Estimating the Benefits of Managing Invasive Plants in Subsistence Communities

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Abstract

Forests in developing countries are significant because of their high biodiversity. However, there are concerns regarding the current rate of destruction and loss of forest ecosystems in these countries. The causes of the depletion of forest resources are multifaceted and complex. Recently, the infestation of exotic plant species has emerged as one of the major threats to forest ecosystems throughout the world. This study addresses two particular limitations of current research efforts on the invasion of exotic plants. The first limitation is that previous studies have disproportionately focused on industrialised countries. The second is that the majority of studies have frequently ignored the non-market effects of invasive plants. Non-market valuation methods are can be used to provide estimates of the benefits of managing invasive plants by eliciting public preferences. However, environmental economists face several practical and theoretical challenges in determining willingness-to-pay (WTP) for invasive plant management in low-income communities. For example, the livelihood effects of invasive plants on rural livelihoods are contentious and estimation of the value of non-market benefits is not straightforward in a subsistence economy due to the relatively low income and education levels of local communities.

This study addresses the issue of estimating the willingness of members of subsistence forest-based communities to contribute to the management of the invasion of exotic plant species by applying the stated preference method of a choice experiment (CE). The study was carried out in the buffer zone of Chitwan National Park in Nepal, where the neotropical vine *Mikania micrantha* is rapidly colonising. The specific question that the research addresses is that of eliciting the subsistence

communities' willingness-to-contribute (WTC) towards the management of the invasion of *Mikania micrantha*.

Two CE surveys were designed to determine the preferences of the buffer zone households with respect to the management of *Mikania micrantha*, and to address the challenges associated with stated preference surveys in subsistence economies. In the first CE (CE-I), respondents of the buffer zone forest user groups were asked whether they were willing to contribute towards the mitigation of invasive plants in the forest in monetary terms. If their response was negative, they were provided with the option of contributing in labour terms in order to address the problem associated with low household income levels. Estimating WTC in terms of labour creates the challenge of placing monetary values on the number of labour days declared by the respondents. This theoretical complexity is confounded by the fact that the opportunity cost of time varies across individuals. Thus, in the second CE (CE-II), the social opportunity cost of labour was estimated by including two cost attributes (monetary and labour) to create choice scenarios.

The results of the household surveys indicate that the invasion of *Mikania micrantha* undermines rural livelihoods and disproportionately affects local households. The results of the CE data analysis show that buffer zone households support a *Mikania micrantha* management programme. However, the existing practice of eliciting individual preferences in only dollar terms excludes the concerns of approximately two-thirds of the rural population—particularly those in marginalised groups. The estimated mean household WTC in monetary terms outbid the mean household WTC in labour terms for the proposed programme. The results also suggest that

rural farmers value their time in this context at a different rate to the current market wage rate.

The estimated value of a *Mikania micrantha* management programme not only focuses on the overall value of mitigation of invasive plants, but also on the WTC for each attribute. This research illustrates that a CE can be applied in a low-income community to estimate the non-market values of a forest ecosystem. The inclusion of non-market values can make a significant contribution to forest policy and sustainable development in the rural areas of developing economies.

The results from this study are likely to:-

- Provide an increased awareness of environmental problems, such as the colonisation of invasive species;
- Provide policy-makers with valuable information regarding community preferences for invasive species management programmes; and
- Enhance the application of non-market valuation as a tool for environmental decision-making.

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Thesis Related Outcomes

Peer Reviewed Papers

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List of Abbreviations

ASC:	alternative specific constant
BZ:	Buffer zone
BZCF:	buffer zone community forest
BZCFUG:	buffer zone community forest user group
CBA:	cost-benefit analysis
CBF:	community-based forestry
CE:	choice experiment
CE-I:	choice experiment one
CE-II:	choice experiment two
CL:	conditional logit
CNP:	Chitwan National Park
DNPWC:	Department of National Park and Wildlife Reserve
IIA:	independence of irrelevant alternatives
IPS:	invasive plant species
NGOs:	non-government organisations
NRs:	Nepalese Rupees
RPL:	random parameters logit
UNESCO:	United Nations Educational, Scientific and Cultural Organization
US:	United States of America
WTC:	willingness-to-contribute
WTP:	willingness-to-pay

Chapter 1 : Introduction of Thesis

1.0. Background

Forests in developing countries have received considerable attention in international climate policy discussions. Forest depletion in these countries is responsible for approximately one-fifth of all anthropogenic carbon emissions (IPCC, 2007). However, despite the fact that they act as a carbon sink, these forests provide numerous global benefits. They are the richest of all terrestrial ecosystems as they house the greatest biological diversity of plants and animals. In addition, more than one billion people rely on these forests to maintain their wellbeing (Myers et al., 2000; Scherr et al., 2003). The causes and drivers of deforestation are multifaceted, and range from subsistence use to commercial exploitation (Geist and Lambin, 2001; Fine, 2002). For this reason, no single strategy can be effective to protect these forests and curb the current destructive trend. Reversing this trend requires addressing a myriad of social issues, including poverty and governance decisions (Agarwal, 2001; Scherr et al., 2003; CFD, 2004).

Forest governance is receiving increasing attention in international forest policy discussions, which are primarily aimed at addressing the problems associated with the depletion of forest resources. The participation of local community and market actors in addressing future governance challenges is necessary to lead to effective governance (Agrawal et al. 2008). Economic valuation is considered a tool for promoting good ecosystem governance through the supply of information about the values, incentives and options of forest management (King, 2007). In developed countries, non-market valuation methods have been widely used to provide

estimates of the total economic values of a wide variety of environmental effects. This has been undertaken by eliciting public preferences.

Non-market valuation methods allow for the estimation of the potential benefits of proposed policies or programmes. They rely on surveys that are designed to estimate consumers' willingness-to-pay (WTP) for hypothetical changes in environmental goods. In other words, respondents are asked to put a price on goods and services that are not traded in conventional markets. Typically, these goods and services are the outcomes of environmental programmes that address the problem under investigation. The WTP measures describe utility changes in the presence and absence of the environmental policy or programme.

The use of non-market valuation techniques to inform policy development is limited in developing countries in general, and in rural areas in particular. The existence of the Environmental Kuznets Curve effect confirming the inverted U-shaped relationship between income and deforestation indicates that environmental goods are luxury goods (Bhattarai and Hammig, 2001), and suggests that low-income communities have too little income to be environmentally sustainable (Martínez-Alier, 1995). This can discourage applied economists from conducting non-market valuation surveys in low-income communities, as a high protest vote can be expected against proposed new taxes for environmental services, and estimated WTP is likely to be relatively low (Bennett and Birol, 2010).

The results of lower WTP can be interpreted as people in subsistence economies not appreciating environmental benefits. This means that policy information based on

such estimations is incomplete. Hence, information with or without the values of non-market benefits may lead to flawed policies, particularly in developing countries where good governance is lacking. Consequently, there is no situation that benefits both the forest and those people in rural areas with low incomes who are dependent on forest ecosystem services. In this context, forest management appears an unattractive land use form. However, natural resources are important inputs for farm household production functions in many subsistence communities. Rural communities have already demonstrated their concern for and willingness to contribute to natural resource management (Ostrom, 1990). The challenge is finding a way to capture these communities' role in producing and providing forest goods and services within a non-market valuation framework.

1.1. Research Problem

In addition to agricultural expansion, the invasion of exotic species poses a threat to the conservation of tropical forests (Usher, 1991). Invasive species are non-native species, which may include plants, animals and microbes. These species have been relocated deliberately or accidentally as a result of the expansion of global trade and increases in human mobility (Meyerson and Mooney, 2007; Holmes et al., 2009). As spillovers of economic globalisation, invasive species are widely regarded as one of the greatest threats to native forest ecosystems and species richness (Wilcove et al., 1998; Moore, 2000; D'Antonio and Kark, 2002). Their introduction undoubtedly creates a change in the supply of ecosystem services as a result of the modification of the structures and functions of the recipient forest ecosystems (Wilcove et al., 1998). For example, invasive plants can influence fire regimes, nutrient cycling, hydrology and energy budgets (Mack et al., 2000).

The study of invasive plant species (IPS) in developing countries is necessary for several reasons. Tourism is a key foreign exchange earner for most developing countries (Mastny, 2001). However, tourism can increase the transportation of exotic species, as these countries do not have sufficient resources to control their imports and territory (Nun˜ez and Pauchard, 2010). Once introduced, invasive plants are likely to become established, particularly in disturbed and fragmented habitats (Moore, 2000; Fine, 2002). Forests in developing countries receive increasing pressure from burgeoning populations and their related anthropogenic disturbances, such as fragmentation due to land use changes. These anthropogenic activities increase the susceptibility of forest ecosystems in developing countries to invasion by exotic plants, thus bringing these previously pristine areas under the invasion of exotic plants.

The negative effects of IPS can be more severe in developing countries. Forests in these countries tend to have highly diverse habitats, and their populations tend to be reliant on forest resources (Myers et al., 2000). Typically, local communities are more sensitive to changes in the supply of available forest products. Hence, they have a greater will to control invasive plants, while the availability of low-cost labour makes large-scale control programmes more feasible (Nun˜ez and Pauchard, 2010). However, research into invasive species is disproportionately focused on developed countries and has often ignored tropical forests based on the assumption that they are resistant to invasion because of their high species diversity (Fine, 2002).

The effects of invasive plants, particularly on rural communities, are more complex than the negative ecological consequences. These plants produce positive externalities, such as the provisioning of basic forest products, the diversification of livelihoods and the rehabilitation of degraded areas (Pasiecznik, 1999; Foster and Sandberg, 2004; Shackleton et al., 2011; Rai et al., 2012b). Therefore, the effects of invasive plants in native ecosystems cannot simply be translated as their negative effects on rural livelihoods. This complexity in the livelihood effects of IPS signals to policy-makers that the management of an invaded rural ecosystem is not straightforward. Social conflicts may arise if public preferences are not thoroughly understood. In this context, the research problem is to understand how specific IPS are affecting the livelihoods of rural communities.

Social awareness is an important tool in gaining public support for the management process (CBD, 2008). This can minimise the potential for conflicts during invaded area management. To ensure this, policy-makers should understand:

i. The effects of particular species on rural livelihoods; and
ii. The costs and benefits of management programmes.

Such information can be generated by assessing the economic effects of invasive plants. There is an increasing amount of economic literature associated with biological invasion. A review of this literature highlights the need for non-market valuation studies to capture a comprehensive account of the effects of invasive species on forest ecosystems (Born et al., 2005; Olson, 2006; Holmes et al., 2009; Pejchar and Mooney, 2009). There is a lack of such studies because most assessments have overlooked any costs and benefits that are beyond the market system (Hoagland and Jin, 2006).

Large non-market economic effects of invasive plants can occur in forested areas close to population centres (Holmes et al., 2009). This means that rural populations in developing countries are most affected by the invasion of exotic plants because the rural landscape is comprised of scattered human settlements with forest patches and farmlands. Estimations that exclude the values of non-market services therefore understate the effects of invasive plants. Information based on such estimations can be counterproductive, as the level of social awareness is an important factor in IPS management (Nun˜ez and Pauchard, 2010). There is a need to capture the full effects of IPS on human wellbeing, including the magnitude of this effect on communities (Pejchar and Mooney, 2009). Hence, the research problem here relates to how much the community is willing to contribute to the management of IPS.

Stated preference methods are considered viable tools for exploring social preferences and gauging public support with respect to IPS management (García-Llorente et al., 2011). The implementation of stated preference surveys in developing countries has previously encountered two particularly difficult barriers—respondents' levels of education and income. Most non-market valuation studies in developing countries have primarily focused on issues relating to education levels and familiarity with stated preference surveys (Wang et al., 2007; Do and Bennett, 2009; Birol and Das, 2010). The complexities relating to communities with low incomes, high rates of unemployment, informal markets and limited access to formal financial institutions are yet to be approached.

Some stated preference studies in developing countries have augmented the existing practices of asking respondents to bid in dollar terms (Mekonnen, 2000; Alam,

2006; Hung et al., 2007; O'Garra, 2009). These studies provide respondents with the option of expressing their contribution in non-monetary terms, such as labour, as an alternative to monetary terms. This seeks to address the cash constraint problem. This thesis attempts to assess the issue through estimated willingness-to-contribute (WTC) for an IPS management programme sensitive to the mode of contribution.

Usually, the results of stated preference surveys are used in social cost-benefit analysis (CBA). However, a problem arises when aggregating individual contributions expressed in labour terms. This is because the opportunity costs of time vary across individuals and situations. The challenge is to estimate the social opportunity cost of time spent in public activities, such as invasive plant management. This provides an appropriate rate to convert the declared amount of labour into a monetary value. Therefore, a subsequent research question addressed in this thesis is whether stated preference surveys are capable of estimating the shadow value of time.

1.2. Research Objectives

The main aim of this research was to enhance the forest management decision-making process in developing countries. For this purpose, a CBA of the forest management programme of IPS was carried out using the WTP approach. The benefits of managing the invasion of exotic plant species in terms of WTP was estimated using choice experiment (CE) surveys. This estimation provided the potential for the application of stated preference surveys in forest management decision-making in subsistence communities.

At a more specific level, the objective of the research was to assess the effects of invasive species on the livelihoods of rural communities. In addition, by using CE, this research sought to elicit subsistence communities' preferences for the mitigation of damages caused by invasive species. The research sought to address theoretical and practical issues to extend the CE survey by using a non-monetary mode of contribution to estimate WTP in low-income communities. This thesis also estimated rural communities WTC to IPS management in terms of labour.

1.3. Research Approach

1.3.1. Choice Experiment

The research reported in this thesis provided two sources of information. First, it estimated the public benefits of managing IPS. Second, it addressed the complexity associated with using CE surveys in low-income economies. A CE is a stated preference method of non-market valuation. It has become popular in non-market valuation, as it has demonstrated several advantages (Hanley et al., 1998a; Rolfe et al., 2000). The CE method not only estimates WTP for environmental policy, but also estimates the part-worth utility of each identified attribute included to create choice scenarios.

Two CE surveys were conducted to estimate the public benefits of managing IPS. The first CE (CE-I) was designed to address the cash constraint problem of low-income households. Respondents were provided with the option of expressing WTC in labour terms, if they did not wish to participate in monetary terms, before completing the choice task. When using a labour mode of contribution, the estimation of WTC labour creates a theoretical challenge: namely, converting this

WTC to a monetary value. Therefore, the second CE (CE-II) was designed to estimate the social opportunity cost of labour spent in invasive plant management programmes. Both monetary and labour contributions were included as attributes in choice sets to estimate a dollar value for the amount of labour declared by respondents. These CEs demonstrate the potential for further implementation of CE as a tool for informing environmental decision-making in low-income communities. Challenges to the implementation of CE surveys in a subsistence economy were dealt with systematically. The linkage between rural livelihoods and invasive species were also assessed as part of the survey.

In accordance with the Environmental Kuznets Curve relationship, developing nations face the challenge of balancing economic growth with forest conservation. In the absence of the values of non-market services, environmental programmes may be given too little influence in policy decisions. This may lead to the inefficient use of natural resources and ultimately compromise public policy (Costanza et al., 1997). Hence, the use of non-market valuation techniques in low-income communities can be a vehicle for local sustainable development.

In summary, the research approach of this thesis sought to elicit public preferences for IPS management by using a CE in a subsistence community. It also addressed the complexity of using CE surveys in such economies. Specific questions associated with the quantification of the effects of IPS in rural livelihoods and the implications of CE were also addressed.

1.3.2. Case Study: *Mikania micrantha* Invasion in Nepal

The CE survey in this study quantified the benefits of managing IPS in a low-income community by using the WTP/WTC approach. The selected area for this case study was the buffer zone (BZ) of Chitwan National Park (CNP) in Nepal. The choice of this site was motivated by the intensity of the colonisation of Mile-a-Minute (*Mikania micrantha*), which is a widespread weed in the tropical and subtropical regions of Nepal. CNP is an important biodiversity region, and was declared a world natural heritage site by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1984. The park is also an income source for the local communities and is one of Nepal's most popular tourist destinations.

1.3.2.1. Forest Management in Nepal

More than two-thirds of Nepal's population lives in rural areas and practises subsistence farming. Empirical studies show that farm households in rural areas depend on forest resources for their survival and daily livelihoods (see for example; Adhikari et al., 2004a; Pandit and Bevilacqua, 2011a). These resources include things such as fuelwood, fodder, medicinal herbs and fibre. The rural areas of Nepal are comprised of small forest patches, human settlements and agricultural land, and are not easily accessible (OED, 2001). The strong association between rural livelihoods and forest products is considered a primary reason for the failure of many previous centralised and protectionist government policies (Acharya, 2002), as these forest management strategies have focused on keeping local communities out of the forest.

The dependency of communities on forest resources is widely acknowledged as a major determinant of forest policy in many developing countries. This has led to a paradigm shift in forest management, from a state controlled policy approach to participatory forest management. Community-based forestry (CBF) programmes have subsequently become a dominant forestry strategy, giving forest management authority to local forest users (Pokharel, 2011). The participation of forest users in forest management and their access to decision-making have made CBF programmes the most successful decentralised programmes in Nepal (Shrestha et al., 2010; Pandit and Bevilacqua, 2011a). CBF programme has been heralded as a vehicle to achieve local sustainable development by assisting forest dwellers out of poverty and improving social equity (Agrawal and Ostrom, 2001; CFD, 2004).

In Nepal, there are over 15,000 community forest user groups directly involved in managing over one million hectares of forest lands (DNPWC, 2011; DoF, 2011). This encompasses one-third of the total population and approximately one-fourth of the total forest area of Nepal. Various laws and policies encourage people's participation in forest management, as envisaged by the Master Plan for the Forestry Sector (MPFS, 1988). This may be the main reason that Nepal is recognised as one of the leading developing countries to have conservation priorities (Agrawal and Ostrom, 2001). Four different models of CBF are in practice:

i. Community forestry in small forest patches;
ii. Collaborative forest management in large patches of Terai[1];
iii. BZ community forests in the BZs of protected areas; and
iv. Leasehold forestry programmes in degraded areas.

[1] Nepal is divided into three physiographic regions: Himalayan, Mid-hills, and Terai from north to south respectively. Terai begins at the southern edge of the Siwalik hills and is recognized as an area of fertile soil.

These programmes are moving towards integrating social and economic aspects into forest conservation through social mobilisation; the inclusion of marginalised groups including those with low incomes, women, and indigenous people; and equitable benefit sharing (CFD, 2004; Adhikari et al., 2007). The implementation of the CBF programme in Nepal diversifies the role of local farmers as forest users and managers, and changes the role of forestry officials from policing to facilitating. The coordination between local people and the forestry department has been institutionalised through the formation of forest user groups. These groups determine forest management activities and develop mechanisms to share the benefits and costs in order to optimise community welfare (Acharya, 2002; Adhikari et al., 2007).

The functioning of forest user groups helps reduce the potential problems of free riders in common property management and overcomes the institutional constraints of forest protection in developing countries (Ostrom, 1990; FAO, 2009). The contribution of forest user groups has been widely acknowledged for slowing the rate of deforestation, rehabilitating degraded land and contributing to rural development (OED, 2001; Shrestha et al., 2010; Pandit and Bevilacqua, 2011a). Generally, forest user groups are directed by two guiding documents: the community forest constitution and the community forest operational plan. The first document is associated with the norms of the user group and the latter describes the detailed planned operations of the community forests. Both documents are prepared by forest user groups and approved by a forest users' assembly.

In general, developing countries have not prioritised the control of invasive species (Nun˜ez and Pauchard, 2010). The CBF management programmes in Nepal follow the same trend. Nepalese forest policies mainly concentrate on involving people in forest management, and local people have a responsibility to manage their forests. While, the invasive of exotic plants in forest ecosystems is not a new phenomenon, identifying invasive plants as an element of forest management and linking this to rural poverty is not an easy task. These plants' additional potential positive effects, such as providing economic and ornamental values, have sparked controversy as to whether they are friends or foe, pest or providence, or weed or wonder (Pasiecznik, 1999; Foster and Sandberg, 2004; Shackleton et al., 2011). This ambiguity demonstrates the need to understand the role of particular IPS in rural livelihoods prior to making decisions.

1.3.2.2. Buffer Zone of Chitwan National Park, Nepal

BZs in Nepal are the peripheral areas of protected areas (national parks and wildlife reserves), including villages, settlements or hamlets, as declared by the Government of Nepal (GoN, 1996). The BZ of CNP covers 750 square kilometres, including 37 village development committees[2] and the two municipalities of Chitwan and Nawalparasi districts (Figure 1.1). It was established in 1996 to facilitate more harmonious relations between the local people and CNP (Straede and Helles, 2000). A total of 21 user committees with 44,918 households manage the BZ of CNP (DNPWC, 2011). Forest patches in the BZ have been categorised into four groups: BZ community forest, BZ religious forest, BZ private forest and BZ forest (GoN,

[2] In Nepal, village development committees are the lower administrative part of the Ministry for Local Development. Each district may have several village development committees and municipalities. The former is rural focused, while the municipality is urban focused.

1996). The Government of Nepal holds ownership of all types of forest, except the BZ private forest.

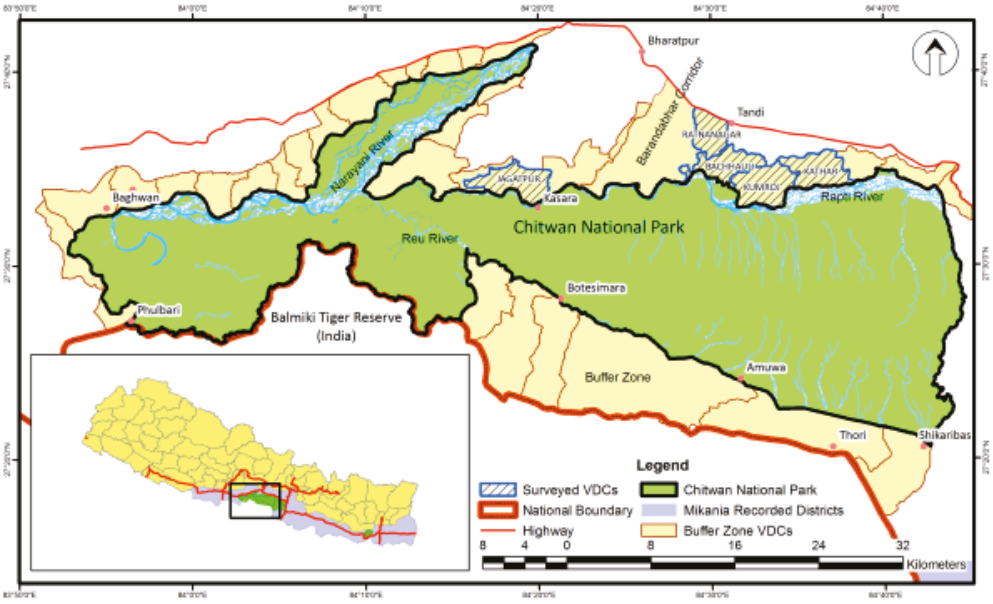

Figure 1.1 Study Area

The BZ community forest (BZCF) is the dominant forest category and is managed by the BZ community forest user group (BZCFUG). The BZ management regulation (1996) defined the user group as a group of people representing each and every household of the village, hamlet or settlement under the units of the BZ. BZCFs are situations in which management of the forest is the responsibility of user groups. These groups hold management ownership, after the operational plan is ratified by the Chief Warden of the protected area (Jones, 2007). This plan usually extends for five years and is prepared by the BZCFUG and approved by a forest users' assembly before ratification by the Chief Warden. It is undertaken with technical assistance from forestry rangers of the Department of National Park and Wildlife Conservation and local non-government organisations (NGOs).

BZ management aims to develop alternatives to the use of the national park for forest fringe villagers, to compensate the local community for their exclusion from national park resources, and to create incentives for local populations to change their practices in protected areas (Agrawal and Ostrom, 2001). The provision of BZCFs helps minimise pressure on protected areas by redistributing benefits to local communities and involving them in park management (Adhikari et al., 2004b). This also helps generate income from eco-tourism (Mehta and Kellert, 1998). Local communities receive 30 to 50 per cent of the park's total annual income for community development. The income a BZ community receives increases with the income of the protected areas. This performance-based benefit-sharing mechanism develops community ownership in protected area management. The participation of local communities in BZ management contributes to reducing conflicts between the park and people, and thus creates benefits for both.

The formation of BZCFUGs succeeds in developing positive perceptions among the local people regarding the management of CNP. This creates sufficient incentive for local cooperation with the potential for increased access to forest resources, and because it fosters the perception of ownership of BZCFs among communities (Adhikari et al., 2004b; Jones, 2007). However, the infestation of IPS, particularly *Mikania micrantha*, in both the core area and BZs is emerging as a new challenge. This infestation has contributed to habitat destruction (Poudel et al., 2005; Sapkota, 2007), and has consequently led to reduced availability of forest products, and fewer tourists.

BZ households are trying to minimise the adverse effects of the exotic species invasion. For example, they are using invasive plants as fodder, even though these are not preferred species (Rai et al. 2012b). As BZ communities have comparatively low levels of education, the possibility of alternative employment opportunities may be limited (Table 7.1). Low income households experience the greatest impact as a result of infestations because they rely on forest resources more than their higher income neighbours do (Adhikari et al., 2004b). In this context, there is increased likelihood of exploiting the core area of CNP by BZ communities to collect forest products, including fodder and fuel wood. In brief, the degradation of BZCFs increases pressure in the core area of the national park. Hence, controlling the spread of *Mikania* in the BZ also contributes to conservation inside the national park.

1.3.2.3. Mile-a-Minute (*Mikania micrantha*) in Nepal

Nepal is likely to host many exotic species because of its government's priority to promote tourism and increase the volume of trade. In addition, inadequate institutional capacity, such as the absence of policy, quarantine facilities and researchers, is likely to create a favourable environment for the establishment of exotic species. In Nepal alone, over 150 invasive species have been identified in various ecosystems, including forests, fallow lands, grasslands, croplands and wetlands (Tiwari et al., 2005). Major plant species invading the forests in Nepal include *Mikania micrantha*, *Chromolaena odorata*, *Imperata cylindrica*, *Parthenium hysterophorus* and *Lantana camara*.

Mikania micrantha (hereafter, *Mikania*) is a native South and Central American climbing perennial weed that has become a significant IPS in many tropical and

subtropical Asian countries (Zhang et al., 2004; Willis et al., 2008). The plant was introduced to Asia on a number of occasions, such as via introduction to the Botanical Gardens and by use as a plantation cover crop (Holmes, 1982; Cock et al., 2000; Li et al., 2006). The vine is listed as one of the 32 worst terrestrial invasive plants (Lowe et al., 2000).

