That is why timely management is essential for minimizing the spread of *M. micrantha*. In the absence of the management method, biodiversity rich forest can be converted into *micrantha* monocultures.

In Chitwan National Park, *Mikania* has invaded three habitat types viz. grassland, riverine forest and wetlands as well and still small amount of invasion in Tall grass land (themeda) and Sal forest. However, only few studies were carried out to know the effect on rural livelihood. Therefore, *Mikania micrantha* is one of the major destructive invasive species that adversely affect the biodiversity. Sometimes invasive plant species are referred to as biological pollution or green cancer (Olson, 2006). The output of this study would be supportive tool for preparing rural livelihood to combat with the possible risk of invasion in newly invaded area and potential geographic areas at risk for invasion.

The overall research goal of this study is to appraise the distribution, effect and utilization of *Mikania* in Janakauli Buffer Zone Community Forest.

MATERIALS AND METHODS

Study area

The study was carried out in Buffer zone of Chitwan National Park which is the first declared National park of Nepal in 1973 covering 932 km^2 and also UNESCO declared it as a World Heritage Site in 1984. The park is bounded, north by the Narayani and Rapti rivers and south by the Panchnad and Reu rivers and a forest road (Sapkota, 2007). Janakauli Buffer Zone Community Forestry (JBZCF) lies in Ratnanagar Municipality ward no. 06 of Chitwan District which has a total area of 77.47 km^2 with 1184 households and 6520 people of various castes and ethnicity composed of indigenous Tharu and Darai communities with hill migrants.

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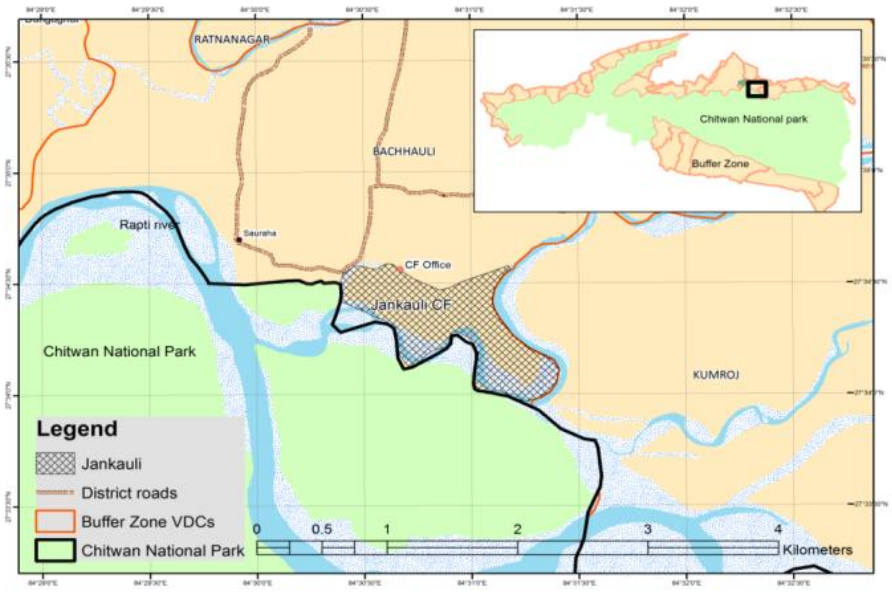


Figure 1: Map of study area

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).

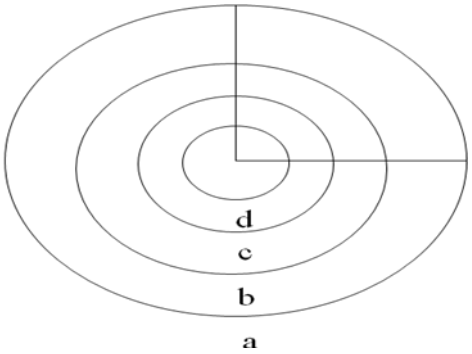
Sampling design

Systematic random sampling was done to analyze the situation and condition of forest so that it represents variety of coverage by *Mikania macrantha* i.e. low, medium and high. The sample plot design was based on the methodology of Rentería et al. (2012), Barbour et al. (1999) and Singh and Singh (1992). Based on similar principle as Renteria et al. (2012), a total of 10 plots were chosen throughout the study site representing a variety of cover densities of *Mikania*. 1% sampling intensity was adopted for collection of forest inventory. The sampling intensity was taken in accordance to "community forest inventory guideline 2061" (GoN/MFSC).

Shape and size of sample plots

Sampling technique

Sampling method: Simple random sampling
Sampling Intensity: 1%
Sample plot type: circular (nested)
Sample plots number: 10 plots
Sample plot size:
a) 500 m^2 for tree
b) 100 m^2 for pole
c) 25 m^2 for sapling
d) 10 m^2 for seedling



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(Community forest resources inventory guideline, 2061)

Materials used
Field logistics, GPS, field data sheets, interview schedules, checklist of questionnaire was used. Knowledgeable local people, community forest user group, DFO was consulted to assist on data collection.

Data collection
Participatory approach was adopted to collect data. The semi-structured questionnaire survey was carried out. PRA tools such as participatory resource mapping, focus group discussion, key informants survey, household survey was used.

a. Participatory Resource Mapping
The participatory resource mapping was done to identify the distribution zone which shows both the impacted zone of forest and private land.

b. Focus Group Discussion
To cross check the collected information during the household survey and key informant survey, the focus group discussion was organized with parks staff, community forest user group.

c. Key Informants Survey
Park staffs, CFUGs, elder person, school teachers, social and conservation worker, and those who involve in community based resource management was considered as key informants.

d. **Household Survey**
Household survey was carried out with the semi-structured questionnaire to find out the effect on livelihood due to the *Mikania* and utilization of *Mikania* in household level. Purposive sampling method, with 10 % sampling intensity of total user's households (1184), was applied to get the unbiased response.

e. Direct Field Observation and Stratification
Field observation was carried out to find affected area, distribution, abundance of the *Mikania micrantha*. The invaded areas was identified and allocated into blocks according to its severity of impact.

f. Vegetation Survey
Each block was divided into various quadrates of 10 m x10 m and these quadrates was randomly assigned, representing 0.25% sampling intensity for tree species and invasion ability of *Mikania*. Within this quadrate, a 5m x 5m quadrate was allocated randomly in two corners for the shrubs and *Mikania* biomass representing 0.025% sampling intensity. Likewise herbs and regeneration was recorded from nesting sampling of 1m x 1m quadrate within the 5m x 5m quadrate representing 0.001% intensity.

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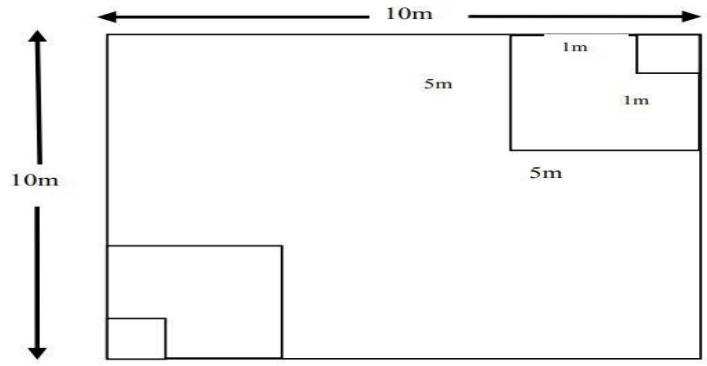

Figure 2: Layout of Quadrates

g. GPS Data Collection

Locations of *Mikania* were recorded using GPS and mapped using Arcview GIS software.

Data analysis

All qualitative data were analyzed by using the statistical software. Data was analyzed using descriptive statistics (mean, percentage, frequency). The findings of the study were presented in different bar-diagram, pie-chart and other graphs. Likert scale test and regression were used for analyzing effect of *Mikania*. The regression analysis was performed between related variables using MS-Excel and SPSS (Statistical Pakage for Social Science) (Arkkelin, 2014; Shrestha, 2015).