Two main characteristics make this vine notorious. First, it exhibits vigorous and rampant growth. It reproduces vigorously by both vegetative and seed (Swamy and Ramakrishnan, 1987; Kuo et al., 2002). Its common name, 'Mile-a-Minute', signifies its terrific growth rate—young plants can grow approximately eight to nine centimetres within 24-hour periods and are able to colonise entire terrestrial ecosystems within a fortnight (Choudhury, 1972). Once established, it can become the dominant plant. It carpets vast areas, invades agricultural and non-agricultural lands, and badly damages tree crops and agro-forestry/multipurpose trees (Choudhury, 1972; Abraham et al., 2002). Habitats that possess extensive past disturbances are particularly vulnerable to the vines (Willis et al., 2008). However, the vine's growth in native habitats is restrained (Shao et al., 2005).

The plant's second characteristic is that unlike other invasive plants, *Mikania* not only displaces native vegetation, but also kills it. It climbs to the top of the canopy and creates a dense cover that damages or kills other plants by blocking light and physically smothering the other plants (Holm et al., 1977). Its allelopathic[3] effects on neighbouring plants are likely to enhance conditions for a *Mikania* monoculture (Ismail and Mah, 1993). For example, the forest of Neilingding National Nature

[3] Allelopathy is the effect of one plant on another plant by the release of chemicals. This can be either beneficial or harmful.

Reserve in Shenzhen, China, is degrading into shrub-land and a *Mikania* monoculture (Li et al., 2006). Forests dominated by *Mikania* have a reduction in density of associated herbaceous species (Ismail and Mah, 1993).

In Nepal, *Mikania* was first reported in 1963 in the east (in the Ilam district) before spreading west (Tiwari et al., 2005). The geographical settings, trade volume and provision of an open border indicate that India is the most likely passage for invasive plants to enter Nepal (Rai et al., 2012b). *Mikania* was introduced to India after World War II to camouflage airfields. It was transported with tea saplings or seeds from Assam in north-east India to Ilam in Nepal (Cock et al., 2000; Tiwari et al., 2005). The species is known to locals by various names, including *Bakhre lahara*, *Banlude jhar*, *Bahramase* and *Lahara banmara*. The affixes of these local names, such as *banmara* ('forest killer') and *Jhar* ('weeds'), reflect the local people's perception of *Mikania* and indicate its destructive behaviour towards native forest vegetation.

Mikania is the most problematic terrestrial invasive species in the tropical areas of Nepal (Poudel et al., 2005; Siwakoti, 2007). The vine is now recorded in 20 eastern, central and western Terai districts of Nepal (Figure 1.2). Three protected areas have been affected by the colonisation of *Mikania*: CNP, Koshi Tappu Wildlife Reserve and Parsa Wildlife Reserve. Akin to its natural habitat, the species has been recorded along the riverbanks and moist areas and among the reed-like vegetation that surrounds standing water (Sapkota, 2007; Siwakoti, 2007). During the fieldwork for this study, the vines were observed along irrigation canals and grasslands. Its westward movement in Nepal, particularly in the tropical regions, suggests that the

colonisation of *Mikania* is likely to destroy the habitats of many charismatic mega-faunas, including the Royal Bengal Tiger (*Panthera tigris tigris*), the One Horned Rhino (*Rhinoceros unicornis*) and the Asiatic Elephant (*Elephas maximus*).

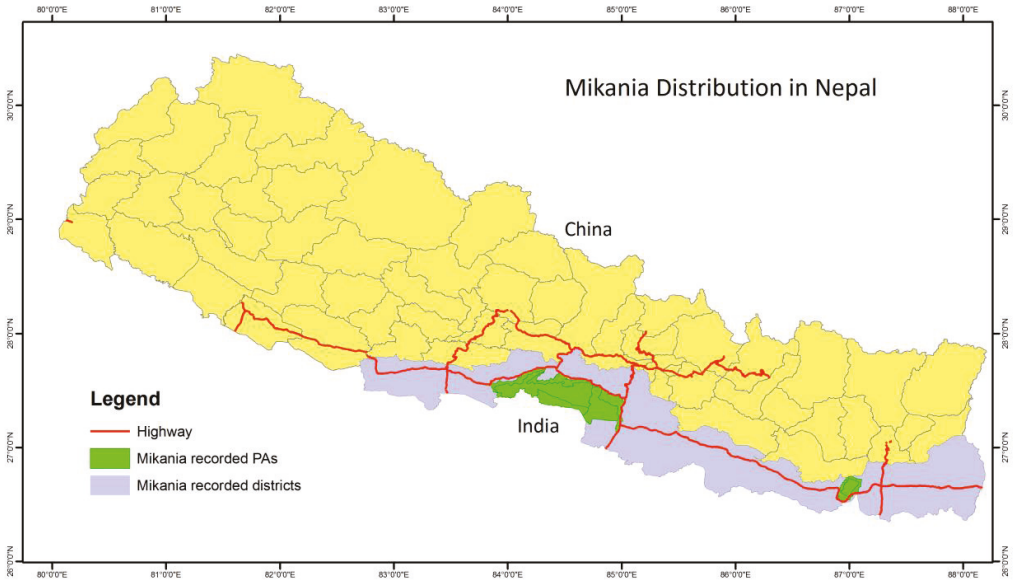

Figure 1.2 *Mikania* Recorded Districts adapted from Rai et al. (2012a)

There are several methods in place to prevent the spread of *Mikania*, including manual removal and the use of bio-agents (Abraham et al., 2002; Kuo et al., 2002; Shen et al., 2005; Lian et al., 2006). The practice of manual cutting has demonstrated that removal of the vines close to the ground once a month for three consecutive months in the summer or autumn can eliminate 92 to 98 per cent of the vines (Kuo et al., 2002; Lian et al., 2006; Rai et al., 2012a). This method seems suitable in the context of BZCFUGs, as forest users contribute to forest management activities. However, BZ communities have undertaken manual removal, including cutting and uprooting, to control the growth of *Mikania* and have found that, without assistance, mitigation is unachievable (Rai et al., 2012b). Typically, BZCFUGs

undertake forestry operations during the winter and only once each year. As winter is the flowering and fruiting time of *Mikania*, cutting in this season may actually help spread the seed (Rai et al., 2012a).

In the BZ of CNP, *Mikania* has demonstrated its hostility by influencing over 100 native plant species—particularly plants with diameters of less than 30 centimetres (Sapkota, 2007). It has covered up to 80 percent of the BZCFs in CNP and Koshi Tappu Wildlife Reserve (Sapkota, 2007; Siwakoti, 2007). The patterns of spread of *Mikania* in Nepal and its aggressiveness indicate that it may create a monoculture destroying biodiversity, particularly in the Terai region, if steps are not taken to control it immediately. The urgency of coming up with a mitigation plan arises from this fact. Otherwise, the abundance of invasive species may increase, subsequently increasing control costs and livelihood vulnerability (Shackleton et al., 2007). In this context, elicitation of public preferences is fundamental to implement IPS management activities in order to improve the condition of forests.

In brief, this research sought to identify information gaps regarding how *Mikania* influences the household activities of the BZ community in CNP. It sought to quantify the potential social benefits resulting from the implementation of a *Mikania* management programme. This information will:

i. Broaden understandings of the problem;
ii. Provide valuable information to assess potential programmes; and
iii. Reduces potential conflicts during the implementation phase.

1.4. Structure of the Thesis

This thesis is divided into nine chapters. Chapter Two reviews the existing literature regarding IPS and their effects on low-income communities in developing economies. It primarily introduces IPS and discusses their effects in terms of the alternation of ecosystem services and interaction with rural livelihoods. This chapter illustrates that the livelihood effects of invasive plants are often ambiguous. In this context, the first research question is developed to understand how the infestation of *Mikania* in the BZ of CNP has influenced households' activities. A preliminary study presented in this chapter indicates that BZ households are aware of *Mikania* and have a WTC to control the spread of *Mikania.* This led to the second research question that addresses whether there is potential to improve social welfare through the management of *Mikania*.

Chapter Three details the background of non-market valuation techniques to assess the economic effects of IPS. Different stated preference techniques to estimate WTP of respondents are discussed. The WTP approach is proposed to estimate the benefits of a *Mikania* management programme. The research elicits BZ households' WTP/WTC. This is done to answer the third research question: How much is the BZ community of CNP willing to pay for a *Mikania* management programme? Two further research questions regarding methodological issues related to non-market valuation in low-income economies are highlighted with reference to conducting stated preference surveys in developing countries. The fourth research question relates to the use of labour as an alternative numéraire to dollar terms. It emphasises that the estimated WTP for a *Mikania* management programme is sensitive to the mode of contribution. However, the estimated WTC in labour terms poses a

theoretical challenge when being converted into dollar terms. The problem is to estimate the shadow value of time spent in a *Mikania* management programme. In part, this thesis calculates the shadow value of time for community members of the BZ of CNP.

Chapter Four introduces the research method of CEs to estimate WTP to mitigate the damages caused by IPS. CE is based on consumer preference theory. The random utility model is designed to estimate utility functions and individual preferences. The output of the random utility model is introduced in this chapter to quantify welfare changes in terms of implicit price and total WTP/WTC. In addition, this chapter also proposed a model to assess the livelihood effects of *Mikania.*

The data collection took place in the BZ of CNP, Nepal. The process of the CE design—particularly efficient design—is discussed in Chapter Five. Two CE surveys designed for the study are described, and data collection strategies are explained. This chapter mainly focuses on questionnaire development in terms of defining the size of the experiment, including the number of attributes and choice set in each version, the framework of the questionnaire and the interview strategy used in a subsistence economy.

General hypotheses and research hypotheses are formulated in Chapter Six. The research questions developed in Chapters Two and Three are the foundations of these hypotheses. The results of the CE surveys are reported in Chapter Seven. This chapter is divided into five parts. The first section describes the socioeconomic variables included in the analysis. The second section assesses the livelihood effects

of *Mikania* and estimates the WTP of the BZ community to mitigate the damages caused by *Mikania* infestation with different modes of contributions, based on CE-I. The third section estimates the shadow value of labour spent in the forestry activities, based on CE-II. The results are linked with the hypotheses in the fourth section and the chapter is concluded in the fifth section.

Chapter Eight discusses the results presented in Chapter Seven. The livelihood effects of invasive species are discussed in terms of their mode of introduction. The research illustrates the wider use of CE; however, the validity of the application of the extended versions of CE in all environmental programmes requires further exploration. This chapter also discusses the policy implications of the results and presents the methodological issues of the implementation of CE surveys in low-income communities. The last chapter concludes the thesis by discussing its limitations, suggesting future research and offering a conclusion.

1.5. Summary

This chapter introduced the research problem central to this thesis. Forests in developing countries have received attention for their high biodiversity, the speed with which they are diminishing in size and their direct involvement with the livelihoods of more than one billion people. With economic growth, forest management issues become more complex. For example, unprecedented invasions by exotic plants are increasing with trade and travel. In this context, the establishment of good forest governance can help curb deforestation and forest degradation. This can be achieved by including non-market values in the decision-making process. For example; in Nepal, local communities manage the forests and

form common property institutions. CBF programmes focus on the multi-functionality of forests; thus, the effects of management decisions extend beyond the scope of market transactions. However, the application of non-market valuation techniques as tools in public sector decision-making in developing countries, and particularly in rural areas, has not received considerable attention.

The income levels of households is the underlying reason that the use of non-market valuation surveys has been limited—this is particularly the case for stated preference methods in rural areas. This research extends CE methods by eliciting social preferences for forest management in terms of the estimation of the benefits of mitigating IPS. The introduction of a non-monetary mode of contribution provides the opportunity for rural respondents to express their stated preferences and maximise individual utility. The CE employed here addresses the practical problem of implementing CE in subsistence economies. Previous non-market valuation literature in developing countries has suggested the use of a labour mode of contribution as an alternative to a monetary mode of contribution.

This research adds to the literature by using a CE survey to estimate the opportunity cost of time spent in public activities. It generally encourages the participation of economists in forest policy formulation in developing countries to ensure sustainable development that seeks a balance between social, economic and ecological components. This research aims to facilitate the participation of low-income communities in forest management through non-market valuation techniques. An overview of the development of research questions is provided in Chapters Two and Three.

Chapter 2 : Invasive Plant Species and Rural Livelihoods

2.0. Introduction

The previous chapter introduced the research presented in this thesis. This chapter provides an introduction of IPS and their effects on forest ecosystem services and rural livelihoods. This chapter is divided into five sections. The first section provides general information about IPS. It highlights how an exotic plant species—whether introduced intentionally or accidentally—can become an invasive plant in the recipient ecosystem.

The second section discusses the effects of invasive plants on the colonised forest landscape in terms of ecosystem services and rural livelihoods. In addition, this section highlights how the effects of invasive plants on rural livelihoods vary in different situations. The third section provides a case study of the invasion of *Mikania* in the BZ of CNP. This case study is reported to demonstrate how BZ communities perceive the effects of the infestation of *Mikania*.

The fourth section presents a decision-making strategy to manage rural ecosystems that have been invaded by exotic plant species. Following the review of literature and a case study, this chapter develops two research questions related to the livelihood effects of IPS and the estimated benefits of the IPS management programme. In brief, this chapter summarises the existing literature on the effects of IPS in terms of the alteration of forest ecosystem services, and how they influence the livelihoods of rural communities. The fifth section concludes this chapter.

2.1. Invasive Plant Species

IPS are exotic species that threaten native forest ecosystems, habitats and species. Their biological capital stock causes economic damage (CBD, 2008; Olson and Roy, 2008). The dispersal of invasive plants beyond their native geographical habitat can be the product of either intentional economic activity (such as plantations of fast growing ornamental and fruit crops) or through being accidentally transported as a result of travel, trade or technology (Bardsley and Edwards-Jones, 2007; Holmes et al., 2009). Invasive plants are an externality of economic globalisation. Their spread increases with the volume of global trade and human mobility (Holmes et al., 2009).

The spread of plant species beyond their native boundary is not a new phenomenon. Historically, colonisation and exploration have been major causes of the spread of species (Chenje and Mohamed-Katerere, 2009). It is widely acknowledged that movement of species is an ongoing process. This occurs wherever and whenever exotic species can find conducive environments. However, their distribution—in terms of the speed of invasion and coverage of wider geographical areas—has greatly increased with the liberalisation of and increase in international travel and trade (Perrings et al., 2002). As a result of their abundance, the costs associated with invasive species are also increasing (Pimentel et al., 2000). This is likely to be the main reason that invasive plants are currently gaining considerable attention from the scientific community.

The introduction of an exotic plant does not automatically assure the plant will become invasive in its new habitat. To be invasive, the exotic species undergoes different phases of an invasion process: establishment, proliferation and persistence

(Mack et al., 2000). Once a species has arrived in a novel environment, there are three possible outcomes (Crowl et al., 2008):

i. It may not survive;

ii. It may survive but fail to spread; or

iii. It may begin to reproduce and naturalise.

Variation in the response of exotic plants is expected because each species tends to have different ecological traits. They are different in their reproductive capacity and tolerance to a broad range of environment and growth rates (Mack et al., 2000; Campbell et al., 2005). Hence, not all introduced plants find their recipient forests suitable (Lodge, 1993).

Even if invasive species become established, not all are able to invade the recipient forests. It is estimated that approximately 10 per cent of all introduced species are able to establish themselves. Of those established exotics, only approximately 10 per cent can invade their recipient forests (Kornas, 1990; Williamson, 1996). Hence, only approximately one per cent of all introduced species become invasive. These species encourage novel biotic interactions and modify existing ones (Crowl et al., 2008).

In forests, plantations of exotic species—particularly fast growing species, including *Prosopis juliflora*, *Acacia sps* and *Ecualyptus sps*—have been a significant source of invasive species (de Neergaard et al., 2005; Shackleton et al., 2007). There are some established invasive species—such as *Chromolaena odorata* (hereafter, *Chromolaena*), *Parthenium hysterophorum* (hereafter, *Parthenium*) and *Mikania micrantha* (hereafter, *Mikania*)—that have been transported accidently (McWilliam,

2000; McNeely et al., 2001; Tiwari et al., 2005). The prominent feature of the species in the latter group is that they are non-woody.

Once species become invaders in forests, they usually exhibit rampant and vigorous growth, with rapid proliferation. Their unprecedented growth in the new forest is encouraged by several factors, such as a lack of natural enemies and the availability of vacant niches (Richardson et al., 1994). In uncompetitive environments, colonisation of IPS leads to homogenisation of the invaded forests, particularly in fragmented and disturbed forests (Loehle, 2003). In such habitats, native plant species are likely to lose their competitive ability. This enables introduced species to be successful in establishing themselves with less competition from the more adapted native species (Moore, 2000; Tilman, 2004).

The habitat preferences of invasive species indicate that forests in developing countries are more prone to the invasion of exotic species. In these economies, forest fragmentation prevails and human-induced disturbances occur due to the collection of forest products and cattle grazing (Ives, 1987; Sharma and Roy, 2007; Nagendra et al., 2008).

IPS have now invaded forests throughout the world. Ecologists identify IPS as one of the greatest threats to native forest ecosystems and species richness (Wilcove et al., 1998; Moore, 2000; D'Antonio and Kark, 2002). The Millennium Ecosystem Assessment identified exotic species invasion as one of the important drivers of ecosystem change as they exert dramatic effects on all facets of ecosystem properties and processes (MEA, 2005). They are the second most serious threat to

natural ecosystems, following habitat fragmentation and loss (Randall, 1996). When habitat fragmentation is coupled with the invasion of exotic plant species, this is likely to accelerate species extinction, particularly in the biodiversity-rich tropical forests. The ecologically negative effects of invasive plants on native forest ecosystem properties and processes are undisputed. As a result of this, IPS have been referred to as 'biological pollution' and 'green cancer' (Stone, 1999; Olson, 2006).

There are several factors that influence the management of IPS in forests (Nun˜ez and Pauchard, 2010). These include the presence of a stable scientific community to work on invasive species, the possibility of large-scale volunteer work, the level of education of local communities, public awareness of invasive species, and the availability of basic scientific data of the local ecosystem. Exploration of these factors has contributed to the concentration of studies on biological invasions being conducted in developed countries (Pyšek et al., 2008). Lack of information, combined with limited availability of funds, are likely to be the main factors behind the absence of management of invasive plants in developing countries.

However, communities in developing countries heavily depend on natural resources and are subsequently sensitive to changes in forest resources. The decrease in forest resources creates an imbalance between the demand and supply of forest products. Usually, demand overcomes supply and this scarcity can force farmers to exploit more resources, if these are available. If they are not, farmers have to reduce their demand or introduce interventions to control the spread of IPS. In a rural community, the latter is more likely (Nun˜ez and Pauchard, 2010). This background

information demonstrates the need to investigate forest management issues in developing countries by focusing on the invasion of exotic plants.

2.2. Effects of Invasive Plant Species

All ecosystems, including forest ecosystems, are composed of individual structural components and dynamic processes. These structural components are biotic (animals and plants) and abiotic (soil, water and air). Ecosystem processes include decomposition, nutrient cycling, production, and fluxes of nutrients and energy. These components and processes create functions of the forest ecosystem. The functions of ecosystems generate goods and services. These ecosystem services contribute to human welfare both directly and indirectly. They are critical to the functioning of the earth's life-support systems (Costanza et al., 1997; Daily, 1997). From an anthropocentric approach, an ecosystem is a production unit.

When a new element enters an ecosystem, it influences the structures and then the functions of the ecosystem. Ultimately, it alters the supply of ecosystem services. By definition, this is destructive to the native ecosystem, which implies that it damages the native ecosystem. However, as a natural entity, invasive plants can also produce some ecosystem services. Instead of completely damaging the system, they may contribute new services and ultimately create new ecosystem functions. This indicates that the assessment of the effects of IPS on ecosystem services is complex. An ecosystem service approach is central to environmental decision-making. A thorough understanding of the effects of IPS on forest ecosystem services is a prerequisite to policy development. This information could be valuable for the CBF programme. In general, CBF management favours an anthropocentric approach, in

which public preferences determine the extent of the utilitarian and natural values of forest ecosystems. The present study adopts that approach.

2.2.1. Alteration of Forest Ecosystem Services

The ecosystem services are classified into four different categories: provisioning, regulating, cultural and supporting services (MEA, 2005). Consumption products obtained from forests are defined as provisioning services. These products include timber, fuelwood, fodder, fibre, medicines, ornaments and natural dyes. The benefits obtained from the regulation of forest ecosystem processes are grouped as regulating services. These services include climate and water regulation, air purification, erosion control, pollination and natural hazard regulation. The cultural services are non-material benefits, including education, recreation, aesthetic value, inspiration and heritage values. Finally, supporting services underpin the provision of all other ecosystem services. These services are not directly used by humans. Examples include nutrient cycling, primary production and soil formation.

The introduction of exotic plants in a forest ecosystem influences the ecosystem components, as they displace native plants. This manipulates the functions of the ecosystem and ultimately influences the services produced by the ecosystem (MEA, 2005; Crowl et al., 2008). For example, the extinction of native vegetation is considered an immediate consequence of the invasion of exotic species (Pfeiffer and Voeks, 2008). The reduction in the availability of native species threatens the continued delivery and quality of many ecosystem services (Charles and Dukes, 2007). This is because plant species richness and ecosystem services are intricately linked, and a change in the state of one of these variables can affect the other variables (Costanza et al., 2007).

In addition, some invasive plants, such as *Mikania*, are notorious for their rapid growth rates. These fast growing plants consume large amounts of nutrients, which can alter nutrient cycles (Mack et al., 2000). For example, in *Mikania* infested soils, lower nitrate-nitrogen levels are reported (Watson et al., 1964). This decreases the carrying capacity of the invaded forests. The carrying capacity of an ecosystem is the number or biomass of different flora and fauna species that the ecosystem can support without destroying that ecosystem (Hui, 2006). A decrease in the carrying capacity of a forest lowers the supply of its supporting and regulating services.

In contrast, an introduction of new species into an ecosystem can add new functions or ecological traits. These species can have the potential to affect ecosystem processes and services positively (Chapin et al., 1996), as has been illustrated by several studies (Saxena, 1997; Pasiecznik et al., 2001; Kaufmann, 2004; Siges et al., 2005). An assessment of the effects of two IPS—Prickly Pear and Black Wattle—on the livelihoods of rural people in Eastern Cape, South Africa, itemised both the positive and negative effects of these species, based on the local people's perceptions (Shackleton et al., 2007). The results indicated that, in this case, the positive benefits perceived by the community outnumbered the negatives. The benefits derived from these two species were not limited to provisioning services. The local communities also benefited from a variety of services, including aesthetic value, protecting plant species' richness by reducing pressure on locally valuable native species, and rehabilitation of degraded areas.

Noticeably, invasive plants have both positive and negative externalities. The connection between invasive plants and ecosystem services is more complex than

the direct negative effects. The concept of ecosystem services is not limited to ecological integrity, but conjoins human benefits (Daily, 1997). There is no evidence—or none that has yet been developed—that species with the greatest ecological negatives will have the most significant effects on ecosystem services (Charles and Dukes, 2007). Hence, an assessment of the effects of a particular species on ecosystem services is preferable to inform policy-makers. Without this, the ecological effects of IPS could be translated into the effects on ecosystem services, but such conclusions can also lead to biases which can result in poor decision-making.

2.2.2. Effects of Invasive Plant Species on Rural Livelihoods

By definition, invasive plants are destructive to human interests (McNeely et al., 2001). However, their multifaceted effects on ecosystem services demonstrate that their livelihood effects cannot be generalised. Studies have illustrated that IPS are perceived differently by different groups in different contexts (Binggeli, 2001). Previous studies assessing the effects of invasive plants on rural livelihoods have been unable to develop a straightforward conclusion, which indicates that 'invasive sociology' (societal-IPS interaction) is a complex issue (Pasiecznik, 1999; Foster and Sandberg, 2004; Laxen, 2007).

This demonstrates the extent of the complexity of invasive species management in rural communities. The management responses to invasive species—particularly for common property resources—depend upon whether the community is able to mobilise cooperation among its members (Mwangi and Swallow, 2008). In part, a community needs to develop a common goal towards managing the invaded

ecosystem. A thorough understanding of how local communities perceive the particular invasive species may assist the process of determining social preferences. Usually, rural people evaluate IPS based on how their economic needs are influenced by the species (Binggeli, 2001; Shackleton et al., 2007).

Typically, people prefer to eradicate invasive plants, rather than implementing preventative strategies (García-Llorente et al., 2011). However, some IPS contribute to the livelihoods of some rural people (Kaufmann, 2004; Siges et al., 2005; Shackleton et al., 2007). These species are an important source of household income and they help to diversify household livelihoods. The eradication of such species may jeopardise the livelihoods of those people who derive benefits from IPS, and may subsequently increase their dissatisfaction (de Neergaard et al., 2005). Recently, forest management strategies, including CBF management, have focused on multipurpose forestry. The CBF approach incorporates social benefits into forest management decisions. Failure to appropriately address these conflicting interests may result in the 'tragedy of the commons' (Hardin, 1968).

The challenge lies in understanding the livelihood effects of invasive plants. As discussed earlier, the spread of IPS beyond their native geographical range is a consequence of anthropogenic activities. In general, there are economic motives behind the transportation of every commodity. An economic agent tries to maximise benefits by introducing new products. The introduction of exotic plants is motivated by their high yield, their performance in poor conditions, and the array of forest products they can produce (McNeely et al., 2001). There are also some species that are transported unintentionally. It can be assumed that these species are unwanted.

Therefore, the livelihood effects of IPS can be explained according to the mode through which each individual species was introduced.

Plant species such as *Prosopis*, Prickly Pear and Black Wattle are valued for different purposes. They provide timber and fuel, and can grow competitively in poor environmental conditions. These species have been introduced in many countries to fulfil the demands of rural populations for forest products, production of biofuels, and rehabilitation of degraded lands (McNeely et al., 2001; Witt, 2010). While they have become invasive, they are still useful for some groups within the community (Pasiecznik et al., 2001; Shackleton et al., 2007). On the contrary, accidentally transported species have adverse effects on rural livelihoods. For example, *Chromolaena*, which entered via the cattle trade in Timor, and *Parthenium*, which arrived in Ethiopia through grain shipments for famine relief programmes, are both undermining rural livelihoods (McWilliam, 2000).

These examples show that the categorisation of invasive plants based on their mode of introduction may contribute to understandings of the livelihood effects of invasive plants. However, basing decisions on the first mode of introduction is limited to the suitability of particular invasive species to supply locally important forest products, such as wood fuel and fodder. There are several examples in which accidently transported species have been transformed into economic goods and have contributed to rural livelihoods (IDS, 2008; Murthy et al., 2010). Variations in the livelihood effects of exotic species are observed not only across landscapes, but also within rural communities. Some species that are detrimental to some people may be useful to others (Shackleton et al., 2007; Kannan et al., 2008; Mwangi and Swallow,

2008). However, the socioeconomic consequences of invasive species are generally perceived as undesirable (Pimentel et al., 2005).

Undoubtedly, an individual perceives the IPS, either positively or negatively, according to how much utility that species can produce personally for him or her. In this context, the variation in the perceived effects of IPS can be described in terms of the microeconomic theory of consumer preferences (Rai et al., 2012b). This theory states that preferences for commodities are determined by individuals' tastes and the characteristics of the commodity concerned. In this case, tastes of rural households are determined by various factors, such as household livelihood strategy, risk aversion in decision-making, the opportunity cost of decisions, occupation, proximity to the forest, and gender. Likewise, attributes of the goods and services refer to the characteristics of the specific IPS. These include whether the species is beneficial or undesirable, and depend on its level of aggressiveness (Shackleton et al., 2007). Rural households may change their preferences for invasive plants over time because the nature of the goods and services provided by the plants may change with time and technology.

In the following subsection, the variations in the relationship between invasive plants and rural livelihood are described based on three factors:

i. Characteristics of rural households;
ii. Characteristics of IPS; and
iii. Time and technology.

2.2.2.1. Characteristics of Rural Households

In a rural economy, basic forest products, such as fuelwood and fodder, are considered major inputs of farm household production functions. However, households' dependency on forest products and their contributions to community development varies with households' socioeconomic characteristics (Adhikari et al., 2004a; Beard, 2007; Sapkota and Oden, 2008). These characteristics include proximity to forests, landholdings, family size, income source and education. When a change occurs in the supply of forest products due to an infestation of IPS, responses of households also vary. In general, households that are highly dependent on forest products are likely to be the most affected by the invasion of exotic plants.

The livelihood strategy of rural households is one of the major determinants of households' perceptions of invasive plants. For example, *Prosopis*—a widely studied invasive species—is a source of fodder and fuelwood in many rural areas of Asia and Africa. In India, rural inhabitants evaluate this species based on the types of energy system they use for cooking and the type of animal husbandry they practice (Saxena, 1997; Pasiecznik et al., 2001; Mwangi and Swallow, 2008). Households that use fuelwood for cooking and heating appreciate *Prosopis* plants as suppliers of fuelwood and have a positive perception of the plant. On the contrary, households that use liquefied petroleum gas instead of fuelwood for cooking have a negative perception of the plant. In the opinion of the latter group, *Prosopis* lowers water tables, lacks aesthetic value and creates monocultures.

Prosopis plants are also a major source of fodder for farmers practicing stall feeding. These farmers harvest *Prosopis* to feed their livestock. However, for pastoralists, the

species is a scourge. The infestation of *Prosopis* converts pasture into shrub land by creating thickets that cannot be grazed. These examples demonstrate that local people evaluate invasive plants based on the ways in which these plants influence their individual needs for forest products. They do not evaluate invasive plants based on the effects the plants have on native vegetation (Binggeli, 2001; Pasiecznik et al., 2001; Shackleton et al., 2007). In general, rural communities are heterogeneous in terms of their social and cultural practices and economic conditions. Therefore, in rural communities, discrepancies in the livelihood effects of IPS are unavoidable (Pasiecznik et al., 2001; Kaufmann, 2004).

Those with low incomes who live in rural areas face greater constraints in managing risk (Khan and Khan, 2009). For rural poor, changing livelihood strategies from traditional farming to another sector is unlikely. These farmers have to live in a competitive environment due to the reduction of forest products as a result of IPS. As a result, they exert more pressure on forests to fulfil the burgeoning needs of a rapidly growing population (Maltsoglou and Taniguchi, 2004). This may result in the creation of an array of natural and human induced ecosystems, and contributes to highly heterogeneous landscapes (Ramakrishnan and Kushwaha, 2001). The diversification in the landscape leads to various livelihood strategies, which ultimately influence individual perception of IPS.

The effects of invasive plants can also differ from a gender perspective. In rural communities, household responsibilities are often divided by gender. Women have distinct roles in the indigenous economy (Tinker, 1994). Typically, they tend to have more responsibilities in household activities, such as collecting forest products,

small livestock production, cooking, and caring for children. Men are generally responsible for cash income and participating in public activities. Their responsibilities determine the use, concern and capabilities of forest management. Ultimately, this can contribute to the variation in benefits or losses imposed due to the invasion of exotic plants (Fish et al., 2010).

The discrepancy in the effects of *Prosopis* from a gender perspective was clearly illustrated in a study carried out in the Lake Baringo area of Kenya (Mwangi and Swallow, 2008). Male members of the community harvested *Prosopis* for various purposes, including subsistence use and commercial use. The study demonstrated that males involved in the trading of *Prosopis* experienced higher benefits or losses than males who used the plant for domestic purposes. On the other hand, female members collected *Prosopis* for subsistence use, such as for fuelwood and fodder. There was not a substantial variation in the benefits or losses experienced between female members of the community. Thus, female members may have similar views regarding *Prosopis*, while male members may have differing views. Other studies have also observed gender discrimination in the use of invasive plants (Kaufmann, 2004; Siges et al., 2005).

2.2.2.2. Characteristics of Invasive Plant Species

As described earlier, not all exotic plants invade their new habitats. Invasive plants have certain ecological traits that make them invaders in particular habitats. Their characteristics determine the speed of colonisation and their interactions with the existing plant and animal communities. The characteristics of invasive plants also influence the competitiveness of the ecosystem to deliver services. Generally, woody plants supply more basic forest products than non-woody plants including

climbers and shrubs. This means that people may have a more positive view of woody invasive plants than other forms of invasive plants. Shackleton et al. (2007) developed a conceptual framework that suggested that the effects of invasive plants on rural livelihoods vary based on two major characteristics: usefulness and competitiveness. Usefulness is defined by the forest products the species delivers and the species' competitiveness in terms of its growth rate.

In general, accidentally introduced plant species with aggressive growth rates are unwanted. These plants severely affect the livelihoods of local communities, and their aggressive growth makes them destructive even before they are recognised as invasive. For example, *Chromolaena* in West Timor, *Mikania* in Nepal, and *Parthnium* in Ethiopia are unwanted by the local communities (McWilliam, 2000; Siwakoti, 2007). A common feature of these species is that they are non-woody. Rural communities are unable to control the spread of these species and require external agencies to assist in management (Shackleton et al., 2007). In the absence of external support, they may consider the control of invasive plants an unattainable mission (Rai et al., 2012b).

On the contrary, useful and less competitive species are manageable. Typically, deliberately transported plants offer benefits. Rural communities exploit these species for their household uses and for commercial purposes. The economic exploitation of invasive plants may keep their spread under control. For example, in Peru, local communities exploit *Eucalyptus* to generate benefits. Continuous harvesting ultimately counters the plant's growth (McGarry et al., 2005; Shackleton et al., 2007). Invasive plants with beneficial traits—whether competitive or not—

may have mixed effects on rural communities. Therefore, their complete removal may generate conflicts (Witt, 2010).

The case of the Prickly Pear invasion in Madagascar demonstrates how the typical characteristics of this plant species contribute to the Mahafale pastoralist way of life (Kaufmann, 2004). The Prickly Pear cactus is a low growing, spreading succulent. Its presence in the semi-arid environment of Madagascar contributed to increases in the sedentarisation of Mahafale nomads by affecting the timing of their transhumance. Transhumance is the seasonal movement of herders with their livestock in search of water and pasture during the dry season. Local people view Prickly Pear as *sakafon-drano* (water-food). The plants keep the livestock alive during the dry season, when grass and water are scarce. The ecosystem services offered by Prickly Pear enhance the rural economy. In additions, its less aggressive growth rate makes it favourable to the local community. However, because of its thorns, the plant is unwanted in certain sites, such as homesteads, gardens, water sources and grazing lands. In such locations, the plant can cause human and cattle injuries (Shackleton et al., 2007).

2.2.2.3. Time and Technology

Time lag effects and inconsistencies in the ecological behaviour of invasive species during different phases (introduction, colonisation and naturalisation) are prominent characteristics of the invasive process (Cousens and Mortimer, 1995; Perrings et al., 2000). By definition, invasive plants become abundant with time. The longer their presence in the landscape, the larger area they occupy. The vulnerability of rural livelihoods increases with the abundance of invasive plants (Shackleton et al., 2007).

This suggests that the effects of invasive plants on rural livelihoods may vary throughout the invasion process. It has been widely observed that species that are found to be useful in the initial stage may become damaging, while initially unwanted species may become valuable resources (Pasiecznik et al., 2001; Kannan et al., 2008; Mwangi and Swallow, 2008; Hall, 2009; Shackleton et al., 2011).

The studies of *Prosopis* plantations in India and Kenya depict how society's perceptions change over time (Pasiecznik et al., 2001; Mwangi and Swallow, 2008). In the early stage of introduction, the plants were welcomed by the local people. This was because *Prosopis* supplied an array of locally important environmental goods and services, such as fuelwood, erosion control and shade. However, after a period, the species colonised farmlands and significantly surpassed grasses and crops. People subsequently began to consider *Prosopis* a harmful tree species. The conceptual framework for interpreting the livelihood effects of IPS depicts similar situations in which, during the naturalisation phase, the invasive plants become abundant and subsequently make rural livelihoods more vulnerable (Shackleton et al., 2007).

The abundance of invasive plants enhances their accessibility while concurrently making indigenous species scarce. This raises the opportunity cost of the non-use of the invasive plants. In the absence of management to control the invasive plants, local communities have three options:

i. Change their livelihood strategy;
ii. Use a coping strategy; or
iii. Use the invasive species.

Low-income households have a limited capacity to diversify or change their livelihoods. They also struggle to maintain their livelihood strategy by using coping strategies. As a result, they try to make the best use of the available resources. This means they frequently pursue the third option, which may lead to the further exploitation of invasive plants (Shackleton et al., 2007). Therefore, in the long-term, invasive plants are likely to become part of the rural economy, either voluntarily or obligatorily.

For example, farmers in the eastern part of Nepal feed *Mikania* to their cattle by mixing it with other grasses. However, the use of *Mikania* reduces milk production and causes abdominal disorders in the livestock (Siwakoti, 2007). Shrubs such as *Lantana camara* and *Chromolaena* are used as fuelwood in Nepal, even though they are not preferred species (Rai et al., 2012b). For local communities, having abundant invasive plants—particularly non-woody species—and low availability of native vegetation can translate into destitution and misery.

On the other hand, having invasive plants in the landscape in the long term can be a source of human innovation. Rural people have a history of interacting with invasive plants, as these plants can be transformed into valuable resources by human intervention (Kannan et al., 2008; Hall, 2009). Technologies have been created to convert accidentally transported species from ecological negatives into economic goods. For example, *Parthenium* and *Chromolaena* can be converted into green manure (Murthy et al., 2010). The latter is also used to make beehive briquettes for heating and cooking (IDS, 2008). Transformation of invasive plants into consumable

goods may motivate rural communities to exploit the species and subsequently control their spread.

The commoditisation of invasive plants has two major benefits. First, it enhances local livelihoods. Second, it helps reduce pressure on economically important native species. For example, *Soligas*—the tribal artisans of South India—use *Lantana camara* to produce furniture, toys and articles of household utility (Kannan et al., 2008). This invasive shrub has become a substitute for local species such as Rattan and *Wrightia tinctoria.* Likewise, communities around Lake Patzcuaro in Mexico used to invest in *Typha domingensis* eradication; however, they now enjoy the benefits of using this plant to introduce new weaving designs (Hall, 2009). The use of *Typha domingensis* to produce animal figurines, office organisers, lampshades, baskets and pet houses helps reduce pressure on native species, such as *Schoenoplectus californicu*. The latter species is an economically and culturally valuable wetland plant.

2.3. Case Study: *Mikania* Invasion in the Buffer Zone of Chitwan National Park, Nepal

The studies that have identified the benefits of invasive plants are inconclusive. For example, they are silent about forest products delivered by the species and whether these are substitutes for native species. Most of the invasive plants assessed have been *Prosopis*, Blackwattle, and Prickly Pear. These species are introduced deliberately, which clearly indicates that they are useful at least for one particular group of people in the landscape. However, there are some IPS, such as *Chromolaena*, *Parthenium* and *Mikania*, whose socioeconomic benefits are not

widely acknowledged, even in their native habitats. Their introduction is accidental in most cases. While their ecological effects have been widely assessed (Ismail and Mah, 1993; Li et al., 2006; Zhang and Wen, 2009; Timsina et al., 2011), they have not received significant attention in terms of invasive plants–societal interaction assessments.

Preliminary work for this assessed the community's perception of three invasive species, including *Mikania*, *Chromolaena* and *Lantana camara*, in the BZ of CNP, which is published in Journal for Nature Conservation (Rai et al., 2012b). This work concluded that the communities in this region have a negative perception of the invasion of *Mikania*. Typically, accidentally transported species with aggressive growth rates are unlikely to receive public support (Shackleton et al., 2007), and, for the BZ communities, *Mikania* does not produce any significant benefits. The infestation of *Mikania* has had two effects on the BZCFs. First, there has been a reduction in native plants, which has meant that basic forest products, such as fuelwood and fodder, have become scarce. Second, *Mikania* is creating impenetrable thickets that destroy wildlife habitats and jungle walking paths. This has also caused wild animals to shift their habitats to the core area of CNP, which means that BZCFUGs receive fewer visitors and a subsequent decrease in their annual income.

The preliminary study indicated that *Mikania* has grown rapidly during the last five years. BZ communities have responded to the invasion by practising control strategies, including cutting and uprooting. However, these techniques have failed to control the spread of *Mikania*. As a result households are either using *Mikania* as fodder or are exerting pressure on the core area of CNP to maintain their farm-based

livelihoods. The basic forest products delivered by *Mikania* are not preferred, thus BZ households are more likely to subscribe to the latter option. This has jeopardised the relationship between the park and the people.

To develop a management strategy, it is crucial to identify the stakeholders and assess how species invasion is affecting their livelihood strategies (Sharp et al., 2011). The preliminary study showed that different social groups perceive the effects of *Mikania* differently. For example, households close to the forest that rely on agriculture as their main source of income and use *Mikania* as a substitute have been most strongly affected by the invasion. However, this study did not investigate how *Mikania* influences the livelihood of the BZ community. Inconsistency in invasion patterns, coupled with global climate change, is likely to make the livelihoods of rural communities more vulnerable (Naylor, 2000). Understanding local communities' responses to particular invasive species is fundamental for community preparedness and for the management of the invaded area (García-Llorente et al., 2011; Sharp et al., 2011).

As a result of this uncertainty, it was necessary to extend the preliminary study carried out in the BZ to supply more reliable policy information. Such information could be obtained by investigating the livelihood effects of *Mikania* in the BZ communities. Therefore, this preliminary study led to the research question:

> **Research question one:** How has the infestation of *Mikania* in the BZ of CNP, Nepal, influenced the local households' activities?

2.4. Benefits of *Mikania* Management Programme

Implementing a *Mikania* management programme is not a straightforward task. In these situations, programmes are often met with the unlimited requests of the stakeholders but are restricted by the limited available resources. When implementing the programme, the limited resources are mutually exclusive—the funds cannot be used for another public project. Therefore, every strategy has an opportunity cost. When working with such scarce resources, any decision must produce the maximum benefits.

A social CBA of a *Mikania* management programme assists policy-makers by providing valuable information on the costs and benefits of mitigation. In a CBA, decisions are made by comparing the present value of the costs with the present value of the benefits of a strategy. The benefits of a *Mikania* management programme would be an improvement of the BZ landscape and protection of the native ecosystem. These improvements would lead to an increase in native plant species and the availability of basic forest products, an improvement of wildlife habitats, and better recreation opportunities. The costs of the programme are associated with the membership fees of BZCFUGs and potentially a new environmental tax. In general, a *Mikania* management programme can be implemented if it fulfils two conditions. First, the programme must generate more benefits than implementation costs. These benefits must affect the wellbeing of individual households. Second, the programme should provide greater net benefits than any other potential public projects.

In this situation, a CBA systematically examines and compares the concerns and contributions of stakeholders influenced by the proposed *Mikania* management programme. It then provides information to assess the relative merits of a *Mikania* management programme in comparison to other potential projects. This enables the ranking and prioritisation of policy options. An *ex ante* evaluation in CBA assists decision-makers to select the most socially desirable programme. The need for this policy information raised the second research question:

> **Research question two:** Is there potential to improve social welfare through the management of *Mikania* in the BZ of CNP?

2.5. Summary

This chapter introduced the invasion process and the effects of IPS on the invaded ecosystem. By definition, invasive plants are exotic species that can establish themselves beyond their natural range of dispersal. This indicates that their dispersal is associated with anthropogenic activities. Transportation of exotic species is either deliberate or accidental. The trend of exotic species dispersal increases with the volume of cross-border trade and travel. However, not all introduced species are able to establish themselves in their new habitats. Only a small number of species become invasive. This is determined by various factors, such as the ecological traits of individual species and the condition of the recipient habitats.

Once plants become invasive, they begin to exhibit destructive behaviour. They displace native vegetation and influence ecosystem functions. Ultimately, they alter the provision of ecosystem services. From an ecological perspective, their negative

effects are unequivocal, and eradication of the species produces absolute benefits. However, recent developments in forest management emphasise the multipurpose use of forests, focusing on social and economic dimensions. Hence, the effect of invasive plants on ecosystem services is one of the major determinants of implementing an IPS management programme.

Studies have shown that invasive plants also deliver specific goods and services. Thus, from a utilitarian approach, the effects of IPS are ambiguous. The ecological negatives of IPS cannot be translated as their effects on ecosystem services. In addition, there is no clear indication that species with the greatest negative ecological effects will have the most significant effects on ecosystem services, and vice-versa. This indicates that the livelihood effects of *Mikania* are more complex than their ecological effects. An array of factors—such as the mode of introduction, the ecological characteristics of the exotic plants, and household characteristics—determine rural households' perspectives of specific invasive plants. Nevertheless, farmers' perceptions of IPS may change over time. This complexity suggests a need to assess the livelihood effects of particular species in order to inform policy.

A case study of the perception of local communities of three invasive plants in the BZ of CNP, Nepal, demonstrates that *Mikania* undermines the livelihoods of BZ households limiting the supply of locally important forest products. Hence, the species is unwanted. Households are practising different management strategies to constrain the growth of *Mikania*; however, they are unable to attain the expected results. This study delivers two messages. First, the BZ community have a willingness to invest in a *Mikania* control programme. Second, the programme

requires external support to accomplish its goal. This study extended this preliminary research and assessed the effects of *Mikania* on the different livelihood activities of the BZ community.

An assessment of these livelihood effects supplies valuable information to enable policy-makers to design an appropriate management programme. The decision of implementation is based on the benefits and costs generated by the programme. To implement the programme, the benefits should overweight costs, and should generate more social welfare than any other potential public project. This can be assessed by using CBA. This assesses the potential for a *Mikania* management programme to improve the social welfare of BZ communities. The following chapter discusses the economic valuation of the effects of IPS mitigation.

Chapter 3 : Valuation of the Effects of Invasive Plants

3.0. Introduction

The previous two chapters introduced the research problem and provided a review of the existing literature on the livelihood effects of IPS. Two research questions related to the livelihood effects of the *Mikania* infestation and quantification of the social benefits of a *Mikania* management programme were developed. Chapter Two primarily focused on the differing effects of IPS on ecosystem services and how these affect rural livelihoods. In addition, this chapter highlighted the need for CBA to assist the decision-making process. The study area under examination is the BZ of CNP, Nepal, where the majority of residents have subsistence farming as their primary source of household income. The previous chapter demonstrated that estimating the public benefits of a *Mikania* management programme is not straightforward in the context of a rural community.

The benefits of a management programme are multifaceted, ranging from ecological to social. Most of these benefits do not have market prices. Usually, such non-market benefits are excluded from analysis. Non-market valuation methods estimate the value of non-traded benefits. This chapter introduces non-market valuation and its relevance to estimating the public benefits of managing the infestation of *Mikania*. Further, it discusses previous stated preference studies in developing economies and examines the potential for implementing a CE survey in a subsistence economy. Here, a subsistence economy is characterised by a farming community with low income and literacy. The forest products are important inputs to household production and function. Non-monetised transactions dominate the

economy. The research questions focus on the practical issues of implementing CE in these types of low-income communities.

3.1. Economic Effects of Invasive Species

The colonisation of invasive plants affects agriculture, forestry and fisheries, and entails costs to mitigate these damages (Pimentel et al., 2001; Perrings et al., 2005). Globally, the costs associated with different forms of invasive species have been estimated at approximately US$1.4 trillion per year in 2001—close to five per cent of the global gross domestic product (Pimentel et al., 2001). Invasive plants alone pose a significant cost to society. For example, the annual cost they incur in the United States (US) is approximately US$34.5 billion (Pimentel et al., 2005). Likewise, in many areas of Asia, Cogongrass (*Imperata cylindrical*)—an invasive grass—has left approximately 60 million hectares of land infertile and has exacerbated poverty (Tomich et al., 1996). This indicates that invasion is a consequence of economic activities and a cause of significant economic losses.

The growing amount of literature on the economic effects of invasive species signifies the importance of this topic (Olson, 2006). Though the literature adopting an economic approach to biological invasion is on the increase, a review of this literature highlights the need of non-market valuation to comprehensively capture the impacts of IPS on the forest ecosystem (Born et al., 2005; Holmes et al., 2009; Pejchar and Mooney, 2009). This is because most of the available economic impact assessments overlook the costs and benefits beyond the market system as they are based on control costs, ex-post evaluation and lost market products such as timber (Pimentel et al., 2001; Buhle et al., 2005; Pimentel et al., 2005). Curnutt (2000), for

example, has shown that many of the control strategies tend to fail or become ineffective when more effective alternatives become available as a result of which the impacts may be overestimated.

On the other hand, even if these control strategies are successful or are found to be the most effective for controlling the spread of IPS, they do not account for external effects, such as the irreversibility of ecological losses and any side effects of the strategy. Control methods such as herbicides use do not differentiate between target and non-target species and they can also negatively affect native vegetation (Zhang et al., 2004). Imperfect assessments of this type of external effects are likely to lead to undervaluation of the effects of invasive plants as they particularly ignore the effects of IPS that cannot be captured by existing markets (Born et al., 2005; Hoagland and Jin, 2006).

Chapter Two illustrated that the effects of invasive plants on ecosystem services and rural livelihoods are multifaceted. These species have a dual role in the production of ecosystem services—they may have destructive effects or may be producers of positive effects. Most estimation of the effects of invasive species has overlooked the value of depletion or appreciation of ecosystem services (Hoagland and Jin, 2006). They have been carried out without reference to alternative states of nature (Costanza et al., 1997). However, as a bottom line, it has been widely observed that the value of the negative effects of IPS far outweigh the benefits (Serbesoff-King, 2003; Turpie et al., 2003).

Studies estimating the values associated with invasive species using non-market surveys are very limited in number (Turpie et al., 2003; Nunes and van Den Bergh, 2004; Kerr and Sharp, 2007; Nunes and Markandya, 2008; García-Llorente et al., 2011). These studies have mainly employed the contingent valuation method to assess the effects of invasive species. They have also occasionally used CE. Additionally, some studies dealing with invasive species have estimated the replacement cost to approximate the indirect use value however eliciting WTP for changes in wellbeing could provide better estimates (Born et al., 2005). Overall, most economic analyses of IPS have not considered the distinction between the value of capital accounts and changes in economic welfare (Holmes et al., 2009). As a result, assessments of the effects of IPS have either overlooked or underappreciated the value of losses or alterations to the ecosystem (Charles and Dukes, 2007).

3.2. Valuing the Benefits of Managing the Infestation of *Mikania*

In practice, economic value directly connects to underlying changes in the wellbeing of consumers and producers. This is based on the principle of welfare economics (Varian, 1992). As described earlier, an ecosystem produces an array of services from which people derive utility. The infestation of *Mikania* affects human welfare through the alteration of ecosystem services. However, not all services are equally important to each member of the community. The value of a forest is viewed and expressed differently depending on the context in which it is used (Goulder and Kennedy, 1997). The value is not restricted to the utility derived from the direct use of ecosystem services; people also derive utility from indirect and potential uses (MEA, 2005). Thus, the total economic value of an ecosystem is the sum of all

service flows at the current time, as well as those that may occur in the future (Barbier, 1989; Pearce, 1990).

The framework shown in Figure 3.1 depicts the multi-dimensionality of the value attached to forest ecosystems. Direct use values refer to the economic dimension, indirect use values link to the ecological dimension, and the other values have social aspects (Cavuta, 2003). Some of these values are related to future use and have a temporal dimension. The total economic value framework mirrors the concept of sustainable development by seeking a balance between social, economic and ecological values, and by considering intergenerational equity (WCED, 1987). The effects of the invasion of *Mikania* can be assessed under this framework (Charles and Dukes, 2007).

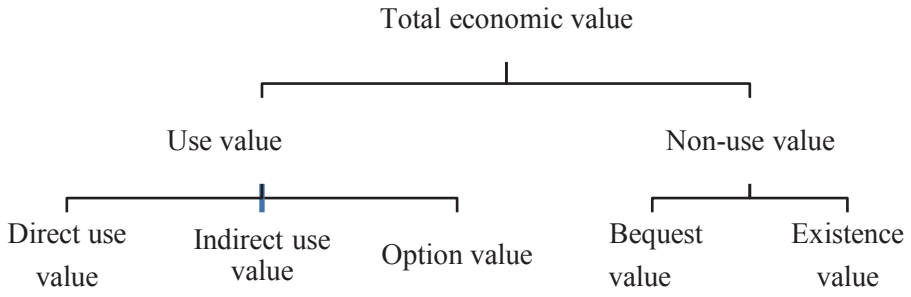

Figure 3.1 Total Economic Value Framework adapted from Pearce (1990)

The use value captures both direct and indirect use. Direct use values include services that are in actual use. Various functions of forest ecosystems may have indirect use values. These values are generated from supporting or protecting economic activities. For example, biodiversity conservation in CNP enhances eco-tourism. Likewise, uncertainty regarding the future demand for forest resources may

enable an option value (MEA, 2005). To secure the forest resources for future use, BZ households are likely to contribute to the management of the *Mikania* infestation. Option values are not related to current use—they relate to potential future use.

Non-use values are not related to current, future or potential use. These values do not have any kind of contemporary or planned use (Cavuta, 2003). For example, the value from the satisfaction of having a diverse forest ecosystem is known as an 'existence value'. Bequest values relate to the utility derived from ensuring that forest resources are available for future generations.

CBA assumes that a monetary value can be assigned to all the costs and benefits of a decision. However, microeconomics literature suggests that there is difficulty in assigning a price to all forest values. Direct use values are relatively straightforward to estimate because most are captured in the market system. However, indirect use and non-use values do not enter the market and thus have no price. The utilitarian approach—to estimate the benefits of mitigating the infestation of *Mikania*—attempts to assign monetary values to all ecosystem services. These values are measured under marginal changes in those services.

A free market fails to account for the benefits of a *Mikania* management programme that are not traded. Usually, the existing market is limited to valuing financial effects; it fails to produce a price for many social and ecological effects. As a result, the implementation costs often outweigh the estimated benefits of an environmental decision, which means that forest improvement programmes may be given too little

importance in policy decisions. Strategies based on such information promote the inefficient allocation of resources and may compromise intergenerational equity for *Mikania* management decisions (Chavas, 2000). Ultimately, this type of decision-making process may compromise the sustainability of humans in the biosphere (Costanza et al., 1997).