RESULTS AND DISCUSSION

Socio-economic characteristics

A total of 118 respondents were interviewed from 1184 households; out of which 55.08% and 44.91% of the respondents were males and females respectively. While almost one third of all respondents (31.36%) had no formal education (Table 1). The main source of income of people living in the area was solely agriculture (58.47%) while business formed the second most important economic activity (20.34%) (Table1). The residential status of the respondent was 55.93% Native and 44.07% Migrant.

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Table 1: Socio-economic characteristics of sampled households in the study area

Variable	Category	Respondents	
		Number	Percentage (%)
Age (Years)	Young (18-35)	46	38.98
	Adult (36-49)	39	33.05
	Aged (50 Above)	33	27.97
Family Size	Small (2-4)	36	30.51
	Medium (5-8)	68	57.63
	Large (>9)	14	11.86
Sex	Male	65	55.08
	Female	53	44.92
Occupation	Agriculture	69	58.47
	Business	24	20.34
	Others	25	21.19
Education	Literate	81	68.64
	Illiterate	37	31.36
Residential Status	Native	66	55.93
	Migrant	52	44.07

Distribution of *Mikania micrantha*

Map was prepared by using GIS software. The distribution of *Mikania* has been found throughout the community forest. It was found that there was no distribution of *Mikania* in private land of 100% respondents.

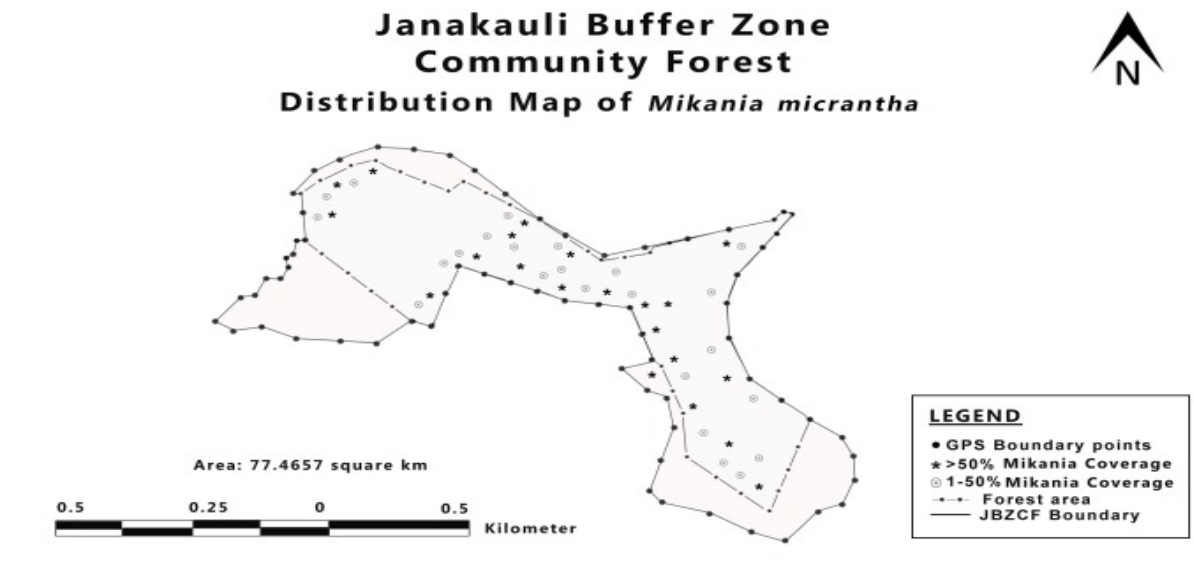

Figure 3: Distribution map of *Mikania micrantha*

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Mikania has been reported spreading from eastern to central Nepal in low altitude below 1400m which has not yet been found from west of Rupandehi district (Baral, 2004). A recent report has indicated that it has already reached as far west as Kapilvastu District in the vicinity of Jagdishpur Reservoir (Siwakoti, 2007). About twenty percent habitat of Chitwan National Park in southern belt is covered with *Mikania* species (Karki & Paudel, 2013). It was found with higher invasion in the area with crown coverage 20-85% (Sapkota, 2009)