The values not captured by the market can be estimated by assessing changes in wellbeing. This can be done by measuring the net change in income that is equivalent to, or compensates, for changes in the quality or quantity of environmental conditions (Haab and McConnell, 2003). These changes are considered equivalent to changes in the welfare of the individual. This can be calculated from the indirect utility function, which is given by:

$$V(p, b, y) = \max_a \{u(a,b)/p, a \leq y\} \quad (3.1)$$

where $u(a,b)$ is the individual preference function; $a=a_1,...a_m$ is the vector of private goods that have a market price; $p=p_1,...p_m$ and $b=b_1,...b_n$ are the vectors of public goods (forest ecosystem services); and y is the income of the consumer. The individual can choose a based on the market price (p), while b is exogenous. The major concern of the non-market valuation is to assign a price to b.

Usually, economists measure a change in welfare using two welfare measures. They are:

i. WTP to attain a gain or avoid a loss; and
ii. Willingness-to-accept compensation for changes (Hanemann, 1991).

Theoretically, there are no differences between WTP and willingness-to-accept welfare measures; either welfare measure should be able to be used interchangeably. However, empirical studies have persistently observed differences between these welfare measures (Hanemann, 1991). In this case study, BZ communities can gain benefits by managing the infestation of *Mikania*. This study estimates the benefits based on theory, yet acknowledges its empirical limitations. The benefits of managing the invasion of *Mikania* can be estimated by eliciting the WTP/WTC of a BZ community for a *Mikania* management programme (Haab and McConnell, 2003).

3.3. Eliciting Individual Preferences for *Mikania* Management

WTP for a *Mikania* management programme can be estimated by two approaches. First, by observing each individual's actual market behaviour related to the concerned goods and services. Second, by allowing respondents state their preferences over a set of alternatives in a hypothetical setting. The former approach is known as a revealed preference approach and methods of estimations include travel cost and hedonic pricing methods. The travel cost method has been used particularly in the valuation of recreation sites, such as national parks. The hedonic pricing methods estimate the values of the specific attributes of a good such as in the housing market. Revealed preference approaches have been criticised because of their limited application. These methods are inappropriate to capture the value of all non-market services (Kroes and Sheldon, 1988; Bennett and Blamey, 2001).

The alternative approach is known as stated preference. This approach is an attractive option to overcome the pitfalls that revealed preference techniques

encounter (Kroes and Sheldon, 1988; Louviere et al., 2000). In this study, a stated preference approach was used to elicit the public preferences for a *Mikania* management programme. A decision based on such information may help gain the support of local stakeholders. Usually, in a stated preference survey, the researcher defines the scenarios hypothetically and respondents are asked to evaluate policy alternatives. This makes stated preference methods comparatively flexible (Kroes and Sheldon, 1988). The hypothetical scenarios relate to changes in the state of environmental and socioeconomic conditions. In this study, these changes represent the outcomes of the implementation of hypothetical *Mikania* management programme.

There are various stated preference techniques that can be used to elicit WTP for non-market services, including contingent valuation method and choice modelling. In the former model, respondents are asked to express their WTP for a specific scenario. In the latter model, they are asked to evaluate two or more hypothetical scenarios (Louviere et al., 2000). Over 5,000 contingent valuation studies have confirmed that the method is the most commonly used and most well-established of stated preference surveys. However, it is also the most criticised (Hanemann, 1994; Bennett and Blamey, 2001). While choice modelling and contingent valuation both have strengths and limitations (Lehtonen et al., 2003), choice modelling (hereafter, CE) has several advantages (Hanley et al., 1998b; Alpizar et al., 2001). Chapter Four details the reasons that a CE approach was adopted for this study.

3.4. Non-market Valuation in Developing Countries

In developing countries, natural resource degradation is considered the major obstacle to economic growth and poverty reduction (Munasinghe, 1993). The burgeoning human population has led to growing demand for forest resources, which has increased the complexity of creating the desired balance between forest conservation and economic growth. If this complexity is not addressed properly, sustainable development– continuous improvement of human welfare and also for generations to come through natural resource management– may become an unattainable goal (WCED, 1987).

In this context, a participatory forestry approach was introduced to facilitate sustainable forest management, particularly in rural areas. The CBF programme has been successful in securing local communities' participation in forest management (Adhikari et al., 2007; Shrestha et al., 2010; Pokharel, 2011). The experience of the CBF programme suggests that public support can be gained by incorporating environmental concern into economic decision-making. Two steps are required to ensure successful implementation:

i. Identify the effects of a policy; and
ii. Assign a value to these effects (Munasinghe, 1993).

In the CBF approach, local communities bear the costs and enjoy the benefits of forest management. In a *Mikania* management programme, the local community should be involved in assessing the programme's costs and benefits prior to any decision being made. This process encourages the community to take ownership of the decision (Brouwer et al., 2010).

Stated preference surveys allow forest users to make implicit trade-offs between policy options, conservation goals, the benefits they can obtain, and the costs of implementation. This is based on the fundamental principles of microeconomic theory, in which an economic agent attempts to maximise utility, given the constraints on their access to resources. The stated preference survey ensures the participation of beneficiaries in the decision-making process through an evaluation of the proposed programme. This allows the community to minimise their losses from the invasion of *Mikania*, and maximise their benefits from the implementation of a *Mikania* management programme. This democratic exercise in decision-making is the key aspiration of the CBF programme. It ensures transparency in evaluating policy options.

Several issues may arise when choosing to elicit WTP of low-income households. For example, it raises the question of whether low-income households and high-income households should contribute equally to the costs of IPS programmes. Low-income households face greater constraints in managing risks, and are expected to have less willingness to invest in public goods (Khan and Khan, 2009). However, the CBF programme is based on the idea that people are likely to have more interest in conserving the forest closest to them (Ostrom, 1990). In CBF management, local forest users have ownership over the resources. This ownership creates an incentive to invest in resource management (Pimentel et al., 2001). Under the CBF framework, the local community can enjoy the benefits generated by a *Mikania* control strategy. Thus, their contribution to the implementation of a programme can be expected. In many cases, forest users and rural dwellers tend to have higher WTP

for forest management than general users, such as urban residents (Hanley et al., 1998b; Brey et al., 2007; Christie et al., 2007).

In a subsistence community, the unemployment rate is high and financial institutions are poorly developed (Fernando, 2011). These communities usually operate a non-monetised and informal financial system. Various barter systems are in practice in many rural areas, including *Parma* (a mutual farm-labour sharing system); labour contribution to development activities (such as voluntary participation in CBF activities); and wages paid in cereals (such as in Food for Work programmes) (Shyamsundar and Kramer, 1996; Cameron, 1998; Adhikari et al., 2004a). Requesting that low-income households—who are more familiar with non-monetised transactions—place a monetary value on public goods may mean they cannot be able to express benefits. This may result in an underestimation of the benefits of a *Mikania* management programme.

A review of past non-market valuation studies in developing countries suggests that some stated preference practitioners have been disappointed because the estimated WTP has been lower than expected (Choe et al., 1996; Lauria et al., 2001). This is not surprising considering the income level of respondents. Typically, WTP for environmental quality is considered a function of respondents' incomes. Many stated preference studies have demonstrated that the likelihood of accepting WTP for environmental services increases with income (Choe et al., 1996; Lehtonen et al., 2003; Do and Bennett, 2009). In an agrarian community, households spend up to 80 per cent of their income on food (Chakrabarty et al., 2011).This means they do not have sufficient discretionary income for environmental quality. However, these

estimations cannot necessarily be interpreted as meaning that low-income households prefer to free ride in their use of natural resources.

As well as issues created by income levels, stated preference practitioners have encountered cultural barriers to implementing surveys in developing economies (Whittington, 1998; Glenk and Weber, 2010). If cultural complexities are not properly addressed, they are likely to increase the risk of inferential errors (Singh, 1995). Non-market valuation studies have progressed with collaboration of researchers from both developed and developing countries (Bennett and Birol, 2010). This cooperation has helped overcome the cultural and technical constraints that may be encountered when implementing stated preference surveys. If stated preference surveys are framed cautiously, their administration in developing countries may be easier than in industrialised countries. This is because of relatively high response rates, and data collection being relatively inexpensive (Whittington, 1998; Hung et al., 2007; O'Garra, 2009).

Despite these complexities, the implementation of stated preference surveys in developing countries has received considerable attention from applied economists (Aylward and Barbier, 1992; Shyamsundar and Kramer, 1996; Alam, 2006; Wang et al., 2007; Do and Bennett, 2009; Birol and Das, 2010). This has occurred for two reasons. First, developing nations are achieving economic growth at the expense of environmental assets, when, ideally, a balance between these two goals is required (Barbier and Cox, 2003; Alam, 2006). Second, levels of income and education, as well as limitations on government expenditure, may challenge stated preference practitioners in designing and implementing non-market valuation surveys. These

complexities can become a source of new knowledge (Hearne, 1996; Whittington, 1998).

The use of CE surveys as non-market valuation tools in developing countries is also increasing; however, most studies have been confined to urban areas (Cook et al., 2007; Tuan and Navrud, 2007; Wang et al., 2007; Do and Bennett, 2009; Birol and Das, 2010). In most developing countries, urban areas have comparatively higher levels of income and education than the national average. These urban studies have mainly focused on health, cultural heritage, wetlands, conversion of croplands to forest, nature-based tourism and water treatment. Only a handful of CE studies have targeted rural communities in developing economies, and these have used a willingness-to-accept format (Adhikari et al., 2005; Casey et al., 2008; Brouwer et al., 2010). A CE has not previously been used to elicit WTP for an invasive species management programme.

3.4.1. Estimating the Benefits of Managing the Infestation of *Mikania*

As explained earlier, the benefits of managing the infestation of *Mikania* in the BZ of CNP is equivalent to the community's WTP for controlling the growth of *Mikania*. This estimated WTP may help decision-makers determine whether to implement a control programme. It is widely accepted that WTP for ecosystem services is a function of an individual's income. BZ households may subsequently protest if a new tax is proposed for a *Mikania* management programme (Bennett and Birol, 2010), and it may result in them having a low value of the benefits of the programme. However, this does not mean that the infestation of *Mikania* has no effect on the BZ community.

The preliminary study concluded that the invasion of *Mikania* is undermining the livelihoods of BZ communities. Forest resources generate economic benefits and support the daily activities of BZ households. These households are more sensitive to the changes in forest resources that may result from the infestation of *Mikania*. They have shown willingness to invest in the control and management of *Mikania* because the mitigation of the damages caused by *Mikania* may ensure the availability of forest products for farm households. In addition, BZCFUGs may receive more visitors. Therefore, this research required an estimation of BZ households' WTP in order to answer the question:

> **Research question three:** How much is the BZ community of CNP willing to pay for a *Mikania* management programme?

3.4.2. Eliciting Willingness to Contribute Labour for *Mikania* Management

Welfare changes are generally measured in monetary terms. For estimation, a payment attribute in the hypothetical scenario enters as a cost of the given scenarios. This is the basis for estimating individuals' WTP. The payment numéraire is meaningful when it is presented as part of a respondent's everyday life because they can understand it in terms of utility to them (Ahlheim et al., 2010). This helps consumers assess their contribution to public goods at the expense of private goods. In an agrarian community such as the BZ of CNP, respondents may not be familiar with cash contributions. Hence, a monetary value may not be the most appropriate means of estimating WTP. A large portion of the rural population may reject cash payments for participation in public works (Hung et al., 2007). The practice of eliciting WTP in dollar terms may not completely capture the values of a low-

income population and may present them as having too low incomes to be environmentally sustainable (Martínez-Alier, 1995).

Household cash income is a main constraint in implementing stated preference surveys in subsistence economies. To overcome this issue, contingent valuation method studies in developing countries have occasionally used non-monetary numéraires to elicit WTP (Shyamsundar and Kramer, 1996; Alam, 2006; Birol et al., 2006; Hung et al., 2007; Asquith et al., 2008; Saxena et al., 2008). Two types of non-monetary numéraire—time and in-kind—contributions have been used to estimate changes in the welfare of low-income communities. These studies concluded that the use of a non-monetary mode of contribution increases the participation of low-income households in environmental decision-making. The results showed that low WTP in subsistence economies is partly a result of study design bias.

The possibility of using in-kind payments, such as baskets of rice, to elicit WTP in a rural community is unlikely (Shyamsundar and Kramer, 1996). In many rural areas, cereals, including rice, are not a staple for everybody, but rather are a symbol of wealth. In addition, cereals have well-established market prices. Thus, the use of cereals instead of monetary terms may not solve the problem of cash constraints (Ahlheim et al., 2010). This implies that using rice as the numéraire is not an appropriate form to estimate WTP of the BZ community for managing the infestation of *Mikania*. Likewise, another study for the protection of a specific forest habitat used beehives to measure a change in the welfare of Bolivian farmers (Asquith et al., 2008). In this study area, apiculture was practised by limited

households—it was also not a familiar metric to the majority of the respondents. Use of an unfamiliar mode of contribution, whether monetary or non-monetary, can lead to an incorrect estimate of non-market benefits.

In agrarian communities, labour contributions are socially accepted. Farm households allocate labour for different purposes, such as forestry, farming, work for wages, and self-employment, to optimise their benefits (Jacoby, 1993; Abdulai and Delgado, 1999; Alam, 2006). The BZ communities participate regularly in the management of community forests, with labour being the major input in the production system of these communities. The availability of cheap labour is considered a strength of developing countries in managing IPS and implementing large-scale programmes (Nun˜ez and Pauchard, 2010). Thus, the benefits derived from a *Mikania* management can be estimated in labour contribution terms. The elicited WTC labour can be monetised once the benefits are measured, in order to estimate the benefits of managing the invasion of *Mikania* (O'Garra, 2009).

This research provides empirical support for the argument that methodological bias to elicit WTP may underestimate the value of benefits of environmental programmes in low-income communities. The CE survey was partly augmented by providing an option of selecting the mode of contribution—money or labour—to elicit WTP for a *Mikania* management programme. This background information raised the research question:

> **Research question four:** Is estimated WTP for a *Mikania* management programme in the BZ of CNP sensitive to the mode of contribution?

3.4.3. Estimating the Shadow Wage Rate of Time

The social value of a *Mikania* management programme can be conceived as an aggregation of individuals' WTP. In the context of using a labour mode of contribution, the sum of labour days declared by households in the BZ is an estimate of the social benefits of a *Mikania* management programme. This may create theoretical complexity when placing monetary values on the number of labour days declared by the respondents, as the opportunity cost of time varies across individuals. For example, government officers receive higher salaries than agricultural labours. As BZ households have diverse sources of income, they also have varying incomes. Their opportunity cost of involvement in *Mikania* management also varies. The issue lies in determining which conversion rate for each labour hour should be used to ensure that, based on the estimated shadow value of time, WTC labour could be appropriately converted into dollar values.

This complexity was partly addressed by assessing the nature of the trade-off made when eliciting WTP (O'Garra, 2009). Generally, in WTP surveys, there are two scenarios. First, when the type and timing of work are fixed, the individual makes a trade-off between work time and time spent contributing towards the environmental programme. In this case, time used for public work could be estimated by the average wage rate. The second scenario is that respondents have the opportunity to choose freely when they contribute labour. In this case, they use leisure time to be involved in public works, which means the value of leisure time needs to be estimated.

Theoretically, when choices are constrained by both time and money, WTP can be elicited using either numéraire (Eom and Larson, 2006). The main aim of stated preference surveys, including CE, is to complete a social CBA of environmental projects. Therefore, the challenge of converting the value of declared labour days should not hinder the efforts of extending the CE surveys. Instead, using time as the numéraire contributes to making CE accessible to rural households with budget constraints. The practice of eliciting WTC labour allows them to participate in environmental decision-making (Farley and Brown, 2007). The participation of beneficiaries in environmental decision-making has been found to be central to ensuring good environmental governance (Gaventa, 2002).

In general, because the agricultural wage is low, the estimated value of WTC in labour terms, based on the market wage rate, is conservative. However, the labour supply of farm households is determined by the shadow wage, rather than the market wage. In CBA, the shadow wage rate is the social opportunity cost of labour (Del Bo et al., 2011). Farm households may enjoy involvement in forestry activities, as they can meet their friends and collect basic forest products. Thus, they value the time spent in forestry activities at a different rate to the market wage rate (Edmeades et al., 2006). Therefore, reliable policy information can be produced by estimating the social opportunity cost of labour. Thus, the research sought to answer:

> **Research question five:** What is the shadow wage rate for community members in the BZ of CNP?

3.5. Summary

This chapter has discussed the importance of non-market valuation techniques to estimate the public benefits of managing the infestation of *Mikania*. The increasing amount of literature on the economic effects of invasive species demonstrates the severity of the problem. The techniques previously employed to estimate the value of mitigation have been limited to assessing financial effects. However, as discussed in the previous chapter, invasive plants alter an array of ecosystem services, which means their effects extend beyond the merely financial to include social and environmental effects. These effects are not captured by existing markets and their exclusion leads to incomplete information that generally undervalues the effects of invasive species. In other words, these methods underestimate the benefits of a *Mikania* management programme, which means the likelihood of a programme's implementation decreases.

The economic value of the effects of *Mikania* infestation is determined by changes in social welfare. A change in welfare is measured by aggregating individuals' preferences. In this context, it is estimated by eliciting individuals' WTP for mitigating the damages caused by *Mikania*. The stated preference approach was found to be appropriate to elicit BZ households' preferences for a proposed programme. In stated preference surveys, hypothetical scenarios that relate to the problem under investigation are presented to respondents to select. A monetary variable is included as a cost of the scenario—this is the utility measurement.

Typically, WTP is a function of a respondent's income. Low-income households may show their inability to participate in a *Mikania* management programme in the

form of cash payments. A few stated preference studies have elicited preferences using non-monetary modes of contribution—such as in-kind and time—in low-income communities. Using labour to measure welfare was found to be suitable to elicit WTP for *Mikania* management in this study area. The usual practice of BZ communities' participation in the BZCF activities and the importance of labour in the IPS management programme made labour appropriate in this context. A comparison of estimated social welfare using monetary and labour modes of contribution provided empirical evidence to address the question of whether estimated WTP was sensitive to the mode of contribution.

Using labour as a numéraire can create theoretical challenges in estimating social welfare. Under the CBA framework, costs and benefits should be provided in monetary terms. This means that estimated WTC labour needs to be converted into dollar values. However, because the opportunity cost of times varies across individuals, this raises the question of which conversion rate should apply. Existing studies have used either the market wage rate or the value of leisure to assess this contribution. Farm households usually determine the labour supply based on the shadow wage rate, rather than the market wage. In CBA, the shadow wage rate is the social opportunity cost of labour. This study estimated the social opportunity cost of labour by using CE. The next chapter introduces CE as a research method to estimate the public benefits of managing the invasion of *Mikania* in the BZ of CNP.

Chapter 4 : Research Methods

4.0. Introduction

The previous chapter outlined the role of non-market valuation to determine public preferences for environmental programmes. It also discussed issues related to the implementation of stated preference surveys in a developing country context. Research questions were developed in Chapter Three by acknowledging the role of non-market valuation studies in estimating social preferences for managing the invasion of *Mikania* in the BZ of CNP. This study addressed these research questions by proposing the application of a CE to estimate the public benefits of managing the infestation of *Mikania*. CEs have increasingly been used in non-market valuation since the first study was undertaken by Adamowicz et al. (1994) of the valuation of environmental services in Alberta, Canada.

In this thesis, a specific CE application was discussed which aimed to manage the issues associated with CE in the context of low-income communities. The origins of CEs are in conjoint analysis. Conjoint analysis is used to rank or rate attributes through a series of trade-offs. CEs differ from conjoint analysis. The former is based on random utility theory and the latter evolved out of the theory of conjoint measurement (Louviere et al., 2000). Conjoint measurement is based on mathematical foundations and is concerned with the behaviour of number systems, rather than human preferences.

A CE requires two components to capture the preferences of respondents:

i. A statistical design plan to create hypothetical scenarios; and

ii. A statistical method to analyse responses (Louviere et al., 2000).

The design is used to create hypothetical scenarios. These scenarios are also known as alternatives; they are the combinations of the attributes. Attributes remain the same across the alternatives. The alternatives are differentiated by the levels of attributes. Respondents are asked to select their preferred alternative from several in a choice set. More than one choice set is presented to a respondent to make repeated choices. The assumption is that preferences will be consistent across the choice sets.

A CE has several advantages. It can be used to model complex choice situations, it allows testing for internal consistency, it offers benefits transfer, it reduces framing bias, and it can elicit more information from each respondent than the widely used contingent valuation method (Hanley et al., 1998b; Rolfe et al., 2000; Alpizar et al., 2001; Bennett and Birol, 2010). Hanley et al. (1998b) prepared a list of advantages of CEs over the contingent valuation method. The CE is widely acknowledged for its credible estimation of the value of non-market services (List et al., 2006). CE studies are increasingly undertaken across various fields, such as health, transportation, marketing, agriculture and forestry. There are several CE studies that have estimated the value of forest ecosystems, such as those by Hanley et al., 1998b; Rolfe et al., 2000; Lehtonen et al., 2003; Brey et al., 2007; Wang et al., 2007; Czajkowski et al., 2009; and Berninger et al., 2010. CE studies have also been employed in developing countries for several purposes (Bennett and Birol, 2010).

Conventionally, CE has been designed to estimate non-market values. It estimates values for each attribute included in the experiment. In addition, it estimates the

marginal rate of substitution between non-monetary attributes. It has become popular as a result of these applications. Its application is not limited to non-market valuation; it has been applied to elicit public preference for selected goods and services. For example, a CE survey was used to elicit preferences for municipal water supply options (Haider and Rasid, 2002). Likewise, a CE survey was used to create a preference list of cattle traits in Kenya (Ruto and Scarpa, 2010). Therefore, CE can be applied to estimate the value of non-market services related to the problem being analysed, and to prepare a preference order of the attributes of the given goods or services included in the choice sets. A preference order of the characteristics can also be prepared simultaneously in the valuation exercise.

This chapter is divided into five sections. The first section discusses the underlying economic theory of CEs. The second section presents econometric models to analyse CE data and estimate social welfare preferences. The third section discusses welfare estimation. The fourth section presents a multiple regression model to analyse the livelihood effects of IPS and the fifth section concludes. This chapter provides a general overview of the CE surveys used in non-market valuation studies.

4.1. Theoretical Approach

The CE is founded on neoclassical microeconomic consumer theory, which assumes that consumers are highly rational decision-makers. Consumers seek to optimise their utility by selecting the best option among the available alternatives in a choice set, subject to constraints such as time and income (Ben-Akiva and Lerman, 1985). In

general, a consumer makes a decision by evaluating the costs and benefits of the given alternatives. They select the one that yields the highest utility. The choice in CE is discrete in nature, which means that respondents can select only one alternative from the given choice set (Hanemann, 1984). This is also known as 'Discrete CE'.

Usually, in CE studies designed for non-market valuation, respondents are given a choice card containing policy alternatives that include a status quo option. The alternatives in the choice set are considered the hypothetical outcomes of policies or programmes related to the problem being investigated. In this case, they were the outcomes of the implementation of a *Mikania* management programme. The outcomes are comprised of attributes and are distinguished by the levels of these attributes. The levels of the attributes could be either qualitative or numerical. These levels indicate the potential change in attributes that result from the hypothetical policy options. A change in the outcomes affects a respondent's wellbeing. Respondents attain varying utility from the different alternatives.

The effects of the alternatives are described based on Lancaster's characteristics theory of value (Lancaster, 1966). This theory states that an individual derives utility from the attributes possessed by the goods, rather than the goods *per se*. In this case, this means that the utility derived from a *Mikania* management programme is equal to the sum of the utility derived from the attributes. An individual implicitly makes a trade-off between attributes when selecting an alternative. Therefore, choices are considered a function of the attributes (Alpizar et al., 2001). In non-market valuation surveys,

monetary value is usually an attribute that reflects the cost of the individual given in the particular alternative. This is the basis of WTP estimation. It is expected that an individual will consider his or her disposable income when making a choice.

The given alternatives are evaluated indirectly through their characteristics. This means there is a possibility that consumers will have a preference when ordering the attributes included in the choice set (Lancaster, 1966). There is no obligation that all characteristics included in the choice set should have a positive association with utility. It is widely accepted that an increase in the level of the preferred attributes or positive externalities will result, *ceteris paribus*, in high utility of the goods or services. On the other hand, the utility of the goods or services decreases with increasing levels of unwanted attributes or negative externalities. For example, a change in the cost of the alternative can cause a discrete switch from one alternative to another alternative. Therefore, the CE links Lancaster's theory with the model for consumer demand for discrete choice (Hanemann, 1984).

The stated preference survey assumes that the utility derived is not restricted to the attributes included in the alternatives. There are other unobservable components that create inconsistency. These could be attributes not included in the experiment, measurement error, and heterogeneity of preferences (Hanemann and Kanninen, 1999). For example, various policy traits were used in previous CE surveys to estimate the value of non-market forest benefits (Rolfe et al., 2000; Lehtonen et al., 2003; Wang et al., 2007). These ecological attributes may interact among themselves. All these

attributes and their interactions cannot be included in a single CE because the size of the CE design increases with the number of attributes and levels included. These unobserved components are unknown to the researcher; however, it is expected that respondents consider them when making a choice (Haab and McConnell, 2003).

Choices made in CEs are analysed by using random utility theory. This includes an error term in the utility function. It captures the effects of the unobservable factors in individuals' utility functions (Hensher et al., 2005) and assumes that the error term enters the utility function as an additive term. The random utility framework links the deterministic model with a statistical model of human behaviour to address inconsistencies (McFadden, 1974; Manski, 1977). The indirect utility function (U) is split into two components: a deterministic component (V) and a stochastic term (ε). A random model with a utility function that states that individual (i) is associated with alternative (j) models the consumer choice behaviour as:

$$U_{ijt} = V(x_{ijt}) + \varepsilon_{ijt} \qquad (4.1)$$

where individual *i (i=1,2,...N)* obtains utility (U) from choosing alternative *j (j=A, B, C)* in each of the choice sets *t (t=1,2,...n)* presented to them. Following Lancaster's theory of characteristics, the utility derived from its observed component (V) depends on the attributes (x) included in the choice set.

Usually, it is assumed that attributes enter the utility function in a linear form. The notion of a linear utility function makes the estimation of parameters and welfare effects

simple; however, it has restrictive assumptions (Ben-Akiva and Lerman, 1985). The linear utility function in non-market valuation indicates a constant rate of substitution between non-market and market goods. This could be unrealistic in the case of non-market goods. The utility derived from attributes may have different functional forms (Hensher et al., 2005) that could be included in quadratic or even cubic terms. Despite the restriction of the linear utility function, following the trend in non-market valuation surveys, this thesis also assumed linear utility functions.