Effects of *Mikania micrantha*

a. Effect of *Mikania micrantha* on regeneration status of native tree species

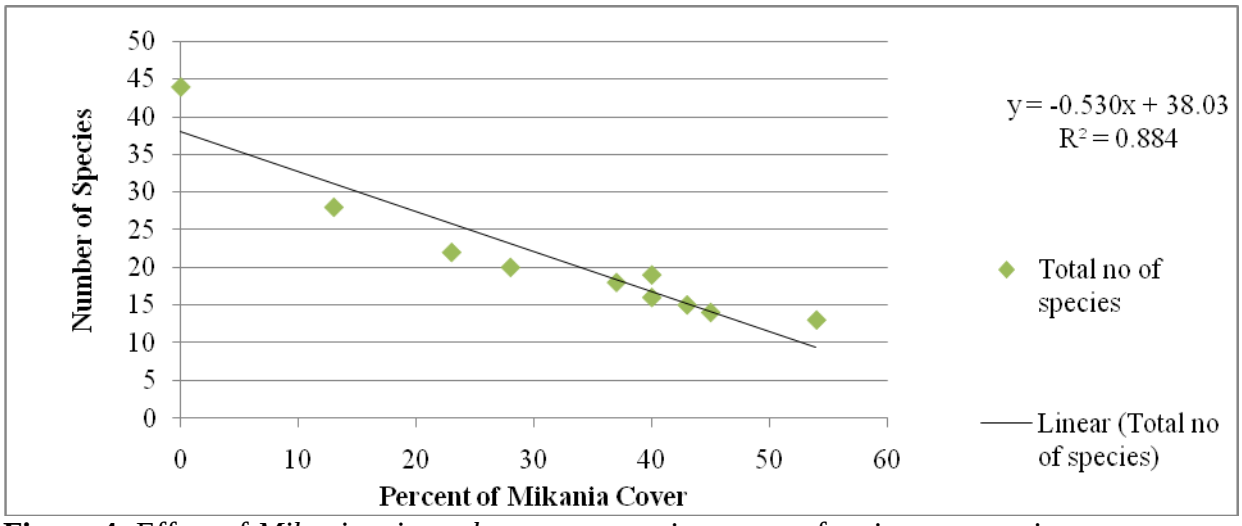

Figure 4: Effect of *Mikania micrantha* on regeneration status of native tree species

Regression analysis showed that the number of plant regeneration of native tree species decreases by 0.530 unit with every 1 unit increment in *Mikania* crown cover. Increases in 2% of *Mikania* crown cover, plant regeneration will decrease by 1 number (Fig. 3). Negative effect of *Mikania* invasion on native species, biodiversity and livelihood of forest dependent community has been well studied in Chitwan National Park (Sapkota, 2007; Siwakoti, 2007; Ulak, 2010; Murphy et al., 2013; Rai & Scarborough, 2014; Shrestha & Dangol, 2015). This is the one of the study that reports the effect of *Mikania* invasion on regeneration condition of native tree species which shows that with the increase in 1 unit percentage of *Mikania*, there will be 0.504 units decrease in regeneration number of native forest species.

b. 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 portion of the respondents (48.31%) believed that *M. micrantha* was introduced via local river flood in 1992, while 24.58% of them had no idea when it arrived in their community forest (Table 2a). While 42.37% of the respondents indicated that the vine had negative effects on their livelihoods, the remaining respondents (57.63%) had mixed perception about its effects; with 27.97% failing to recognize

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any effect (Table 2b). The majority of respondents also indicated that *Mikania* had significantly decreased the provision of fuel wood and fodders (55.93%), while 22.88% of the respondents showed that there was no significant effect of the invasive species to the native forest resources (Table 2c).

Table 2: Arrival of *Mikania micrantha* and its effect on daily life and forest resource

	Respondent	
	Number	Percentage
a)Date of arrival of *Mikania*		
After floods in 1992	57	48.31
Few years before	31	26.27
Don't know	29	24.58
b)Effect of *Mikania* on daily life		
Harmful	50	42.37
Can't say	35	29.66
Nothing	33	27.97
c)Effect of *Mikania* on Forest resources		
Negative on forest but positive on livelihood	3	2.54
Increased fuelwood and decreased fodder	18	15.25
Decreased fuelwood and fodder	66	55.93
Decreased grass, fodder, fuelwood	4	3.39
No change	27	22.88

The abundance of invasive plants usually reduces the availability of native plants, which can influence the delivery and quality of forest products, and ultimately affect the livelihood strategy of rural farmers, as forest products are the major farm household production input (Rai et al., 2012a). This is because plant species richness and ecosystem services are intricately linked, and a change in the state of one of these variables can be expected to have an impact on the other (Costanza et al., 2007). In general, the vulnerability of rural livelihoods and control costs increase with increased abundance of invasive plants (Shackleton et al., 2007).

Utilization of *Mikania micrantha* for household level

According to the Figure 3, the less number of beneficial insect were recorded as 24.44 % as compared to 75.56% to harmful insects study rice field.

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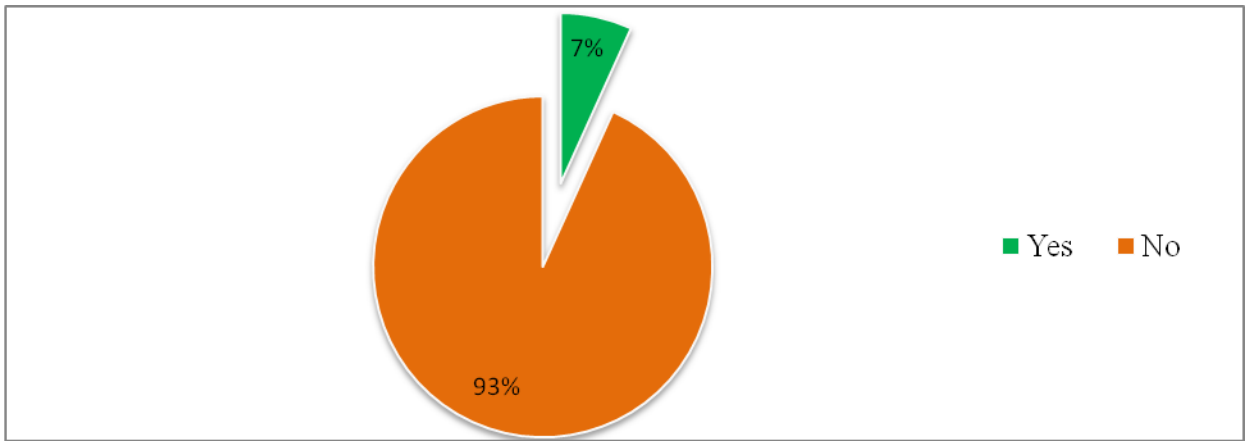

Figure 5: Utilization of *Mikania micrantha* for household level

6.78% of the respondents were using *Mikania* in household level (Fig. 4). The rural people were using *Mikania micrantha* for various purposes with the decrease in availability of natural forest products mainly during the dry season. Respondents who said they were using *M. micrantha* for making briquettes (65%), as fodders (58%), medicine (49%), and manure (30%) (Fig. 5)