In a choice set, the alternative *j* will be chosen over "alternative *g*", if the expected utility for individual *i* , (U_{ij}), exceeds the expected utility (U_{ig}) for all alternatives. This implies that the probability of selecting an option is likely to increase with utility from the option. The probability (*P*) that individual (*i*) will choose option *j* over option *g* in a complete choice set (*R*) is given by:

$$P\{\text{choose } j\} = P\{(U_{ij} > U_{ig}, \text{ s.t. } \forall\, g \in R, \text{ and } j \neq g)\} \qquad (4.2)$$

In order to estimate equation 4.2, an assumption of the distributions of the error terms must be made. Usually, it is assumed that the errors follow identical and independent distribution (*iid*), and that they are independent of the observed component (McFadden, 1974). The *iid* assumption is considered restrictive because it does not allow error components for different alternatives to be correlated (Hensher and Greene, 2003).

4.2. Model Specifications

Of the two aforementioned components required for the CE, this section discusses the latter component: a statistical method to analyse the responses. The CE design is described in the next chapter. This section presents two models:

i. Multinomial/conditional logit; and

ii. Random parameters logit.

4.2.1. Multinomial/Conditional Logit Model

The *iid* assumption of the error term provides the foundation for theconditional logit (CL) model (McFadden, 1974). This model was further developed by Hanemann (1984). The assumption of the *iid* error term implies that the choice probability in equation 4.2 can be expressed as:

$$P(i) = \exp(\mu V_j) / \Sigma_{j \in C} \exp(\mu V_g) \qquad (4.3)$$

where a scale parameter (μ) is assumed to be equal to one. This implies that error variance is constant. The model becomes deterministic as $\mu \to \infty$, and choice probability becomes 1/2 as $\mu \to 0$ (Ben-Akiva and Lerman, 1985). The *iid* assumption results in the independence of irrelevant alternatives (IIA) property. This property states that, for any individual, the probability of an alternative being selected remains the same because of the inclusion or omission of other alternatives in the choice set (Ben-Akiva and Lerman, 1985).

In the CL model, the attributes of the problem being analysed are the major determinants of the expected utilities. The simplicity and ease of estimation of the parameters are the main reasons behind the wider use of CL model. Equation 4.3 can be estimated by:

$$V_{ij} = ASC + \beta X_{ijt} \quad (4.4)$$

where *ASC* is the alternative specific constant and β is the coefficient of the attribute (x), which is included in the choice set. The alternative specific constants (ASC) are unique for each of the alternatives considered in the choice sets. They capture the influence on choice of unobserved components relative to specific alternatives. They enter as a dummy variable into the utility function. In this thesis, the value of the ASC for the status quo was zero and for the alternative programmes was one. The model presented in equation 4.4 is important to understand the significance of attributes in explaining respondents' choices across the alternatives included in the choice set.

In general, there are two problems associated with the CL specification:

i. A limitation in modelling the variation in taste among respondents; and
ii. The assumption of IIA property (Alpizar et al., 2001).

The model presented in equation 4.4 cannot explore the taste variation among the respondents. A more general model may be obtained by combining the multinomial and conditional logit models. In the extended model, the expected utilities depend on

individual characteristics (*s*) as well as the attributes of the choices. The extended model can be expressed as:

$$V_{ij} = ASC + \beta X_{ijt} + \gamma S_i \quad (4.5)$$

where γ is the coefficient of individual characteristics, *s*. These socioeconomic variables are constant across the choice scenarios for any respondents; however, they vary across individuals. The constant variables do not permit the analyst to estimate the model (Hensher et al., 2005); there needs to be some variance. This variance can be created by interacting either with the attributes or with the ASC.

Usually, CE surveys—including those used in this research—are conducted with three alternatives per choice set. These include a status quo (no policy intervention) and two alternatives. This can facilitate the choice task for respondents; however, it may lead to violation of the IIA condition. In general, the trade-offs a respondent makes between alternatives unaffected from the inclusion of the opt-out alternative seem unrealistic. For example, selecting the status quo may differ from the presented alternatives. The status quo alternative cannot be seen as just another choice alternative. Hence, the violation of IIA is likely (Haaijen, 1999).

The violation of IIA implies that any experimental findings may be systematically biased. This may inform policy incorrectly if consumers have the option not to choose. This poses econometric challenges to the researcher of how to detect and solve possible IIA violations (Kontoleon and Yabe, 2003). IIA violations can be detected by

conducting the Hausman test (Hausman and McFadden, 1984). This test is conducted in two stages. First, an unrestricted model with all alternatives is estimated. Second, a restricted model is estimated (Hensher et al., 2005). The restricted model has a limited number of alternatives, while the model specifications in terms of the attributes and other variables remain the same.

4.2.2. Random Parameters Logit

The violations of the assumption of *iid* error components and IIA property can and do occur (Hensher et al., 2005). There are several logit models for relaxing the IIA property. The most commonly used models are nested logit and random parameters logit (RPL). The nested logit model relaxes the *iid* and IIA assumption by partially dividing alternatives into different subgroups. In the nested logit model, variance occurs across the subgroups, but remains the same within each group. Therefore, error terms distribute independently, but are non-identical (Bhat, 1995). The RPL model, also referred to as 'mixed logit', relaxes the *iid* assumption in terms of the covariance (Louviere et al., 2000; Train, 2003). This study used the RPL model to address the problem associated with the CL model.

In RPL models, the error components of alternatives are allowed to correlate. For this to occur, an additional stochastic element enters the utility function. This may be heteroskedastic and correlated across the alternatives (Hensher et al., 2005). The observed component (βX_{ijt}) in equation 4.4 can be divided into the sum of the population mean (β') and individual deviation (η). The coefficient vector (η) captures a

random, unconditional and unobserved type of taste heterogeneity of each random parameter (β') (Grosjean and Kontoleon, 2009). The utility function in the RPL model is:

$$V_{ij} = ASC + \beta'_i x_{ijt} + \acute{\eta}_i x_{ijt} \quad (4.6)$$

The later component ($\acute{\eta}_i x_{ijt}$) is correlated among the alternatives presented in the choice sets. This indicates that the model does not suffer from the IIA property. However, the RPL model presented in equation 4.6 is considered ill-suited to explain the sources of heterogeneity (Boxall and Adamowicz, 2002). This can be explored by introducing the socioeconomic variables (s) to the utility function (Grosjean and Kontoleon, 2009). These variables enter the utility function as interaction terms with the ASC and attributes. After including the socioeconomic variables (s) with the coefficient vector (γ), the estimated indirect utility function becomes:

$$V_{ij} = ASC + \beta'_i x_{ijt} + \acute{\eta}_i x_{ijt} + \gamma s_i \quad (4.7)$$

In RPL models, taste parameters are considered to have statistical distributions. These distributions arise from potentially different parameters for each individual. The random parameters provide information about the degree of preference heterogeneity. This can be assessed through the standard deviation and through interactions between the mean parameter estimate and deterministic segmentation criteria (Hensher et al., 2005). These parameters may have several distributions, including normal, lognormal, uniform and triangular.

Usually, random parameters are assumed to have lognormal and normal distributions. These distributions are often used for estimations (Carlsson et al., 2003). The normal distribution places no constraints on the signs of the parameters (Train, 2003). This means that respondents are allowed to have both negative and positive preferences for the attributes under investigation. The lognormal form is used if the parameter needs to have a specific (non-negative) sign (Hensher et al., 2005). Their study suggests that lognormal is not suitable for WTP calculations, as the distribution has a very long right-hand tail and may result in higher WTP values.

This thesis followed a procedure suggested by Hensher et al. (2005) to estimate the models. First, all attributes, except payment attributes, were considered random parameters. Then, parameters that had insignificant standard deviations were re-estimated as non-random parameters. The models were estimated several times by assuming different distributions and their combinations. The selection of the models and distributions of the parameters was based on the fit of the model. However, generally, analysts prefer normal distributions and select the model with normal distributions if minimal differences occur.

4.3. Output of Choice Models

The theoretical underpinnings of CE—particularly microeconomics' consumer theory axioms—allow estimation of the welfare effects of changes in the attributes included in choice sets. Decisions are made by respondents through a trade-off between the attributes. The respondents are asked repeatedly to select the preferred alternatives.

Levels of attributes vary across the choice sets. These features of CE allow the estimation of marginal rates of substitution between attributes (Carlsson et al., 2007). In non-market valuation surveys, the inclusion of a cost attribute in choice sets allows the estimation of the marginal value of the attributes.

Based on these estimations, values of various scenarios can be estimated both at the household and community levels. In this study, these values were equivalent to the benefits of a *Mikania* management programme. This was expressed in the form of WTP values. This reflected the utility that respondents obtained from the implementation of a particular decision. In general, the economic valuation of a *Mikania* management programme examined whether the social welfare of the BZ community would improve following the implementation of a programme. The CE responses estimated:

i. Implicit prices;
ii. Households' WTP; and
iii. Total WTP of the BZ community.

The WTP is the opportunity cost equivalent to the utility with and without non-market goods. The WTP for a *Mikania* management programme can be interpreted as a BZ household's Hicksian Compensating Surplus (Roe et al., 1996). Hence, the estimated compensating surplus can be used to carry out the CBA of the proposed programme. The CBA provides the foundation of a *pareto optimality* by estimating the monetary value of a change in the level of provision of attributes. The association of the estimated

WTP with the applied welfare economics indicates that CE is concerned with policy recommendations (Sen, 1970).

4.3.1. Implicit Price

In linear utility models, the marginal rate of substitution between two attributes is the ratio of their coefficients. When the marginal rate of substitution of any attribute estimates with the cost attribute, this is referred to as the 'implicit price'. The expected value of WTP can be directly obtained from the ratio between the coefficients in a logit regression of the individual's binary response for accepting or rejecting offers with given costs (Hanemann, 1984). For attributes that have linear parameters, the implicit price (*IP*) is the negative ratio of the respective attribute coefficient (β_k) and the coefficient of the monetary attribute (β_c):

$$IP_k = - \beta_k/\beta_c \qquad (4.8)$$

If one of the parameters is estimated as a random parameter, the estimation of implicit price must take the distributions of this parameter into account. Equation 4.8 is extended by including an additive component as a product of the standard error and distribution of a random parameter with the coefficient of that random parameter. Suppose the attribute (*k*) is estimated as a random parameter with a normal distribution, then the implicit price can be estimated by using the following relationship:

$$IP_k = - (\beta_k + \sigma_k * \varphi_k)/\beta_c \qquad (4.9)$$

where σ_k is an estimated standard error of the random parameter, and Φ_k is a draw from the standard normal distribution assumed for each β_k.

For policy purposes, the ultimate goal of stated preference studies is to estimate WTP measures and obtain their confidence intervals (Alpizar et al., 2001). There are several methods to estimate the confidence intervals for WTP, including the delta method, bootstrapping and the Krinsky-Robb method. Bootstrapping is the most widely used method. This re-samples the raw data and re-estimates the model for each draw (Efron and Tibshirani, 1993). In contrast, the Krinsky-Robb method uses random draws from the estimation results (Krinsky and Robb, 1986). Comparative studies of these approaches have concluded that their estimated confidence intervals are accurate and similar (Cooper, 1994; Hole, 2007). The estimation of confidence intervals by using any of these approaches is considered far superior than not estimating the intervals at all (Hole, 2007).

4.3.2. Total Willingness to Pay

The implementation of an environmental programme or policy including IPS management may cause changes in different attributes. The welfare estimates of compensating surplus can be measured at the household level as a household's WTP for the change scenario. According to Lancaster's theory of characteristics, the mean households' WTP for a scenario can be estimated by the sum of WTP for the attributes (Lancaster, 1966). An array of compensating surpluses can be estimated by establishing

multiple alternative scenarios. The implicit price can be used for the estimation. The compensating surplus for the change scenario can be calculated from the following:

$$CS = - (V_0-V_1)/\beta_c \quad (4.10)$$

where *CS* is the compensating surplus, β_c is the coefficient of the cost attribute, V_0 represents the utility of the current situation and V_1 represents the utility of the invasive species management programme.

The compensating surplus can be estimated for the individual household is used for the social CBA of a *Mikania* management programme. Hence, the use of CE to elicit social preferences for a specific environmental policy or programme ensures public participation in the environmental decision-making process. This promotes the efficient allocation of resources for invasive species management programmes (Nunes and Markandya, 2008). The social benefits of the invasive species management programme for the entire BZ community as total WTP can be estimated by:

$$\text{Total WTP} = WTP_{hh} \times N \times P \quad (4.11)$$

Where, WTP_{hh} is mean household WTP, *N* is the total household in the BZ and *P* is the percentage of respondents willing to invest in *Mikania* management activities.

4.4. Effects of the Invasion of *Mikania* on Rural Livelihoods

A conceptual framework proposed by Shackleton et al. (2007) describes the livelihood effects of IPS based on their characteristics using a two-by-two matrix of species competitiveness and usefulness. The framework had two categories for each

characteristic: weak and strong competitive ability, and highly and least useful. This study assumed that invasive species' usefulness depends upon two factors: (i) life-form of the species —woody or non-woody, and (ii) their mode of introduction —accidental or deliberate (Table 4.1). As discussed in previous section woody plants are more suitable for providing locally demanded forest products compared to non-woody plants. So, their status in the landscape— invasive or non-invasive—does not limit their role to contribute rural livelihoods. On the contrary, the invasion of non-woody species is likely to undermine rural livelihoods as these species are mostly unsuitable to produce locally important forest products. Hence, woody plants are considered as highly useful and non-woody plants as least useful.

Table 4.1 A Two-by-Two Matrix of Species life-form and the mode of introduction adapted from Shackleton et al. (2007)

Mode of the introduction	Life-form	
	Woody	Non-woody
Deliberately	Negligible or low impact on rural livelihoods— the species are already a part of the rural ecosystem and woody plants are also able to produce locally important forest products,	Moderate impact on rural livelihoods— the species are already a part of the rural ecosystem and local people may have derived benefits from these plants through appropriate technology,
Accidentally	Moderate impact on rural livelihoods — at least a group of people can get benefits from woody-plants such as households who use fuelwood.	Most severe effects on livelihoods species— these species have no or limited direct or indirect benefits to rural people as local communities are not well familiar with the species.

Usually, accidentally transported species are widely regarded as unwanted (McWilliam, 2000; McNeely et al., 2001). In contrast, deliberately introduced species generate benefits for at least some of the community, who welcome their introduction. For instance, *Lantana camara*; is considered as a notorious herb, yet is still appreciated as an ornamental plant (Ghisalberti, 2000). In addition, deliberately introduced species usually stay longer than the accidentally transported species before they become invasive. As described earlier in the Chapter 2.2.2.3, a long stay of exotic species in a landscape may lead to innovation and the species becoming an economic good. Hence, it can be presumed that deliberately transported invasive plants provide benefits to the local community regardless of their life-form.

In this proposed framework, *Mikania* falls under the category of accidentally introduced non-woody species. The framework demonstrates that the species under this category have the most severe effects on rural livelihoods as they have no or limited benefits to rural people and their abundance reduces the availability of locally important native species. When rural households face risk to their livelihood security, they become active to continue farm-based livelihood activities employing several coping strategies (Frankenberger, 1992). These households have developed a wide range of coping strategies as they have been confronted with adverse situations that undermine their livelihoods (Carver et al., 1989; Berzonsky, 1992).

In general, most of the households in society employ coping strategies; however, crisis-affected and poorer households adopt coping strategies more frequently relative to

unaffected and wealthier households (World Bank, 2011). This study assumed that affected households mostly practised larger numbers of coping strategies to adapt to the shortage to forest products. Therefore, 'coping strategy'—defined as the number of strategies (listed in Table 7.4) practised by households—was used as a proxy variable for measuring livelihood effects. Since, coping strategies vary across individuals, socioeconomic variables including age, proximity to forest, landholding size, family size, income source and gender, were used to explain the livelihood effects of *Mikania*. These variables were important determinants of forest product consumption patterns in Nepal (Adhikari et al., 2004a; Sapkota and Oden, 2008).

The following multiple regression model was proposed to identify the determinants of the livelihood effects of the *Mikania* infestation:

$$Cope = \alpha+\beta_1 X_1+ \beta_2 X_2+ \ldots\ldots\ldots\ldots\ldots +\beta_q X_q \quad (4.12)$$

Where, *Cope* is the coping strategy value from one to four (considered linear), α is a constant term, and β_1, β_2 ,….. and β_q are the vectors of the coefficient of the first independent variables X_1, X_2,….. and X_q, respectively. The descriptions and values of variables (x) are presented in Table 7.1.

4.5. Summary

This chapter introduced the CE method—a method that has received considerable attention from applied economists. Unlike other stated preference methods, CE provides a number of choice situations that contain different alternatives. These alternatives are

the bundle of attributes resulting from policy options. Alternatives are differentiated by the levels of the attributes. It is expected that a respondent selects the alternative from which they expect to gain the highest utility. Microeconomics consumer theory is the foundation of the CE.

The CE is founded on the assumption that a respondent makes an implicit trade-off between attributes when selecting an alternative. These attributes may produce utility to respondents. In general, the likelihood of selecting the alternative increases with the level of preferred attributes. Therefore, attributes are the major determinants of utility from the alternative. This is the notion of Lancaster's theory of characteristics. However, utility derived from the alternative does not solely depend on the given attributes; unobserved factors also influence utility. This error term (unobserved component) enters the utility function as an additive term. This provides a means to analyse respondents' behaviour under the random utility framework.

The error term is assumed to have independent and identical distribution. This is the main support for CL models. However, this has major two pitfalls:

i. It overlooks preference heterogeneity; and
ii. It assumes there are *iid* error terms.

The first of these can be handled by introducing socioeconomic variables in utility function. The latter imposes the IIA property. However, this property is too restrictive and can lead to inconsistent parameter estimation. To relax this problem, the CL model

is extended to the RPL model. Here, the observed component is divided into two parts, which allows the error components to be correlated across the alternatives.

By using the analysis of stated preference responses, the CE estimates preference parameters (that is, part-worth utilities). This is also called the 'marginal WTP' or implicit price of the attribute. CEs prepare the preference list of attributes included in choice sets. This allows individuals' WTP to be aggregated to estimate social welfare. Hence, CE has applications in policy decision-making.

In addition, this chapter also outlined the analysis of the effects of *Mikania* on the BZ households of CNP. Usually, non-woody plants are not suitable to produce locally important forest products. Hence, their infestation mostly undermines rural livelihoods and households are assumed to use coping strategy to minimise the risks. This study proposed an assessment of livelihood effects of *Mikania* based on the number of coping strategies households are practising. This is based on an assumption that crisis-affected households mostly practised larger numbers of coping strategies to manage the shortage in forest products. The following chapter presents this study's data collection strategy.

Chapter 5 : Data Collection

5.0. Introduction

The previous chapter outlined the theoretical framework of CEs and the model specifications used to analyse CE data. This chapter focuses on the implementation of CE surveys used to determine the preferences of households in the BZ of CNP in Nepal for a *Mikania* management programme. This chapter presents a detailed description of the steps involved to elicit individual preferences in the BZ of CNP. CE surveys require the following four steps to collect data (Alpizar et al., 2001):

i. Identification of the attributes and their levels, and a payment vehicle;
ii. Experimental design;
iii. Questionnaire development; and
iv. Sampling strategy and interview.

This chapter describes how this study sought to address the issues relating to non-market valuation in developing countries in general, and in rural areas in particular. The issues related to low-income communities were handled during attribute selection and definition of the payment vehicle. The complexities associated with education and heterogeneous societies were addressed with several strategies, such as visualising choice scenarios, recruiting local enumerators, and conducting interviews in local dialects. As described earlier, labour contributions were used to elicit BZ households' preferences in consideration of household income levels.

Two CE surveys were undertaken to answer the research questions developed in the previous chapters. These two surveys were used to manage the problems associated with implementing CE surveys in subsistence communities. These were based on

two different experimental designs. CE-I examined whether estimated WTP is sensitive to the mode of contribution. The results of the first CE survey highlight the importance of using labour as a mode of contribution. CE-II was designed to estimate the social opportunity cost of time, while eliciting WTP for a *Mikania* management programme.

This chapter is primarily divided into two sections, based on the experiments' designs. The main differences between the two experiments were the attributes included and the provision of an option to select the mode of contribution. In CE-I, respondents were asked whether they were willing to contribute towards the mitigation of *Mikania* in monetary terms. If their response was negative, they were provided with the option of contributing in labour terms. to choose their preferred mode of contribution before the choice task. In contrast, in CE-II, respondents were asked their preferred mode of contribution as a follow-up question. In addition, two payment attributes (monetary and non-monetary) were included in CE-II. The dataset for assessing the livelihood effects of *Mikania* in the BZ community was part of the CE survey. The information from CE-I was used for this purpose.

5.1. Choice Experiment-I

This experiment addressed two issues:

i. Estimation of the BZ community's WTP for a *Mikania* management programme; and
ii. Estimation of the BZ community's WTP to manage the invasion of *Mikania*, sensitive to the mode of contribution.

In addition, this survey assessed the key determinants that influenced the selection of the mode of contribution, while completing the choice task. Information collected from this survey also addressed the livelihood effects of the invasion of *Mikania*.

5.1.1. Designing the Choice Experiment

In the CE survey, respondents were asked to select their preferred option among the given hypothetical alternatives in the choice set. The CE design created a set of hypothetical choice scenarios/alternatives to present to respondents. These scenarios should be fit for statistical analysis. A choice experimental design requires two steps:

i. Selection of the attributes relevant to the issues being analysed and their levels; and
ii. Development of a set of choice tasks (hypothetical scenarios) that are presented to respondents.

The questionnaire was completed only after the choice tasks were designed. The challenge in designing a CE suitable for a developing economy was to create choice scenarios that were appropriate for the respondents (Whittington, 2002). Such scenarios assist respondents to efficiently choose trade-offs between changes in the levels of the attributes (Bennett and Birol, 2010).

There are a large number of properties and services related to ecosystems. These properties are sensitive to the ecological, economic and social dimensions of environmental policies, including IPS management programmes. Ecologists define these properties in their own way. In this context, economists face two major challenges when estimating values for forest ecosystem services (Czajkowski et al.,

2009). First, they have to determine the most relevant services on which to focus. Second, they have to translate ecological indicators into plain language that respondents can understand. These issues are sensitive and complex, particularly in the rural areas of developing countries. Individuals' levels of education may not enable them to make trade-offs between a large number of attributes, and they may have their own means of defining ecosystem services.

5.1.1.1. Selection of Attributes

The hypothetical scenarios presented in the CE surveys were considered the policy outcomes related to the problem under investigation. They were comprised of attributes, which were the characteristics of the products of services under valuation. In other words, they were the potential outcomes of hypothetical *Mikania* management programmes. The alternatives were distinguished by the levels of the attributes and their combinations. In any CE study, making correct decisions at the design stage is important to ensure the success of the survey. These decisions include determining the number of attributes, the attribute levels, and how the levels and attributes should be described (Hanley et al., 1998b; Bergmann et al., 2006). The literature suggests that attributes should be relevant to the problem being analysed, clear to respondents, realistic, and applicable to policy analysis.

In low-income settings, the selection of attributes is a challenging task. This is because communities have low levels of education and CE surveys are likely to be a new experience for respondents. Given that non-market valuation is a democratic process, the participation of concerned stakeholders to define and select attributes can assist in translating the ecological indicators into plain language. This is

considered one of the challenges of applied economists in non-market valuation (Czajkowski et al., 2009). Two strategies—focus group discussions with local communities and questionnaire pre-testing—are effective in identifying appropriate attributes (Bergmann et al., 2006; Do and Bennett, 2009).

To this effect, for this study, five focus group discussions in five different BZCFUGs were conducted with local communities (see Appendix 5.1). The prerequisites to select from the pool of potential BZCFUGs were:

i. The intensity of *Mikania* colonisation in the respective community forests; and
ii. The location of the forest user groups—whether in villages or urban areas.

The BZCFUGs with different levels of *Mikania* infestation were considered and selected accordingly. A total of 74 local forest users, including general users and members of the BZCFUG executive committee, of both genders participated in the focus groups. They took part in the intensive discussion and questionnaire pre-testing. All focus groups were undertaken at the offices and meeting places of the respective BZCFUGs. These groups focused on the selection of attributes, the levels of the attributes, and the payment vehicle.

The focus group discussions were divided into two sections:

i. Selection of the attributes and their levels; and
ii. Pre-testing of the draft questionnaire.

At first, all focus group participants were given a copy of a plain language statement (Appendix 5.2)[4], which was also read aloud to them. This statement briefly introduced the research. The participants were then asked whether they were willing to participate in the research. Following the approval to take part in the research, photographs and specimens of *Mikania* were shown to the participants. This was mainly to establish a consensus about the plant species under investigation. The focus group were asked whether they had encountered any difficulties in identifying the species. If they confirmed that they had, other participants were requested to describe the species to the uncertain group members.

After confirming the identification of *Mikania*, participants were asked how they considered the spread of the vines in their landscape. There was consensus that *Mikania* does not offer any of the benefits required for their livelihoods. Instead, it imposes social costs by negatively influencing the rural ecosystem. The effects of *Mikania* include a decrease in plant species and forest product availability. In addition, participants had experienced a decrease in the frequency of wildlife sightings, and damage to the jungle walking path. A decrease in the number of visitors to the community forests had also been observed. A list of the effects of *Mikania* infestation, both positive and negative, was prepared. The focus group participants mentioned a long list of effects that were observed after the infestation of *Mikania* in the BZ. While evaluating the effects of *Mikania*, participants were encouraged to compare the current situation with the situation of five years ago.

[4] Received ethics approval (Project No: 2010-213) from the Human Research Ethics Unit, Deakin University.

The inclusion of all effects mentioned by the focus group participants in the CE was not possible, as the size of the experimental design increases with the number of attributes. Inclusion of all effects in the survey would demand a large amount of resources. The main issue was to determine the most relevant effects (Czajkowski et al., 2009). As CE is based on the respondents' responses, inclusion of the attributes they consider relevant may encourage them to participate in the research. This is only possible by consulting the target population. In addition, the CE needs to be designed so that the findings are relevant to policy decisions, and so that they accurately reflect public preferences. The task was to select the most preferred attributes.

The focus group participants were asked to prioritise the effects of *Mikania* (Bergmann et al., 2006). This was performed by a majority voting system. Each participant was allocated four voting rights. They were given freedom to use their voting rights either all for one attribute or one for each attribute. The intention behind the four voting rights was to include five attributes in the choice set. The monetary value as an attribute is a mandatory attribute in the estimation of WTP. Therefore, there was a need to select the other four attributes of public importance among the list of effects.

The rankings of each attribute from all focus groups were added individually. An average of their rank was then estimated for individual attributes. The selected attributes were similar to the motivational factors influencing individuals' WTP to support IPS management in a hypothetical market (García-Llorente et al., 2011).

Based on the preferences of the focus group participants, the following four attributes were given highest priority:

i. Forest product availability;
ii. Number of plant species present;
iii. Number of visitors to community forests; and
iv. Forest density.

The prioritisation of these attributes was followed by the pre-testing of a draft questionnaire. Choice scenarios in the draft questionnaire were with five choice sets containing three hypothetical alternatives in each set. The choice scenarios for the questionnaire test were prepared based on literature, information from local newspapers and discussion with local experts. The alternatives were the bundle of five attributes. After completing the questionnaire, participants were asked about the questionnaire. They were then requested to suggest how the questionnaire could be improved in terms of its design and clarity. The focus group participants stated that they were anxious when forced to make a trade-off between the attributes. They realised the choice task was complex. In addition, they were overwhelmed due to the number of attributes and choice scenarios presented. They suggested reducing the number of attributes and choice sets in each version.

In developing economies, determining the appropriate number of attributes and their levels is particularly important to enhance the efficacy of the choice task (Bennett and Birol, 2010). Following the focus groups, the number of attributes was reduced to four, including the cost attribute. This provided a balance between the competing objectives of estimating WTP for forest attributes and ensuring the task was

cognitively feasible for the rural respondents. Limiting the number of attributes may not influence the effectiveness of the CE. The majority of previous CE studies included a range of three to six attributes, plus cost (Scarpa and Rose, 2008). The top three were selected from the priority list to include in the choice set for this study. The fourth attribute—forest density—was excluded from the design.

The selected attributes covered an array of values under the total economic value framework. For example, 'forest products availability' was related to direct use value. 'Plant species present' represented non-use values and was related to biodiversity. Some of the plant species had links with cultural values. Bequest and existence values were also covered by this attribute, as respondents wanted to protect native species from extinction. The attribute 'visitors to community forest' directly reflected the indirect use value of recreation. In addition, this attribute was linked with habitat protection of wildlife and biodiversity. In general, the attributes are the outcomes of policy decisions. They have to be measurable so that respondents can evaluate the changes. All these attributes may appear to be direct use values; however, they are influenced by changes in indirect and non-use values.

5.1.1.2. Payment Vehicle

Every project requires a mechanism to raise funds to implement the proposed programme under investigation. This is called a 'payment vehicle'. The importance of selecting an appropriate payment vehicle has been widely acknowledged in stated preference literature (Bateman et al., 2002; Ivehammar, 2009). An appropriate payment vehicle helps involve stakeholders in decision-making. It also acts as a borderline to decide whose preference should be elicited. In CE, it is a challenge to

select the appropriate payment vehicle, and this is even more problematic in subsistence economies. The dominance of non-monetised economic transactions and poorly developed financial institutions limit the available payment vehicles in low-income settings (Bennett and Birol, 2010).

Previous CE studies have used payment vehicles in the valuation of non-market forest benefits are compulsory annual payments and voluntary once-off donations. Compulsory payment methods—such as changes in income tax and utility bills—may not be relevant to all respondents. As farm households have subsistence incomes, they are not familiar with income tax. In addition, rural areas have inadequate facilities, such as electricity, and other utilities are often freely available, such as drinking water. Thus, using utility bills as a payment vehicle may not encompass all stakeholders. On the other hand, a voluntary once-off donation may encourage respondents to exaggerate their WTP (Ivehammar, 2009), and rural populations in developing countries are not familiar with monetary donations.

Two possible payment vehicles were discussed during the focus group discussions:

i. A BZ level fund for *Mikania* management; and
ii. An annual membership fee for the BZCFUGs.

Usually, rural people have serious concerns about the misuse of public funds. Focus group participants were not confident about the proper use of funding when centralised at the BZ level. They were not supportive of a *Mikania* management programme that proposed the establishment of special central level fund. Instead, they proposed to manage the fund at the BZCFUG level. This involved charging all households an annual membership fee for the respective group.

They were confident that a fund collected as an annual membership fee, at user group level, could be allocated for forest management activities. The users would have the ability to monitor the BZCFUG fund. In addition, they would have input into the expenditure of the fund. This is because the user group assembly is the supreme body of BZCFUGs. The payment vehicle selected was a mandatory yearly contribution in the form of an annual membership fee. All member households of BZCFUGs would make payments to a fund exclusively devoted to improve the condition of their community forests through the implementation of a *Mikania* management programme.

5.1.1.3. Levels of Attributes

Typically, the levels of attributes measure a change in the quality or quantity of the given attributes. The combination of the different levels of attributes distinguishes the alternatives presented in the choice set. Well-defined and realistic levels of attributes help respondents assess hypothetical changes in policy outcomes. The levels of attributes should be meaningful to respondents who are making the decision (Adamowicz et al., 1994; Bennett and Blamey, 2001). Therefore, the focus groups were asked to define possible levels of attributes. They were requested to define the levels based on how they assessed a change in the given attribute.

For example, the BZ community could compare a change in forest product availability in terms of the time required to collect firewood and fodder for one day's supply. They preferred not to assess this attribute as a change in the quantity of products. If forest products are in short supply in the BZCF, community members explore other areas in the national park. This means that villagers are collecting the

same amount of forest products. However, it may take more time to reach the core area of the national park, as they have to cross their BZCF. In addition, entering the park to collect forest products is strictly prohibited, thus there is also a risk of being caught by the park authority. This means they cannot harvest freely, which means harvesting may take more time. The availability of forest products in the BZCF in sufficient quantities means a shorter collection time for harvest—and vice-versa. This attribute was refined after taking into consideration these aspects. It was renamed as 'forest product collection time' and the levels were defined based on the hours required to collect forest products.

A review was undertaken of the literature and the reports of BZCFUGs, and the NGOs—the National Trust for Nature Conservation and Terai Arc Landscape, World Wildlife Fund, Nepal; and Partnership for Rhino Conservation—working to support biodiversity conservation in the BZ of CNP. This information triangulated the information gathered during the focus group discussions. In addition, it also provided quantitative information to define the levels of the attributes. The attributes and their levels were finalised after a series of comprehensive discussions with local experts, including officials from CNP, the District Forest Office, and NGOs working in the study area (Do and Bennett, 2009; Brouwer et al., 2010). The involvement of local experts to define attributes and their levels helped make attributes more relevant and meaningful to policy-makers and forest managers (Do and Bennett, 2009). It is important to link CE results with policy decisions.

Table 5.1 reports this study's selected attributes and their levels. Four attributes—including the cost of policy outcomes—with 13 different levels were selected for the

estimation of WTP to mitigate the damages caused by the *Mikania* invasion in the BZ of CNP. Three attributes relating to policy outcomes had three levels each. These were 'forest product collection time', 'plant species present' and 'visitors to community forests'. The 'cost' of the policy had four levels. In non-market valuation studies, it has been frequently observed that the number of levels used for the price attribute is larger than those used for the other attributes presented in a choice set (Scarpa and Rose, 2008).

Table 5.1 Attributes and Levels used in Choice Sets (CE-I)

Attributes	Description	Current situation
Forest products collection time	Time required to collect forest products (mainly fodder and fuelwood) for daily requirement after arriving at the forest, excluding travel time to and from the forest. There were three levels: four hours, two hours and one hour.	Four hours
Plant species present	The number of plant species in the community forests. There were three levels: 102, 115 and 126 species.	102 species
Visitors to community forests	The number of tourists visiting community forests annually. There were three levels: 20,000, 27,000 and 35,000.	20,000
Cost	An annual membership fee in each BZCFUG that users are required to pay in local Nepali rupees (NRs.).[5] There were four levels: In cash (NRs.): 350, 1,050, 1,750 and 2,450; In labour[6]: one day, three days, five days and seven days.	No contribution

The levels of 'forest product collection time' and 'cost' (annual membership fee) were selected based on the local experience, as discussed in the focus groups.

[5] Local currency: Nepalese Rupees (NRs.). 1 US$ = NRs. 71.00 (during the study period).
[6] Local market wage rate per day was NRs. 350.00 during the study period.

According to the focus group participants, before the introduction of *Mikania*, an hour was a reasonable period in which to collect the daily requirement of fodder and fuelwood. This does not include walking time. After the colonisation of *Mikania*, approximately four hours on average was required for the same purpose.

Regarding the levels of the 'cost' attribute, participants were asked how much their household could contribute annually to mitigate the damages caused by *Mikania*. A realistic range of the attribute was suggested as being between one to seven days of labour contribution annually, or the equivalent wage. The level of 'plant species richness' in the riverine grassland and forest was initially determined from the literature (Lehmkuhl, 1994; Sapkota, 2007). The inventory record of the concerned forest user groups was also reviewed. The plant species recorded in the forest patches of the study area had reduced from an estimated 126 plant species of different life forms to approximately 106 species, excluding *Mikania*, between 1994 and 2007. Based on the literature and operational plans of the BZCFUGs, the levels of the plant species' present attributes were determined.

The levels of 'visitors to community forest' attribute were primarily based on the visitor records of the BZCFUGs. The upper limit was their target to increase the number of visitors to community forests. The records of the studied BZCFUGs were added and averaged. It was calculated that forest user groups were hosting approximately 20,000 visitors annually. Five years ago, this had been up to 27,000 visitors, on average. According to the focus group participants, the decrease in visitor numbers in their BZCFUGs was mainly due to the colonisation of *Mikania*, as the likelihood of seeing wild animals was lower due to habitat shifting. The trails

for jungle walks were also unclear. However, the number of visitors in CNP had continued to increase during the past five years (DNPWC, 2010; DNPWC, 2011). After the focus group meetings, a discussion with the executive members of the concerned BZCFUGs was held. They indicated that they had planned for an increase in the number of visitors by at least 50 per cent of the existing number.

5.1.2. Experimental Design

The experimental design created the hypothetical scenarios required for the choice task. There are two general types of CEs: labelled and unlabelled (Louviere et al., 2000). The label reflects the information regarding alternatives. For example, Czajkowski et al. (2009) named alternatives as an extension of the national park, and used other forms of protection to estimate the value of forest diversity. On the other hand, unlabelled CE uses generic titles for the alternatives, such as 'Option A', 'Option B', and 'Status quo'. The type of CE—whether labelled or unlabelled—does not restrict the number of alternatives in a choice set (Hensher et al., 2005).

Unlabelled designs have significantly smaller numbers of possible alternative combinations than labelled designs. This is because, in labelled designs, it is assumed that all labels are presented in a choice set and that the same label does not appear more than once in a choice set. In an unlabelled CE design, the same label is allowed to appear more than once but the same item is not able to appear more than once in a choice set (De Bekker-Grob et al., 2010). For example, in this CE, each choice set had two alternatives (excluding the status quo) with four attributes. Three attributes had three levels and one had four levels (Table 5.1). This yields 11,664

possible alternative combinations ($(3^3 \times 4^1) \times (3^3 \times 4^1)$) for a labelled design, while an unlabelled design could produce just 108 ($3^3 \times 4^1$).

There are several other benefits of using unlabelled designs, including:

i. They do not require the identification and use of all alternatives within the universal set of alternatives; and
ii. They may be more robust in terms of not violating the *iid* assumption.

In unlabelled designs, the alternatives are less correlated with the attributes compared to labelled designs (Hensher et al., 2005). In fact, unlabelled designs encourage respondents to choose an alternative by trading-off attribute levels. This is the most desirable condition from a non-market valuation perspective (De Bekker-Grob et al., 2010). Therefore, an unlabelled design was selected to estimate the BZ community's WTP to mitigate the damages caused by *Mikania*. In the choice sets, the alternatives were named 'Current situation (no intervention)', 'Alternative A' and 'Alternative B'.

In a stated preference survey, choice alternatives (hypothetical scenarios) are created by a systematic and planned design process. This process manipulates the attributes and their levels to permit statistical analysis (Louviere et al., 2000). The alternatives are differentiated by the levels of the attributes in a choice set. In CE surveys, a common practice is to create hypothetical scenarios using an orthogonal design. An orthogonal design satisfies attribute level balance, and all parameters are independently estimable. The CE estimates the part-worth utility for each attribute by aggregating responses from all respondents. It must ensure orthogonality of attribute levels both within and between the given alternatives. Generally, the design

is called a factorial design. This may be full factorial, which includes all treatment combinations (108 profiles in this study), or fractional factorial, which considers only a subset of all treatments (Louviere et al., 2000).

The use of a full factorial design in a stated preference survey guarantees that all attribute effects are truly uncorrelated. However, this may not be appropriate for several reasons (Louviere et al., 2000). First, most non-market valuation studies are too large to design the study using a complete factorial plan. Consideration of all profiles is not possible due to resource and time constraints. Second, not all effects are equally interesting—very few are of real interest (Louviere et al., 2000). Thus, in order to make a more parsimonious CE, these combinations can be reduced by choosing an efficient subset that exploits the sparsity-of-effects principle (Wu and Hamada, 2000). A study that selects an efficient subset for its survey has a fractional factorial design.

An array of fractional factorial design plans exists. Some investigate main effects only, others investigate main effects with some two-way interactions, and others investigate main effects plus all two-way interaction effects (Louviere et al., 2000). Only a few effects in a factorial experiment are statistically significant, and attributes under the experiment have low order interactions (Wu and Hamada, 2000). An orthogonal main effects experimental design is applicable for this purpose. This is because approximately 70 to 90 per cent of the variance within linear models can be explained by main effects (particularly considering that choice models are linear in utility functions) (Dawes and Corrigan, 1974; Louviere et al., 2000).

Orthogonal designs are more relevant for linear models. They are unlikely to be efficient in the context of discrete CE. This is because choice responses are non-linear and have logistic specifications (Scarpa and Rose, 2008; Bliemer et al., 2009; Bliemer and Rose, 2010). In addition, cost effectiveness—which is a consideration in many non-market valuation studies—can be achieved by reducing the size of the experimental design (Kerr and Sharp, 2010). Therefore, in the context of CE, the goal is to generate an optimal or statistically significant design, rather than focusing on orthogonality (Hensher et al., 2005). D-efficiency design strategies produce significantly improved results, in the sense of relative efficiency (Rose et al., 2008). The non-linearity of the CL model specifications is likely to influence the efficiency properties of the maximum likelihood estimator in estimating preference parameters from CE data (Ferrini and Scarpa, 2007). For these reasons, Ngene[7] software was used to develop an efficient design for this experiment after defining the attributes and their levels.

An efficient design requires prior parameter information. Some studies consider the null hypothesis (zero priors), while others assume prior knowledge about the parameters (Bliemer and Rose, 2010). These values can be obtained from different sources, such as previous studies, piloting and assumptions based on the available information. Bliemer et al. (2009) argue that, as one can apply zero prior values, the need to use prior parameters should not be considered a major deterrent in applying efficient designs. The design can be improved based on the prior information available, such as knowledge of the sign of the parameter (Ferrini and Scarpa, 2007; Rose et al., 2008). Misspecification of priors may decrease the efficiency of the

[7] Ngene 1.0.2 is software for generating experimental designs for CEs. It was developed by ChoiceMetrics.

design; however, an efficient design will still tend to perform better than other design types (Bliemer and Rose, 2006). The designs for this study were optimised on the D-error by using different combinations of the prior values.

This study presumed that the analyst is able to define some *a priori* belief on the values of β vector, and that the status quo is positive and equal to unity (Scarpa and Rose, 2008). This experimental design was based on a best guess—mainly on the sign of parameters. The value of parameters was fixed based on the relative importance of attributes to rural households. It was postulated that, for a farm household, 'forest product collection time' is a highly significant variable in determining preferred forest policy. It was assumed that, in a rural community, respondents would prefer this time to be minimised. Hence, this attribute was assigned a negative sign.

The study area is a popular tourist destination. Tourism is one of the major income sources of the BZCFUGs and many local households. It was assumed that 'visitors to community forests' was the second most significant attribute, followed by the 'plant species present' attribute. BZ households value different plant species for various purposes, such as for sustenance, medicine and religion. A positive sign was assumed for these two parameters, as both have a positive influence on rural livelihoods. As usual, the 'cost' attribute was assumed to have a negative sign, indicating that a lower amount was preferred by respondents.

The utility specification used in generating the designs can be summarised as follows:

$$V_1 = \alpha+\beta_1 x_1+\beta_2 x_2+\beta_3 x_3+\beta_4 x_4$$

$$V_2 = \alpha+\beta_1 x_1+\beta_2 x_2+\beta_3 x_3+\beta_4 x_4$$

$$V_{sq} = 1 \qquad (5.1)$$

Where, V_1 and V_2 are the utility from alternatives A and B, respectively, and V_{sq} is the indirect utility from the 'status quo (no intervention)' alternative. The prior parameters for this study were taken as $\alpha = 0.20$, $\beta_1 = -0.7$, $\beta_2 = 0.2$, $\beta_3 = 0.6$ and $\beta_4 = -0.35$. Here, α is the constant term and β_1 to β_4 denote the coefficients of the parameters 'forest product collection time', 'plant species present', 'visitors to community forests' and 'cost', respectively. The design iteration with the lowest CL-D error (0.053) in 127,908 iterations was chosen.

An experimental design was chosen with 24 choice situations. These were blocked into six versions (Appendix 5.4), which meant that each respondent faced four choice situations. During the questionnaire pre-testing, it was observed that five choice situations in a version of the questionnaire would take more time, and respondents would lose concentration. Respondents of this study generally had a relatively low level of education (see Table 7.2), and were new to this type of exercise. The study attempted to minimise the cognitive burden of the questionnaire. The focus group participants expressed the opinion that a higher number of choice sets may lead to inconsistencies in choice selection. Thus, it was determined that four choice sets in each version of the questionnaire would be the most appropriate for this study.

5.1.3. Survey Administration

CEs are based on conducting questionnaire survey. The mode of survey and strategy to approach the respondents plays a paramount role in developing country contexts (Bennett and Birol, 2010). The survey strategy determines the quality of the data, as responses depend on the level of understanding of the choice task. The responses are usually collected based on the questionnaire. The questionnaire contains various issues related to the problem being analysed, as well as choice scenarios created by the experimental design. The following subsection provides information about the questionnaire; the research used, in terms of content and design; the sample selection; and the data collection strategy that was executed to collect responses during the field study in the BZ of CNP, Nepal.

5.1.3.1. Questionnaire

The questionnaire consisted of three sections, which were translated into the Nepali language (Appendix 5.5). The first section consisted of introduction and background information about the invasion of *Mikania* in CNP, and the spreading of the species. This information was unbiased and did not mention the effects of *Mikania*. This left respondents to evaluate the infestation of *Mikania* themselves. This was done because the evaluation of invasive plants varies between individuals in rural areas (Shackleton et al., 2007; Mwangi and Swallow, 2008). To understand respondents' knowledge and the ways in which they evaluated the invasion of *Mikania*, they were asked about the problem. These questions examined respondents' perceptions of *Mikania*, including how they believed it was transported and when it was introduced. This was included because public support for IPS management depends

on individuals' knowledge and perceptions of particular invasive plants (García-Llorente et al., 2011).

This section also contained details of the proposed plan to mitigate the damages of *Mikania*, with the inclusion of four different choice scenarios. These choice scenarios were created based on the efficient design. The scenarios were presented to elicit public preferences and WTP to mitigate the damages caused by *Mikania*. Additionally, this section provided supporting information about selecting the best options from the given set. Follow-up questions were asked to understand respondents' decision-making strategies and heuristics (Carlsson et al., 2010). These follow-up questions also helped to identify 'protest respondents', who reject or protest against some aspect of the constructed market scenario (Meyerhoff and Liebe, 2008). This is useful in developing countries because a significant number of respondents to stated preference surveys in these economies tend to protest (Do and Bennett, 2009).

As the survey targets a rural community with limited education, choice task complexity is a crucial issue. In order to enhance the efficacy of the choice task, scenarios were presented visually to enhance clarity. Visual decision aids can improve respondents' choices by reducing the task complexity. This can be effective when respondents have low literacy rates (Jae and Delvecchio, 2004; Bennett and Birol, 2010). In rural settings, communications that describe attributes via pictures, and attributes' levels via charts and graphics have been found to be effective. This can make the attributes more legible, and enable respondents to make trade-offs with greater ease (Adhikari et al., 2005; Brouwer et al., 2010). The attributes with

pictures and the levels with vertical bars were visualised. Efforts were also made to minimise the text (Figure 5.1). This was done not only for respondents, but also for enumerators, as visual aids helped them describe the choice situation effectively.

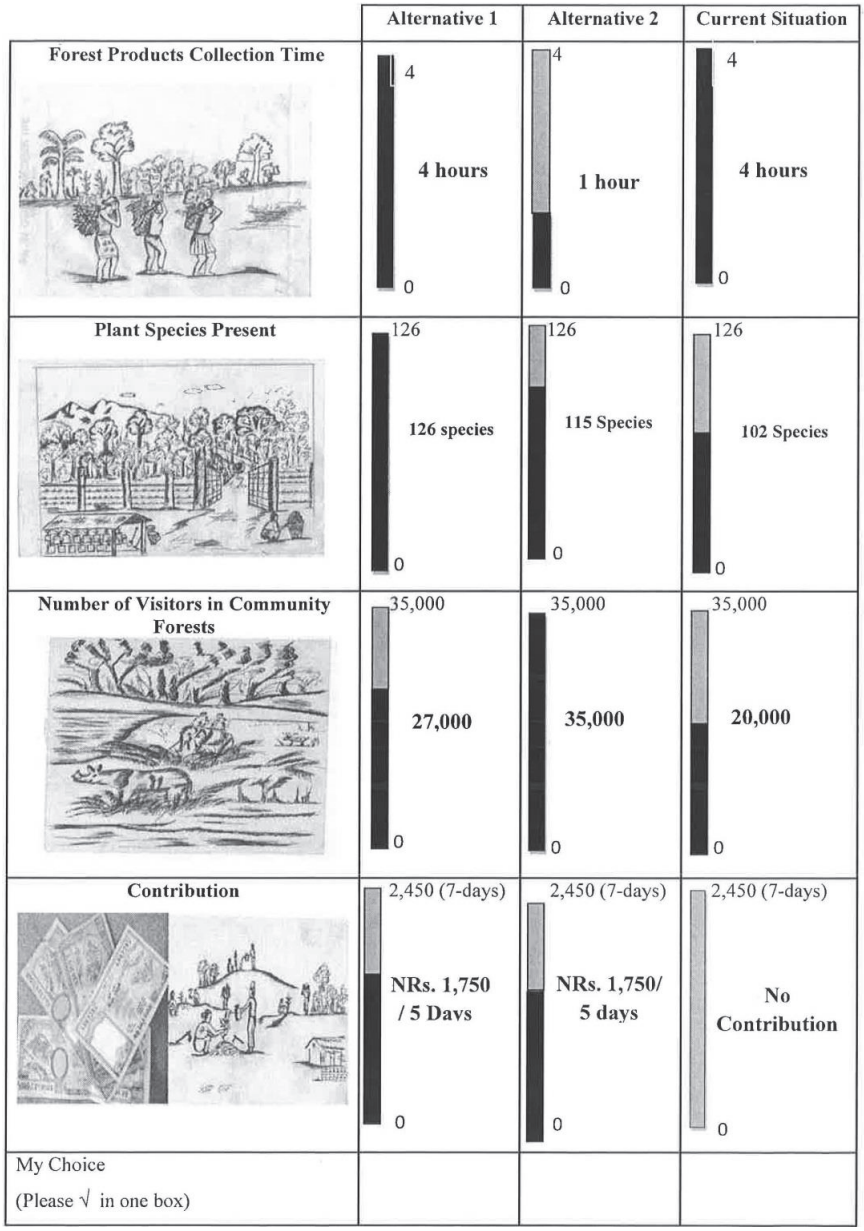

Figure 5.1 Example of Choice Set used in the CE-I (Translated to English)

The choice situations varied in each version of the questionnaire. Each version contained four choice situations with three alternatives in each set. The number of

observations in the CEs was therefore increased by presenting a number of choice sets to a single respondent. The form of a repeated choice task is likely to raise auto-correlation. This is ignored in the standard logit or probit models that are usually applied in CEs (Bates, 1988).

The respondents were told that the alternatives contained hypothetical outcomes that could be accomplished with management intervention in the community forests. The hypothetical annual membership fee used as a payment vehicle was to be collected for five years. This is a common timeframe for the operational plans of the BZCFUGs. As respondents were given an option of electing the preferred mode of contribution in the CE-I, this section of the questionnaire was prepared accordingly. This meant that respondents who were willing to contribute in labour terms received choice scenarios with labour contributions, instead of an annual fee, and vice-versa.

The second section of the questionnaire assessed the link between the *Mikania* infestation and the livelihood activities of BZ households. This section sought information related to the changes that the rural people had experienced since the invasion of *Mikania.* These changes included forest product collection time, plant species that were used for different purposes, the number of livestock, and the amount of forest products collected. Furthermore, it sought to elicit information about how respondents were responding to changes in forest product collection time, what effects they were experiencing in their farmland, and whether they were using *Mikania* for any purpose. In this section, respondents were asked to compare the current situation with that of five years ago, as the invasion of *Mikania* came to public notice in 2004 (Poudel et al., 2005)

The final section of the questionnaire was designed to collect socioeconomic information about the respondents. This included age, household income source, duration they had lived at their current address, gender, education, family size, landholding and proximity to the forest. These variables were included in the CE response analysis to detect the preference heterogeneity of the respondents. The inclusion of individual specific variables can increase the systematic component of utility and decrease the random component (Rolfe et al., 2000).

5.1.3.2. Household Survey

In developing countries—particularly in rural communities—respondents have low education levels. In addition, they are unfamiliar with the exercise of selecting a preferred option in a hypothetical scenario. In this context, asking them to read a complex questionnaire and expecting them to select a preferred alternative is difficult (Do and Bennett, 2009). In the study area, the average education level of respondents was not above primary school level (Table 7.2). This situation does not favour the drop off–pick up method of data collection. Hence, face-to-face interviews based on the questionnaire were undertaken (Bennett and Birol, 2010). The head of the selected households was interviewed.

Several strategies can be used to improve data quality in household surveys in developing countries. These include the involvement of researchers in the field during data collection; entering and verifying data in the field; recruitment of a local interview team, consisting of male and female enumerators; and ensuring the interview team receive appropriate training (Puetz, 1993). A team of local enumerators was selected to conduct the household survey. As these enumerators

were not familiar with CE exercises, appropriate training for them was crucial to ensure the success of the CE study (Bennett and Birol, 2010). They were trained by the research team and supervised regularly throughout the interview process.

When selecting the enumerators, various social and cultural issues were considered. For example, rural communities in Nepal have diverse cultural practices. Rural people, particularly women, do not openly engage with outsiders. Even if they encounter outsiders, they are hesitant to have an open conversation with them. In addition, these rural communities have heterogeneous ethnic groups that have their own dialects, such as *Tharu* and *Derai*. Usually, a person can understand clearly when s/he is informed in their native language compared to information provided in a second language. Conducting an interview in a language other than the respondent's native language may limit their understanding, as their education level is comparatively low. The team of enumerators for this study were chosen to represent different ethnic groups and genders. This ensured that the study was able to have participation from women and ethnic groups.

Two advantages of the involvement of local enumerators were observed during the data collection. First, it ensured the participation of all parties, including women, who are limited to household activities. Second, it reduced the task complexity by describing the choice task in local dialects. This is important in countries such as Nepal in general, and in rural communities in particular, where people hesitate to speak openly with outsiders. In addition, over 100 dialects are spoken throughout the country (CBS, 2001). The interviews were conducted in different languages,

including Nepali (the official language) and *Tharu* (a local dialect). Interviewees were asked their preferred language prior to the interview.