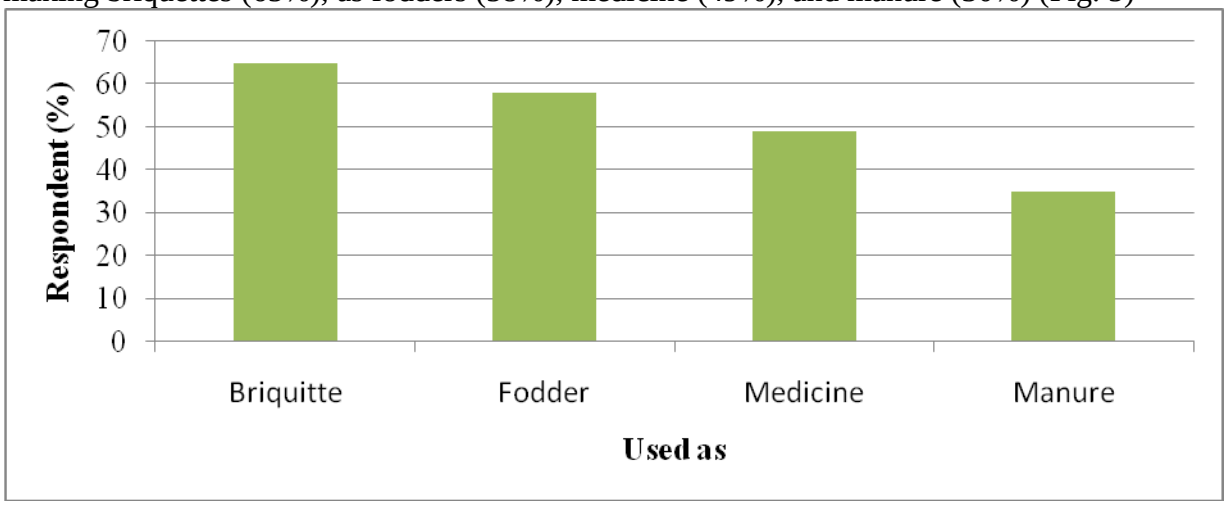

Figure 6: Uses of *Mikania micrantha* by communities in the study area

(Sapkota, 2009) have reported that they have started to feed little bit on *Mikania* however the species has been used just as an emergency food. Twenty three percent of the households sampled indicated that *mikania* is collected for fodder on an ad hoc basis from the core Park and community forests (NTNC, 2009; Rai et al., 2012). Different test results show that the use of this weed to produce briquette fuel will generate a potential source of alternative energy and will help in conserving biodiversity in long run (Singh et al., 2013). *M. micrantha* was also used as fodder to feed livestock despite the fact that it has been 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

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infestation directly pressurizes the supply of those products from the buffer zones (Rai et al., 2012b; Sapkota, 2007). The uses of the invasive plants are likely to be constrained as the basic forest products including firewood and fodder they offer are mostly secondary rather than preferred since they are being used during the dry season, when there is a scarcity of good quality fodder. This indicates that the accidentally transported species such as *Mikania, Chromolaena,* and *Lantana* challenge the ability of the invaded landscape to farm and prosper (e.g. McWilliam 2000; Siwakoti 2007). In the absence of external support, the farm household response to invasive plants is to make the best out of the worst situation. They, therefore, use invasive plants as fodder, fuelwood and fencing to adapt to the changing situation incurred due to the colonization of invasive plants. On the other hand, these environmental negative can be transformed into economic goods with external support (Hall 2009; Kannan et al. 2008). For example, *Chromolaena* is being used to prepare compost by the respondents and in other parts of Nepal to make bee-hive briquettes (e.g. Integrated Development Society 2008). This indicates that invasive plants may contribute to diversify rural livelihoods through human intervention. This could be the reason that the number of *Chromolaena* users outnumbered its non-users.

CONCLUSION

This study shows the distribution of Mikania micrantha in total forest cover area and some parts of grass land adjoining Dungra khola of JBZCF. Distribution of Mikania in the private land was not found. Regression analysis showed that increases in 2% of Mikania crown cover, plant regeneration will decrease by 1 number. The effects of the invasion of M. micrantha on rural livelihoods depend 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. Accidently 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. Only 6.78% of respondent were using Mikania in household level. The use of Mikania is to produce briquette fuel, fodder, medicine as well as manure. The threat of invasive alien species to biodiversity is a problem that may undermine other conservation efforts. Actions must be put in place to address this issue but these must be based on a sound understanding of the biology of invasions.

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Author Contributions

S. Shrestha designed and performed experiments, analyzed data and wrote the paper.

Conflicts of Interest

The author declares that there is no conflict of interest.

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