The sampling frame for this study was the members of the BZCFUGs of CNP. The BZCFUGs were selected randomly by considering different intensities of *Mikania* colonisation. Local experts who were working in the field of biodiversity conservation were consulted when selecting the forest user groups for the study. The households for the interviews were stratified based on their proximity to the respective community forest. This was because dependency on forest products can vary with the distance between the households and the forest (Sapkota and Oden, 2008). The manner in which households perceive the effects of *Mikania* are also influenced by proximity to the forest (Rai et al., 2012b). Households were divided into three groups, based on the distance from the house to the community forest. These groups were based on three distances: less than one kilometre, one kilometre to two kilometres, and more than two kilometres from the forest.

A total of 500 households were interviewed for CE-I. All approached households participated in the interview. In household surveys in developing countries, a 100 per cent response rate is expected when local enumerators are employed to conduct interviews (Hung et al., 2007; O'Garra, 2009). As the problem under investigation is relevant to respondents' daily life, this also motivates them to participate in the research. The interviews were carried out between January and March 2011.

The households were selected systematically. The first household was selected randomly and then every following tenth household considering their locations on

both sides of the street was interviewed along with scattered houses as well. The first household received the first version of the questionnaire, and the second household selected the second version, and this pattern of distribution was continued. This meant that every seventh household answered the same version of the questionnaire. Household heads of either gender were interviewed based on their availability during the visit. In rural economies, men have more decision-making power for household expenditure, while women are considered key players in natural resource management (Tinker, 1994; Agarwal, 2001; Angel-Urdinola and Wodon, 2010).

Respondents were first given a plain language statement to read (Appendix 5.3). This statement was read aloud to participants who were unable to read the information. They were then asked whether they were prepared to participate in the research. After their approval was obtained, photographs and specimens of the vines were shown to respondents. This helped establish a consensus about the plant species under investigation. They were then asked whether they were able to recognise the species. As the villages were in close proximity to the forest and had regular interaction with forest resources, identification of the vine was not a problem. However, the vine was known locally by different names, such as *Lahare banamara* and *Lahare jhar* (Rai et al., 2012b).

Each enumerator was given a file with a set of colour choice cards. Enumerators described the choice scenarios with the help of the colourful cards (Figure 5.2). Respondents were asked to look at the colour cards to select the best option for them. Both parties—the respondents (particularly older people) and the

enumerators—found the cards helpful to understand and describe the choice scenarios. During the pre-tests, the participants confirmed that clear choice cards could facilitate an efficient choice task. Additionally, the use of such colourful cards helped minimise the size (number of pages) of the questionnaire. In this condition, presenting choice scenarios with pictographs in each set of the questionnaire was not necessary.

Figure 5.2 An Enumerator Showing Colour Choice Scenarios

Respondents were provided with the option of expressing WTC in the non-monetary term of labour contribution, if they were willing to participate in a *Mikania* management programme, but did not wish to contribute in monetary terms. The labour contribution was monetised based on the local wage for agricultural labour. It was considered that the respondents were well informed about the type and period of work they would have to undertake (O'Garra, 2009). Usually, BZCFUGs have well

defined times for forestry activities. The estimation of the value of time spent on forestry activities, based on the market wage rate, was conservative, as the agricultural labour wage is low.

Based on their response to the initial question regarding the preferred mode of contribution, respondents were presented with the choice sets. Respondents who preferred to contribute in labour terms were given choice sets with labour contribution as the cost attribute. Respondents who elected to pay in monetary terms were given choice sets with annual membership fees as the cost attribute. These respondents were asked to make a trade-off with the annual membership fee. The corresponding values of levels of monetary and non-monetary terms were based on the labour wage during the survey period. For example, if the respondent selected one day in labour terms, in monetary terms, this was NRs. 350, while three labour days cost NRs. 1,050, and so on.

5.2. Choice Experiment-II

The second CE survey was similar to CE-I in terms of the data collection methods, study area and experimental design. The enumerators were also the same. However, there were several differences between the two surveys. These included the attributes included in the choice set, the inclusion of priors in the CE design, and the selection of the mode of contribution prior to the choice scenarios. This subsection discusses the ways in which CE-II varied from CE-I.

As mentioned earlier, this survey used information from the first survey to design the experiment. There was no duplication of focus group discussions, piloting, and

discussion with local experts to define attributes, attribute levels, and the selection of payment vehicles. In this survey, two payment-attributes 'labour contribution' and 'cost'—were included in the choice sets. The attribute 'plant species richness' included in the CE-I was omitted in this CE (Table 5.2). Thus, this experiment had four attributes with 14 different levels, which can produce a total of 144 ($3^2 \times 4^2$) possible combinations in an unlabelled design.

Table 5.2 Attributes and Levels Used in Choice Sets (CE-II)

Attributes	Description	Current situation
Forest product collection time	Time required to collect forest products for daily requirements, excluding travel time. There were three levels: four hours, two hours and one hour.	Four hours
Visitors to community forests	The number of tourists visiting community forests annually. There were three levels: the same number as currently, 1.5 as many as currently, and twice as many as currently.	20,000
Labour contribution	An annual labour contribution for forest management activities. There were four levels: zero days, three days, five days and seven days.	No contribution
Cost	An annual membership fee in each BZCFUG, which users were required to pay in local Nepali currency. There were four levels (NRs.): zero, 1,050, 1,740 and 2,450.	No

The rationale behind the separate CE design was to estimate the value of time that agricultural households would like to contribute to a *Mikania* management programme. In the stated preference studies, WTC in the labour term was monetised later, according to the market wage rate (Hung et al., 2007; O'Garra, 2009). As described in Section 4.3.1, the CE provides an opportunity to estimate the marginal

rate of substitution between each attribute. The marginal rate of substitution with cost attribute is known as the implicit price of that attribute. Hence, the labour contribution as an attribute with monetary value was included in the choice sets. The inclusion of the two modes of contribution allowed the estimation of the implicit price for labour, which is the opportunity cost of labour. The estimated shadow value of labour helps address the criticism of using labour as a numéraire, due to various opportunity costs across the individual. This also provides a means of comparison between WTC money and labour.

Members of the BZCFUGs were paying a fixed annual fee for fodder, and were also participating in forest management activities. Hence, this study expected that respondents were familiar with these two types of contribution. In addition, the choice sets considered a level equal to zero days, with a positive annual membership fee; and a level with a zero membership fee, with a positive labour contribution. This provides respondents with the opportunity to respond in terms of only one mode of contribution, if this was their preference.

As in the CE-I, 24 choice sets were constructed using an efficient design. These were divided into six blocks (Appendix 5.6). The priors for CE-II were taken from the CL model estimations of the previous choice data (Table 7.7) to design the experiment. As the coefficient of the constant was insignificant in the model estimations, the value of α was set to be zero, as shown in equation 5.1. The iteration with the lowest CL D-error (0.043) in 64,642 iterations was chosen. As with CE-I, choice sets were presented visually in this experiment.

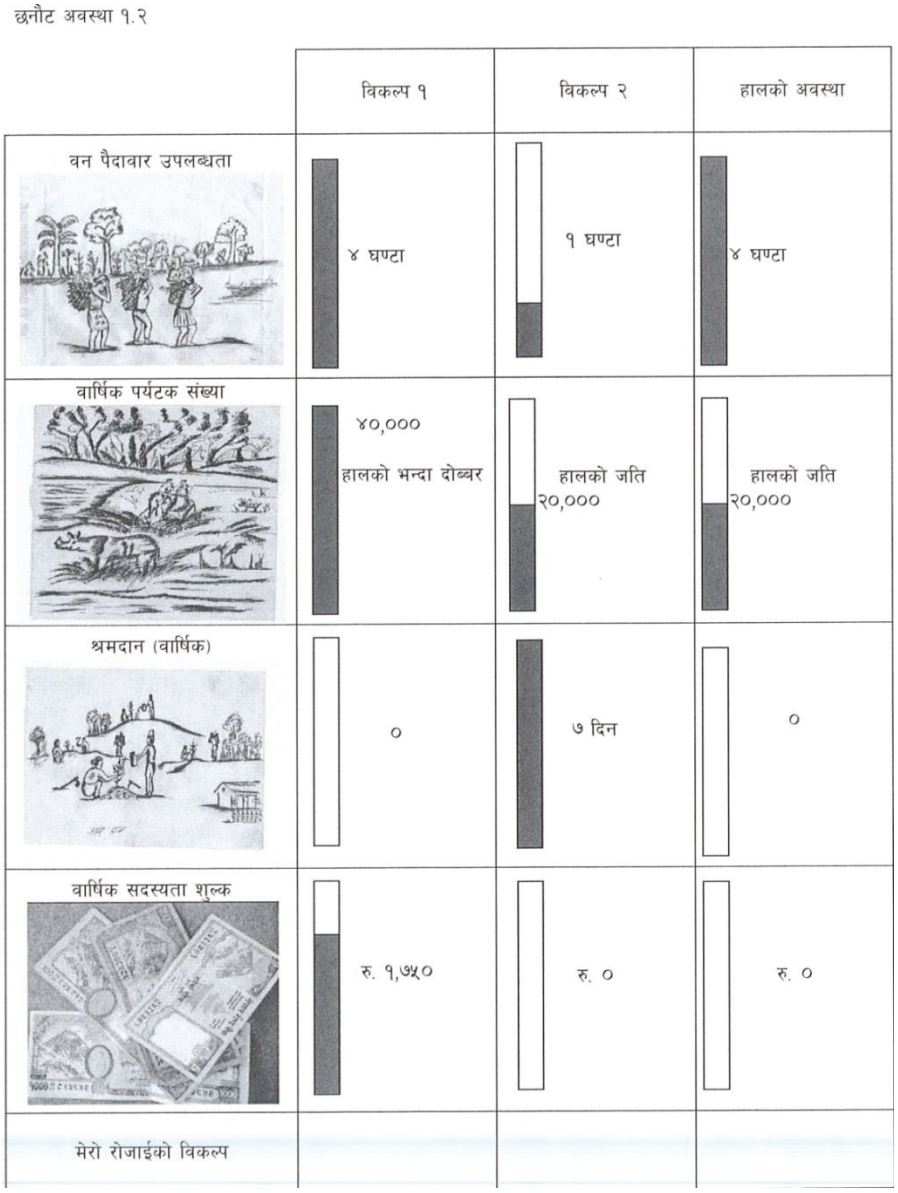

Figure 5.3 Example of a Choice Card used in the CE-II (in Nepali)

The previous team of enumerators was again recruited for this survey. They were informed about the changes in the choice scenarios. A similar strategy was adopted to select the respondents, inform the interviewees about the research, use colourful cards, and conduct the interviews in the respondents' preferred dialects. Unlike the CE-I, respondents were not provided with the opportunity to select the mode of contribution before the choice task. Instead, this was included in the follow-up questions.

The time frame for the proposed programme was similar to CE-I (five years). The personal information section was extended in this survey in order to obtain further details about household information—mainly annual income and expenditure. A total of 325 households were interviewed from the same BZCFUGs as CE-I. The head of the household—whether male or female—was interviewed; based on their availability during the visit. The interviews were conducted between August and October 2011.

5.3. Summary

The chapter discussed the implementation of CE surveys targeting low-income communities. It discussed this study's research design and survey implementation strategies, and how these were used to determine public preferences for a *Mikania* management programme in the BZ of CNP, Nepal. This thesis was based on two CE surveys. CE-I estimated WTP for the proposed programme based on two different modes of contribution. This study investigated whether the estimated social benefits were sensitive to the mode of contribution in a subsistence community. It found that focus group discussion is central to CE surveys in low-income settings, as this helps select appropriate attributes and define them in plain language. In addition, focus groups help define the appropriate size of the experiment and develop questionnaires suitable for respondents. Consultation with local experts during the design phase helps link CE results with policy decisions.

An efficient design was used to create hypothetical scenarios. It was helpful to define the size of the experiment, and was also meaningful, as CE responses were analysed through logistic regression models. Choice sets were presented using

pictures, and vertical bars to the choice exercises enhanced the clarity of the survey for respondents with low levels of literacy.

The employment of local enumerators and the consideration of gender and cultural aspects encouraged the participation of disadvantaged groups, such as women and indigenous people, in the decision-making process through the CE survey. This is the main notion of CBF—to ensure good forest governance.

CE-II was employed to include both monetary and non-monetary payment attributes in the choice sets. This was used as a basis for estimating the shadow value of time spent in a *Mikania* management programme. This provided a means of comparison between the estimated WTC labour and money. The following chapter develops the research hypotheses that were tested by this thesis.

Chapter 6 : Research Hypotheses

6.0. Introduction

The previous chapters introduced the research problems, research questions, method of CE and data collection strategies for this research. In this chapter, the research questions developed in Chapters Two and Three are developed into the general hypotheses that were addressed by this thesis. These general hypotheses are formulated into specific research hypotheses, which will be tested in Chapter Seven.

This chapter has two sections. The first section outlines the general hypotheses for the individual research questions. These general hypotheses are then developed into the research hypotheses that were tested in this study. A conclusion to the chapter is provided in the second section.

6.1. Hypotheses

6.1.1. Livelihood Effects of *Mikania*

Chapter Two indicated that the livelihood effects of invasive plants are ambiguous. Invasive plants have dual roles of both destroyer and producer of the supply of ecosystem services. However, plant invasion has a largely negative public image, and policy decisions mainly aim to eradicate these plants. Such decisions may overlook the concern of those households who are benefitting from the species. This may create conflict in the implementation of decisions. This infers the need for a thorough understanding of the interactions between particular species and rural communities prior to programme design. A preliminary study showed that BZ households have negative perceptions of *Mikania.* The first research question outlined in Chapter Two extends the preliminary study by posing the following

question: How does the infestation of *Mikania* in the BZ of CNP influence households' livelihood activities? This research question was addressed by the first general hypothesis, which was:

> **General hypothesis one**: The infestation of *Mikania* undermines the livelihoods of the BZ community of CNP, Nepal.

This general hypothesis was tested by the research hypotheses, which are outlined in the following section. These hypotheses estimated a change in current activities compared to the activities of five years ago. These were based on the assumption that accidentally transported non-woody plants undermine the livelihoods of rural communities. This means that the community was in a better position in the past than it is currently. The research hypotheses presented here were mainly tested by descriptive statistics.

Naturally, the abundance of *Mikania* reduces the availability of native plants. This ultimately threatens the quality and quantity of the forest products delivered from the BZCFs. A shortage in the supply of forest products in common property forces households to seek alternative sources for forest product, use coping strategies, or change their livelihoods. This ultimately reduces their dependence on BZCFs—particularly for those who can afford alternative strategies. This can be translated in the form of a statistical hypothesis as:

> **H_1:** The infestation of *Mikania* has led to a decrease in the number of households collecting forest products from BZCF.
>
> **H_0:** The infestation of *Mikania* has led to no change or an increase in the number of households collecting forest products from BZCF.

The next research hypothesis considered the change in forest product collection time for a day's requirement of forest products:

H_2: The infestation of *Mikania* has led to an increase in collection time for a day's requirement of forest products.

H_0: The infestation of *Mikania* has led to no change or a decrease in the collection time for a day's requirement of forest products.

Shortage in the supply of forest products, including fodder, may force households to adjust their demand, which may lead to a change in the average livestock holdings per household. This led to the research hypothesis:

H_3: The infestation of *Mikania* has led to a decrease in the average livestock holding.

H_0: The infestation of *Mikania* has led to no change or an increase in the average livestock holding.

The second research question, raised in Chapter Two, related to the potential of a *Mikania* management programme to improve the welfare of the communities in the BZ of CNP. This question is addressed in Chapter Eight in the policy implication discussion of the research results. The general hypothesis to address research question two was:

General hypothesis two: The implementation of a *Mikania* management programme would increase the social welfare of the BZ community.

The estimations from the CE analysis were compared with the current budget that the Government of Nepal allocated to manage the BZ of CNP. Based on this, the research hypothesis was:

H_4: The benefits of a *Mikania* management programme are greater than the BZ management budget.

H_0: The benefits of a *Mikania* management programme are equal to or less than the BZ management budget.

6.1.2. Eliciting Willingness to Pay for a *Mikania* Management Programme

Implementation decisions regarding public projects such as a *Mikania* management programme depend on the benefits and costs generated from the programme. Usually, these costs are expressed in monetary terms. Complexity arises in estimating the monetary value of the benefits of the proposed programme, as these benefits extend beyond the financial. The CE method of stated preference approach elicited WTP for a *Mikania* management programme. Typically, the elicitation of WTP for non-market services is not preferred in low-income communities. The third research question was developed to quantify the BZ community's WTP for a *Mikania* management programme. This will be addressed in Chapter Seven by estimating households' WTP and total WTP from the analysis of CE responses.

In Chapter Three, the research argued that the use of non-market valuation surveys as policy tools in developing countries is mainly influenced by the design problems. The use of a non-monetary mode of contribution has occasionally been used to determine WTP. This research elicited WTC labour for a *Mikania* management programme. The CE survey was designed to select the preferred mode of

contribution—money or labour—to answer the fourth research question, which stated that the estimated public benefits of a *Mikania* management programme are sensitive to the mode of contribution. The second general hypothesis based on this background was:

General hypothesis three: The estimated WTP for a *Mikania* management programme is sensitive to the mode of contribution.

In general, WTP for public goods is a function of an individual's income. Thus, socioeconomic variables that influence the income of households and supply of labour have a significant influence on selecting the mode of contribution. This led to the following hypotheses:

H_5: An individual's age is a significant factor in selecting the mode of contribution.

H_6: Education level is a significant factor in selecting the mode of contribution.

H_7: Gender is a significant factor in selecting the mode of contribution.

H_8: A household's proximity to the forest is a significant factor in selecting the mode of contribution.

H_9: A household's landholding size is a significant factor in selecting the mode of contribution.

H_{10}: A household's main source of income is a significant factor in selecting the mode of contribution.

H_{11}: A household's size is a significant factor in selecting the mode of contribution.

H_{12}: A respondent's origin is a significant factor in selecting the mode of contribution.

The alternative hypotheses for hypotheses five to 12 were that the socioeconomic characteristics are not significant in the preference of the mode of contribution to complete the choice task.

Most BZ households depend on subsistence farming and have comparatively low incomes. It was expected that most of these households would demonstrate inability or unwillingness to participate in a *Mikania* management programme in monetary terms. This led to the hypothesis:

H_{13}: The number of households choosing to contribute in terms of labour outnumbers the number of households choosing to contribute in monetary terms.

$H_{0:}$ The number of households choosing to contribute in terms of labour is equal to or less than the number of households choosing to contribute in monetary terms.

As mentioned earlier, WTP or WTC is functions of households' incomes; thus, households with higher incomes generally prefer to pay in monetary terms. This led to the research hypotheses:

H_{14}: The WTP of households choosing to contribute in monetary terms is greater than the WTP of households choosing to contribute in labour terms.

$H_{0:}$ The WTP of households choosing to contribute in monetary terms is equal to or less than the WTP of households choosing to contribute in labour terms.

Social benefits are the aggregate of an individual's WTP or WTC. In accordance with H_{13}, the majority of households are assumed to contribute in labour terms. Hence, the testable research hypothesis was:

H_{15}: The total WTC of households choosing to contribute in labour terms is greater than the total WTC of households choosing to contribute in monetary terms.

H_0: The total WTC of households choosing to contribute in labour terms is equal to or less than the total WTC of household choosing to contribute in monetary terms.

In the CE, the public benefits of a *Mikania* management programme were estimated based on changes in attributes. These were included to create hypothetical scenarios that differed from the current situation. These attributes were selected from the focus groups that were conducted with individuals who represented the population from which the sample was drawn. Respondents were expected to assess the alternatives on the basis of the selected attributes. Hence, each of these attributes was expected to significantly influence the selections among the alternatives included in the choice sets. The testable research hypotheses were:

H_{16}: Forest product collection time is a significant attribute in the choice of invasive species management policy, and is negatively signed, with an increase in collection time reflecting a decrease in the utility of respondents.

H_{17}: Visitors to community forests is a significant attribute in the choice of invasive species management policy, and is positively signed, with an

increase in the number of visitors reflecting an increase in utility of respondents.

H_{18}: Plant species present is a significant attribute in the choice of invasive species management policy, and is positively signed, with an increase in the number of plant species reflecting an increase in the utility of respondents.

H_{19}: Labour contribution is a significant attribute in the choice of invasive species management policy, and is negatively signed, with an increase in labour days reflecting a decrease in the utility of respondents.

H_{20}: Annual membership fee is a significant attribute in the choice of invasive species management policy, and is negatively signed, with an increase in the annual fee reflecting a decrease in the utility of respondents.

The alternative hypotheses to hypotheses 16 to 20 were that the attributes included in the choice scenarios are not significant in selecting among the alternatives in the choice sets.

6.1.3. Shadow Value of Labour

The use of a labour numéraire raises a challenge in identifying the appropriate rate of conversion of time into monetary value. In a community, individuals have different occupations, thus their income varies. This means their opportunity cost of time spent in a *Mikania* management programme also varies. In Chapter Three, a research question was developed to identify the social opportunity cost of time. This examined the value of the shadow wage rate. It is widely accepted that farm households value their time by its marginal worth to households, and they supply

labour accordingly (Edmeades et al., 2006).The general hypothesis to address this research question was:

General hypothesis four: BZ households value the time they are willing to contribute in a *Mikania* management programme at a different rate to the current wage rate.

When farm households participate in forest management activities, they derive utility from meeting with friends and collecting forest products for household use. Thus, the research hypothesis to test the general hypothesis was:

H_{21}: The market wage rate is higher than the estimated shadow value of time.

H_0: The market wage rate is equal or less than the estimated shadow value of time.

6.2. Summary

This chapter has developed the general hypotheses and research hypotheses that this study tested. As discussed in Chapter Two, the livelihood effects of *Mikania* are determined by several factors, which lead to ambiguity. A policy needs to properly understand the effects of *Mikania* on livelihood activities. However, this research argues that accidentally introduced species have adverse effects on the provisioning of ecosystem services. The first general hypothesis attempts to contribute empirical evidence to this assumption by proposing that the infestation of *Mikania* undermines the livelihoods of the BZ community of CNP. This proposition was tested in three research hypotheses. First, the abundance of *Mikania* in BZCF reduces the availability of native species. This may create forest product supply shortages. Thus,

the number of households that depend on BZCFs for forest products decreases. Second, a reduction in the production of forest products means an increase in collection time. Third, to create a balance between the demand and supply of fodder, households must decrease their demand, which infers that they must downsize their livestock holdings.

It was expected that the implementation of a *Mikania* management programme would generate benefits to the BZ community. The second general hypothesis provided valuable policy information by comparing the costs and benefits generated by the programme. The cost of the programme was the government budget to manage the BZ of CNP. The benefits were estimated through the analysis of the CE responses.

The following two hypotheses arose from the practical issue of implementing CE surveys in a subsistence economy. The third general hypothesis focused on the implementation of a CE survey to elicit low-income households' WTP to manage invasive plants. The argument was that the use of a monetary mode of contribution is a major hindrance to implementing stated preference surveys in subsistence economies. Hence, it was expected that appropriate mode of contribution would help broaden the use of non-market valuation techniques in subsistence economies. This research contributes empirical evidence to this assumption by proposing that the estimated social benefits of a *Mikania* management programme are sensitive to the mode of contribution. This hypothesis was tested by using research hypotheses based on the assumption that WTP is a function of respondents' incomes. This study also tested the role of the socioeconomic characteristics of respondents (individuals

and households) in selecting the mode of contribution, and of attributes when selecting among alternatives.

The conversion of estimated WTC labour into monetary value naturally posed a question regarding the most appropriate conversion rate. Individuals within the community have different professions and incomes—they literally have different opportunity costs of time. Usually, farm households value labour based on its marginal worth to households. The third general hypothesis investigated whether the shadow value of time was different to the market wage rate. It has been widely observed that rural people enjoy participating in public activities such as forest management. Therefore, the general hypothesis was tested by proposing the research hypothesis that the estimated shadow value of time is less than the market wage. The next chapter presents the results of the two CE surveys and their analysis.

Chapter 7 : Results

7.0. Introduction

The previous chapters developed the research questions and hypotheses, and briefly presented the research methods and data collection strategy. This chapter presents the analysis of CE responses to the two surveys. Data were analysed using different statistical tools and software. The findings presented here provide insight into the decision-making strategies of the BZ community to mitigate the damages caused by *Mikania*. In addition, this section discusses how the BZ community is responding to the infestation of *Mikania* in the absence of external support to control the spread of the invasion.

This chapter is divided into five sections. The first section defines the socioeconomic variables included in the analysis. The second section reports the results from CE-I. This section is divided into three subsections. First, it presents the characteristics of the sample. Second, it reports on the livelihood effects of the infestation of *Mikania* and identifies how BZ households are responding to the infestation. Third, it estimates BZ households' WTC to a *Mikania* management programme with different modes of contribution. This subsection also presents the socioeconomic determinants of selecting the mode of contribution while completing the choice task. The third section presents the results from CE-II. This section estimates the shadow value of time spent in a *Mikania* management programme, while estimating the benefits of the programme using the WTP approach. In section four, the results of the CE surveys are outlined with respect to the research hypotheses developed in Chapter Six. The chapter concludes in the fifth section.

7.1. Description of Socioeconomic Variables

The socioeconomic variables described in this section are included in the analysis throughout the thesis (Table 7.1). The socioeconomic variables were household and personal (interviewee) specifics. The selection of these variables was based on the respondents' dependency on community forests and by selecting the alternatives presented in the choice sets.

Typically, rural communities in developing countries have heterogeneous socioeconomic strata of households. This heterogeneity exists in terms of private property (parcel size and livestock holdings), households' income source, family size, proximity to forests and place of origin. They were selected based on their dependency on BZCFs and their perception of CBF practices (Adhikari et al., 2004a; Sapkota and Oden, 2008; Pandit and Bevilacqua, 2011b). This research expected that factors positively associated with dependency on community forests would be more sensitive to changes in forest products due to the infestation of *Mikania*. These factors were expected to strongly influence these households' will to assist with the control of *Mikania* (Nun˜ez and Pauchard, 2010; García-Llorente et al., 2011).

Individual specific characteristics, such as age, gender and education, have a significant influence on WTP for non-market forest services (Lehtonen et al., 2003; Wang et al., 2007; Do and Bennett, 2009). In addition, gender roles in rural communities are important in terms of managing and using natural resources (Agrawal, 2001). Consideration of gender is important in invasive plant management, as gender differences exist in respect to invasive plants (Mwangi and Swallow, 2008; Fish et al., 2010).

Table 7.1 Description of Socioeconomic Variables

Variables	Description	Notation
Age	Age of the respondent (year).	Age
Gender	Gender of the respondent: male = 1, female = 0.	Gender
Livestock unit	Livestock unit per household. The average herd size was described by the livestock unit equivalence measure, using the livestock conversion scale to estimate the livestock unit: buffalo = 1, cattle = 0.7 and goats = 0.08, considering 500 kilograms per unit (Kosilla, 1988).	LU
Landholding size	Land owned by household in 'Katha', which is a unit of area approximately equal to 66.89 square metres.	Land
Walking distance	Time required to travel between respondents' residences to respective community forest by walking (expressed in minutes).	Dist
Forest visit	Visits to forest to collect forest products: non-visit = 0, visit = 1.	Visit
Education	Number of years attended school.	Edu
Agricultural Income	Household income source: agriculture = 1, off-farm = 0.	Inc_ag
Off-farm income	Annual family income from off-farm activities, including business, job, foreign employment and cottage industry (in NRs.).	Off-farm
Native	Native to BZ: native = 0, immigrant = 1.	Na
Family size	Number of adult members living in the same house.	Fam
ASC	Alternative specific constant (ASC): alternatives = 1, status quo = 0.	ASC

7.2. Choice Experiment-I

7.2.1. Socioeconomic Characteristics of Sample Households

Table 7.2 shows the socioeconomic characteristics of sample households. The majority of the total respondents (500) were female (60 per cent). The target group of this survey was the heads of the randomly approached households. The high number of female respondents was not surprising given that, in rural economies, women mainly stay at home. In many households, the men were absent as they were working away from home. However, the disproportionate representations of gender

should not influence the results, as respondents answered the questions by considering their household situations, rather than their personal situations. The survey is actually likely to produce pragmatic results in forest management, as women are the primary managers of forest resources (Agrawal and Ostrom, 2001). In addition, the government's priority is to encourage women's participation in the decision-making process of forest user groups (MPFS, 1988).

Table 7.2 Socioeconomic Characteristics of Sampled Households

Variables	Male	Female
Respondents	199	301
Livestock unit per household	2.17 (1.71) [a]	2.20 (1.79)
Age (years)	44.96 (12.62)	42.30 (12.30)
Education (years)	4.86 (5.32)	2.20 (3.55)
Average landholdings	12.77 (12.73)	11.40 (12.83)
Average family size	6.33 (2.81)	6.20 (2.56)
Native to study area	117	104
Income source (agriculture only)	58	89
Income source (agriculture and off-farm)	138	198
Income source (off-farm only)	3	14

[a] Standard deviation in parentheses

As CNP is one of the popular tourism destinations and is situated in the Terai region of Nepal. There is a large immigrant population. In total 56 per cent of respondents were immigrants. The employment opportunities in different off-farm activities, including tourism and access to foreign employment, have diversified economic activities. Thus, more than two-thirds of respondents had both agriculture and tourism as household income sources. However, 29 per cent of households still solely depended on agriculture. Households that had off-farm activities as their single source of income comprised only 3.4 per cent of the total household sample.

The mean age of participants was 43.19 years, the average family size was 6.25 people, and the average size of landholding was 11.95 Katha.

As expected, male respondents had higher average schooling in years than female respondents; however, the average schooling year was not above primary education. Only four per cent of respondents were university educated—undergraduate and above. This was not surprising, as education development in Nepal only began after democracy in 1951 (Wood, 1965). The average age of the respondents and the negative correlation between age and education supported the expectancy of a lower level of education among the respondents (Appendix 7.1).

The average land parcel size per household was less than the average Terai and national statistics (CBS, 2001). This might be due to migration—the high proportion of immigrants demonstrates the population pressure in the area. The high value of standard deviation indicated a disparity in landholding patterns. This unequal distribution of land was also due to the variations in family size, as family size and landholding size have a positive correlation (Appendix 7.1). The average family size was larger than the national average (CBS, 2001). This was not unexpected, as the study area was dominated by the indigenous *Tharu* community, who live in large joint families (Cederroth, 1995).

Similar to other parts of Nepal, cattle, buffalo and goat were the main forms of livestock in the study area. The average number of cattle per household was 0.69 (standard deviation: 1.20), whereas buffalo was 1.48 (1.50) and goat was 15 (2.75). Unlike other rural areas, the average cattle herd size was smaller than the buffalo

herd. The number of buffalo was mainly due to milk production and the dung required for biogas plants. In addition, local farmers use machines to plough their fields, thus do not keep oxen. The average household herd size was 2.18 livestock units.

7.2.2. *Mikania* and Livelihood Activities of BZ Households

7.2.2.1. Awareness of *Mikania*

All respondents were aware of a *Mikania* infestation in the BZ. They recognised the species by sight. According to the respondents, *Mikania* was first noticed in the BZ after the flooding in the Rapti River in 2003. They believed that the Rapti River, which flows to the south-west, brought the species to the BZ of CNP. This corroborates existing studies that *Mikania* moved westward in Nepal (Tiwari et al., 2005). No respondents believed the infestation of *Mikania* to produce benefits. They stated that any use they make of the vines has been forced upon them.

About three-quarters (73 per cent) of total respondents said that the condition of their community forests was comparatively worse than five years ago. However, BZCFUGs were regularising the collection of forest products and had imposed a ban on cattle grazing. Of all respondents, 95.4 per cent (477) had experienced a change in forest product availability. Only a small portion (3.8 per cent) had not noticed any changes in forest products, particularly of fuelwood and fodder. There were two main reasons for this: some households had only recently migrated to the area, and some households did not collect forest products from the community forests.

Respondents observed that *Mikania* had become more abundant in both the BZ and the core area of CNP over the last five years. *Mikania* is rapidly colonising the forest patches close to water sources (Rai et al., 2012b), which is displacing native regeneration and colonising respondents' gardens. Respondents noted that the abundance of *Mikania* is destroying wildlife habitats and jungle hiking trails. In search of suitable habitats, wild animals have moved towards the core area of the CNP. As a result BZCFUGs are receiving fewer visitors, even though visitor numbers have increased steadily over the last five years in CNP (DNPWC, 2010; DNPWC, 2011). In addition, 99.6% (498) of the total respondents thought that forest products were scarce in their community forests. This is creating a huge gap between the community's demand and community forest's ability to supply.

Unlike the focus group participants, 11 per cent (56) of the total respondents were using *Mikania* as fodder, particularly for goats during the winter. Of the total *Mikania* users, 75 per cent were female (14 per cent of the total female respondents), and 25 per cent were male (seven per cent of the total male respondents). The use of *Mikania* as fodder during the dry season (winter), when fodder becomes limited, indicates that the vines are not the preferred species to use for fodder (Rai et al., 2012b). Feeding *Mikania* to livestock can cause abdominal problems and is usually fed to livestock by mixing with other native grasses (Siwakoti, 2007).

7.2.2.2. Change in the Livelihood Activities of Households in the BZ

Like the focus group participants, respondents of the CE surveys also had negative views of the *Mikania* infestation (Rai et al., 2012b). The invasion of *Mikania* had influenced household activities. This was illustrated by a change in the forest

product collection time, the amount of collected forest products per trip, and the average size of livestock holdings compared to five years ago (Table 7.3).

The number of households visiting the community forest to collect forest products had decreased from 98 per cent to 46 per cent in the previous five years, due to the shortage of forest products. Forest product collection time for one day's requirements had increased more than twice. The frequency of visiting the community forest to collect forest products decreased substantially from six days to 1.6 days per week. Forest products collected per trip decreased. For example, fodder decreased from 1.13 to 0.55 Bhari, and fuelwood from 1.29 to 0.40 Bhari. The average livestock size per household decreased by 49 per cent.

Table 7.3 Change in the Livelihood Activities of BZ Households

Variables	Five years ago	Current situation
Households visit community forest (CF)	491	231
Average FP collection time[8] (hours/ trip)	1.49 (0.66)	3.64 (1.04)
Visit CF to collect FP (days/week)	6.0 (1.94)	1.6 (2.12)
Fodder (Bhari/trip)[9]	1.13 (0.56)	0.55 (0.52)
Fuelwood (Bhari/trip)	1.29 (1.02)	0.40 (0.54)
Livestock per household	9.63 (8.47)	4.93 (3.42)

Note: Standard deviation is in parentheses; FP is the abbreviation of 'forest products'.

Most households had faced adverse effects on their household activities. They were living in inferior conditions as a result of the *Mikania* infestation (Figure 7.1). Households who had reduced the frequency of visiting the BZCF to collect forest products comprised 86 per cent of the total sample. Likewise, 52 per cent and 67 per

[8] Forest product collection time was expressed as time spent per trip to collect either fodder or fuelwood for one day's requirement. This did not include the travel time between the forest and households.

[9] Bhari is the traditional unit of measurement for fuelwood and forage in rural areas. One Bhari is equivalent to 25 kilograms.

cent of households were collecting less fodder and fuelwood, respectively, per trip compared to five years ago. Despite a heavy reduction in the amount of forest products collected per trip, 65 per cent of households were spending more time for a single trip to collect forest products compared to five years ago. This may be the reason that 70 per cent of total respondents were downsizing their livestock herd.

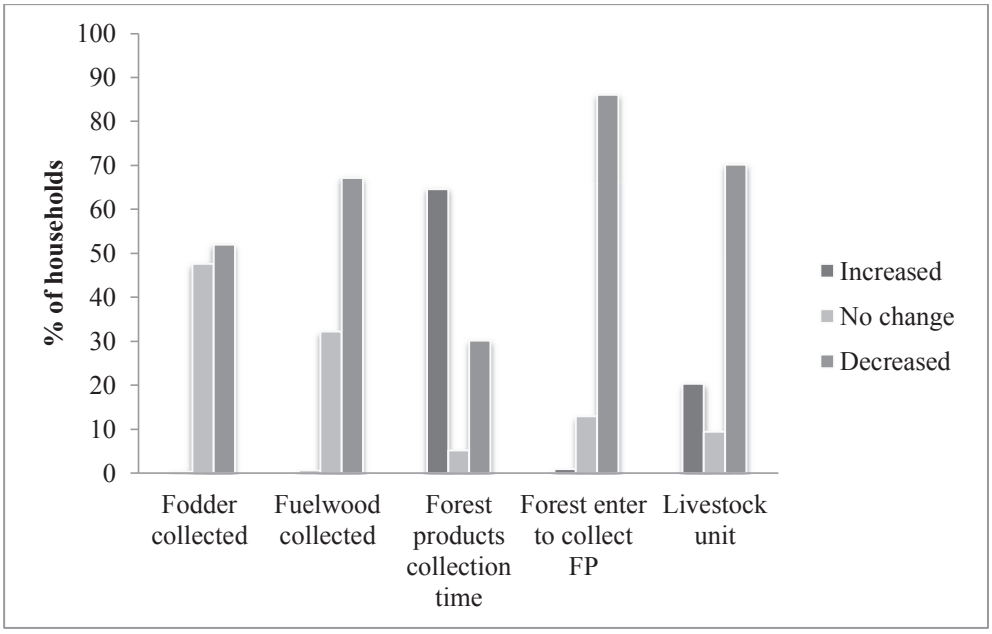

Figure 7.1 Households' Changing Activities Over the Last Five Years (%)

There was also a significant portion of the population who had not encountered any changes in the amount of fodder (48 per cent) and fuelwood (52 per cent) collected per trip. In addition, a small portion of respondents were collecting more than before. According to respondents, there were two reasons for this:

i. The collection of forest products is not limited to their BZCF because they can illegally enter the core area of CNP; and

ii. A large number of the sample households had decreased their dependency on the BZCF.

The latter scenario has become an opportunity for those who visit the forest regularly. Close to one-third of households (30 per cent) were spending less time than before. This was mainly due to a reduction in the amount of forest products collected per trip.

7.2.2.3. Determinants of Implementing Coping Strategies

The preliminary study showed that the BZ communities responded to the infestation of *Mikania* by employing different control strategies, such as uprooting and cutting. However, this failed to achieve the expected results. In this context, they were using different livelihood strategies to cope and recover from the stresses and shocks caused by the forest resource degradation. All households, whether using *Mikania* or not, were employing different coping strategies to mitigate the scarcity of forest products. Four main coping strategies were used by the BZ community at the household level to adjust for the decrease in forest products due to the invasion of *Mikania*. These are displayed in Table 7.4.

Table 7.4 Households Practising Compensating Strategies

Strategy	Households practising (%)
Explore greater area	149 (30%)
Agro-forestry	425 (85%)
Buy (rice straw and fuelwood)	361 (72%)
Alternative energy	279 (56%)

Of these strategies, planting trees on private land was the most common method (85 per cent of total respondents); followed by buying rice straw to feed livestock and buying fuelwood from the local market (72 per cent); followed by using alternative energy, including biogas, liquefied petroleum gas and sawdust stoves (56 per cent);

followed by exploring further areas in the national park (30 per cent). Households were not limited to a single strategy; many executed more than one strategy. There were external supports from government agencies and NGOs for local farmers to install biogas plants and sawdust stoves as substitutes for fuelwood. More than one-quarter of respondents (138) had installed biogas plants. This comprised 49 per cent of the total households practising alternative energy.

The results of the multiple regression model (equation 4.12 and extended version in Appendix 7.6h) are reported in Table 7.5. The results show that variables such as age of household heads and households' income source, livestock size and proximity to the community forest are significant variables that influence households' coping strategies. Households with agriculture as their main source of income and older household heads are more likely to undertake a greater number of coping strategies. Likewise, the number of coping strategies depends on the size of livestock herds. More distant households practise fewer strategies than those living closer to the community forest.

Table 7.5 Factors Influencing Practice of a Number of Compensating Strategies

Variables	Coefficient (standard error)
Constant	1.470 (0.246)***
Age	0.011 (3.14E-3)***
Male	0.111 (0.081)
Inc_ag	0.504 (0.230)**
LU	0.126 (0.023)***
Land	-8.35E-4(3.22E-3)
Dist	-4.24E-3 (1.93E-3)**
Adjusted R^2	0.46

Note: ** and *** denote significance at five per cent and one per cent, respectively.

7.2.3. Choice Responses

As previously indicated, the CE survey was carried out to estimate the benefits of a *Mikania* management programme in the BZ of CNP. Socioeconomic statistics indicated that the majority of respondents in the study area were subsistence farmers. There are limitations associated with the application of non-market valuation techniques, including CEs, in low-income economies. In part, this is due to a concern that using money as a mode of contribution may not capture the potential contribution of low-income households. To address this limitation, respondents in this study were provided with the option of expressing WTC in labour contribution if they declined to express WTC in monetary terms.

The following section begins the data analysis with an overview of the socioeconomic determinants of selecting the mode of contribution. The results of the CL and RPL estimations of the CE responses are included. CE data were divided into two groups based on the elected mode of contribution. The implicit price of each attribute and the aggregated social benefits from the implementation of a *Mikania* management programme were estimated in different scenarios. This section mainly quantifies the benefits of managing IPS, particularly *Mikania*, in the BZ of CNP, in terms of WTP. In addition, the estimated values of WTC, expressed in two different modes of contribution, are compared.

7.2.3.1. Determinants of Selecting the Mode of Contribution

Approximately 35 per cent (176) of the total respondents elected an annual membership fee as the mode of contribution to complete the choice task. The remaining 65 per cent (324) of the total respondents were unwilling to participate in

monetary terms, but completed the version of the CE with the labour mode of contribution. Of the total male respondents, 46 per cent (91) and of the total female respondents, 28 per cent (85) expressed their WTC in monetary values. Respondents who selected the monetary mode of contribution had better educations and larger landholdings than the respondents who selected the labour mode of contribution. The socioeconomic characteristics of sample households are presented by mode of contribution in Appendix 7.2. Due to the high value of standard errors, the descriptive statistics were not sufficient to describe the effects of the socioeconomic characteristics of households in selecting their preferred mode of contribution. Therefore, further analysis was carried out to identify the socioeconomic determinants of selecting the mode of contribution.

A regression analysis was used to understand the factors influencing respondents' selections of preferred mode of contribution. The data analysis was carried out using STATA/SE-12. In this analysis, 'mode of contribution' was the response or dependent variable. This variable contains two possible outcomes: household selects a monetary value as a mode of contribution (1) and labour contribution (0).

Therefore, a binary logistic model was used for analysis. The model used was:

$$Mode = \alpha+\beta_1\times Male + \beta_2\times Edu+ \beta_3\times Land+ \beta_4\times FA+ \beta_5\times dist+\beta_6\times visit+\beta_7\times NA+\beta_8\times inc\_ag+\beta_9\times Age \quad (7.2)$$

where *Mode* denotes the mode of contribution and β_1 to β_9 are the vectors of the coefficients of the respective variables.

Table 7.6 Variables that Influence Selection of the Mode of Contribution

Variables	Coefficients (standard error)
Constant	-1.039 (0.666)
Male	0.680 (0.247)**
Education	0.082 (0.031)***
Landholding size	0.091 (0.012)***
Family size	-0.120 (0.048)**
Distance	-0.012 (0.005)**
Forest visit	-0.448 (0.230)**
Native	0.463 (0.245)*
Income_Agri	-0.914 (0.262)*
Age	0.001 (0.011)

Note: *, ** and *** indicate significance at 10 per cent, five per cent and one per cent, respectively.

The results of the binary logistic model, with Chi-square value 134.38, log-likelihood -257.14 and *pseudo* R^2 0.207, are reported in Table 7.6. The results show that migrant male respondents with higher education were more likely to select the monetary mode of contribution. Likewise, the likelihood of electing this mode of contribution increased with the size of landholdings. The likelihood of electing the labour mode of contribution increased with the distance between households and community forest, larger family size and greater frequency of visits to community forests to collect forest products. In addition, households having agriculture as their only source of income elected the labour contribution format more frequently than households with off-farm income sources did.

7.2.3.2. Model Specifications

All respondents showed their WTC to a *Mikania* management programme. As expected, respondents who were unwilling to participate in monetary terms expressed their preferences in labour terms. The responses were grouped according

to the elected mode of contribution to complete the choice task. Hence, two datasets emerged: monetary and labour. Estimations were made individually for each group and were then compared.

None of the respondents were found to select the 'current situation' in all scenarios presented. They all also believed that BZ households were responsible for a *Mikania* management programme. As each respondent was given four hypothetical choice scenarios, 704 and 1,296 observations were made for the monetary and labour groups, respectively. The choice data sets were analysed using NLOGIT 4.0 (with Limdep 9).

7.2.3.2.1 Multinomial logit

For each group, two different CL models were estimated (Table 7.7). The first model (Model-I) was basic, and included attribute variables with the ASC (Appendix 7.6a). This model demonstrates the importance of the attributes in explaining respondents' choices across three different alternatives in a choice set: current situation (no-intervention) and two alternatives. In the second model (Model-II), selected socioeconomic variables were included in interaction terms. They were interacted with the ASC and attributes (Appendix 7.6b).

Usually, the prevention and management of invasive species have gender dimensions (Fish et al., 2010). Empirical evidence has shown that there is a considerable difference in the distribution of benefits and costs of plant invasions between men and women (Mwangi and Swallow, 2008). To address this, the gender

of respondents was considered an important factor in detecting the heterogeneity. Hence, the gender of respondents was interacted with the attributes.

Table 7.7 Coefficients Estimate for CL Models (CE-I)

Variables	Monetary		Labour	
	Model-I	Model-II	Model-I	Model-II
ASC	2.23E-2	7.41E-2	6.48E-2	0.1228*
	(9.13E-2)	(8.66E-2)	(6.93E-2)	(6.51E-2)
FP collection time	-0.697***	-0.436***	-0.6706***	-0.323***
	5.98E-2	(9.97E-2)	(0.0414)	(5.63E-2)
Plant species	6.75E-2***	4.89E-2***	0.0695***	4.43E-2***
	(5.56E-3)	(9.31E-3)	(4.31E-3)	(6.08E-3)
Visitors	2.02E-4***	1.37E-4***	2.05E-4***	1.28E-4***
	(1.21E-5)	(2.09E-5)	(9.17E-6)	(1.26E-5)
Contribution	-6.08E-4***	-6.17E-4***	-0.210***	-0.194***
	(6.65E-5)	(9.25E-5)	(1.68E-2)	(1.95E-2)
Age × ASC	-	7.75E-2***	-	5.51E-2
		(2.22E-2)		(7.24E-2)
Edu × ASC	-	0.384*	-	-0.231
		(0.220)		(0.220)
Fam × ASC	-	-0.168	-	0.961
		(0.102)		(0.748)
Male× FP collection time	-	0.185	-	1.25E-2
		(0.131)		(9.58E-2)
Male × plant species	-	-2.34E-2**	-	-2.60E-2***
		(1.19E-2)		(9.70E-3)
Male × contribution	-	1.60E-4	-	8.15E-3
		(1.30E-4)		(3.30E-2)
Male × visitors	-	-3.10E-5	-	-2.19E-5
		(2.69E-5)		(2.06E-5)
Log likelihood	-447.05	-415.37	-787.53	-712.43
Pseudo R^2	0.116	0.174	0.121	0.202

Note: Standard error in parentheses.

*, ** and *** indicate significance at 10 per cent, five per cent and one per cent, respectively.

The model fit improves by including respondents' individual specific characteristics. This was indicated by the improved log-likelihood and increased value of *pseudo* R^2 in the CL (Model-II) of both groups. As expected *a priori*, respondents preferred lower payment and a decreased forest product collection time. They preferred to have their community forest with higher numbers of plant species and visitors. This supported the hypothesis made on the signs of parameters during the experimental design (equation 5.1). The ASC is positive, showing preferences of the respondents to change the current situation. However, this was not significant at the five per cent level in all the models.

In Model-II of the labour group, none of the socioeconomic variables interacting with the ASC were significant in determining choice. This suggests that there was a degree of consensus among the villagers who elected the labour mode of contribution. Therefore, socioeconomic characteristics were not important in determining choices. The interaction between the socioeconomic variables and the attributes indicated that female respondents were more likely to prefer plant species richness than their male counterparts.

Unlike the labour group, socioeconomic characteristics such as age, family size and education were significant variables in the monetary group. However, the latter two variables were significant only at the 10 per cent level. For this subset of data, the likelihood of selecting the alternatives to mitigate the effects of *Mikania* increased with the age and level of education of the respondents. On the contrary, it decreased with family size. The interaction term between the gender of respondents and the

attributes demonstrated that female respondents were more likely to prefer plant species richness than their male counterparts, as was found in the labour group.

To test the validity of the IIA/*iid* condition underpinning the CL models, a Hausman test was performed for each group of data. It is found that both datasets did not support the test, as the difference matrix was not positive definite. Therefore, further analysis was performed for both groups.

7.2.3.2.2 Random Parameter Logit

In this thesis, RPL models were estimated for both data sets (Appendix 7.6c). Both RPL models were statistically significant overall, with Chi-square statistics of 1,407.80 and 719.49 (with 13 degrees of freedom) for the labour and monetary groups, respectively. Akin to CL models (Model-II), the selected socioeconomic variables were interacted with the ASC and gender of respondents with attributes.

Following Hensher et al. (2005), the distributions of the random parameters were detected. The models reported in Table 7.8 are the outcomes after testing several estimations. As there were minimal differences, the model was selected with 1,000 random draws and the attribute of 'visitors to community forests' as a random parameter with normal distribution. The random variable indicated that respondents had heterogeneous preferences over this attribute. Respondents had consensus regarding the two attributes of 'forest product collection time' and 'plant species present', as these were estimated as non-random parameters.

Table 7.8 RPL Model Results (CE-I)

Variables	Monetary	Labour
ASC	-4.09E-2	5.71-E2
	(0.141)	(9.53E-2)
Visitors	2.00E-4***	2.00E-4***
	(4.16E-5)	(4.16E-5)
FP collection time	-0.734***	-0.450***
	(0.210)	(0.107)
Plant species	7.34E-2***	5.51E-2***
	(1.87E-2)	(1.01E-2)
Contribution	-9.29-4***	-0.288***
	(1.88E-4)	(4.91E-2)
Age × ASC	7.94E-2***	6.30E-2
	(2.44E-2)	(7.64E-2)
Edu × ASC	0.389*	-0.230
	(0.218)	(0.228)
FA × ASC	-0.201*	0.935
	(0.114)	(0.779)
Male × FP collection time	0.334*	3.89E-2
	(0.201)	(0.128)
Male × plant species	-3.20E-2*	-3.42E2**
	(1.86E-2)	(1.44E-2)
Male × contribution	1.53E-4	1.50E-2
	(4.31E-5)	(4.77E-2)
Male × visitors	-4.29E-5	-3.48E-5
	(4.31E-5)	(3.09E-5)
Standard deviations of parameter distributions		
Visitors	2.15E-4***	1.76E-4***
	(7.90E-5)	(6.11E-5)
Log likelihood	-411.247	-708.91
Pseudo R^2	0.182	0.206

Note: Standard error in parentheses.

*, ** and *** indicate significance at 10 per cent, five per cent and one per cent, respectively.

The signs of the coefficients of variables in both datasets were similar to the results of CL models. The attributes were highly significant, with both data sets showing preferences for less 'forest product collection time' and 'contribution', and high numbers of visitors and plant species in community forests. In the labour group,

none of the socioeconomic variables that were interacted with the ASC were significant. Only the interaction term between gender and plant species was significant with a negative sign. This implies that female respondents were more likely to select the alternative with more plant species than their male respondents.

In the monetary group, the variation of selecting alternatives across the individuals was more distinct. Women were more likely to prefer a community forest with more plant species and less forest product collection time, compared to their male counterparts. Usually, females saw the forest as a means of meeting their basic needs. They had more responsibility for collecting forest products (Fish et al., 2010), and the supply of forest products is intricately linked with plant species richness (Costanza et al., 2007). Education level was positively associated and family size was negatively associated with selecting alternatives in this group. The signs of these variables corresponded to the results of the binary logistic model reported in Table 7.6.

The likelihood of selecting alternative programmes increased with the age of the respondents. Typically, rural elders posed good knowledge of the use of forest resources (Phondani et al., 2010). Respondents with knowledge of the ecological resource under investigation chose improvement options more frequently (Do and Bennett, 2009). This was probably due to the opportunity cost of changing livelihood strategies as a result of the alteration of the availability of forest products. For older people, the possibility of alternative employment opportunities may be limited.

Swaite-Louviere log-likelihood ratio tests were carried out to compare the superiority between the CL and RPL models in both data sets. Following Rolfe et al. (2000), the comparison was made between the calculated χ^2 and χ^2 statistics. The calculated χ^2 statistics were estimated from the following formula:

Calculated $\chi^2 = - 2(LL_1-LL_2)$ (7.3)

where LL_1 and LL_2 are the log-likelihoods in the CL-II and RPL models, respectively.

The calculated χ^2 value for the monetary and labour groups was 8.26 and 7.04, respectively. These values were greater than the χ^2 statistic of 3.84 at one degree of freedom. The degrees of freedom were given by the differences in the numbers of parameters estimated in the two models. Here, CL models (CL-II) had 12 and RPL models had 13 parameters each. The greater calculated χ^2 values indicated that the RPL models in both subsets of data were a better fit than the CL models. In addition, the values of *pseudo* R^2 also supported the RPL models in both datasets. Hence, the results of the RPL models were used for further analysis and discussion.

7.2.3.3. Estimation of Willingness to Pay

The key outcome of CE is the part-worth of each attribute included in the choice set. The part-worth is the marginal utility (also known as the implicit price) of the attribute. This is the negative of the marginal rate of substitutions between attribute (*k*) and payment attribute. Using the bootstrapping procedure, confidence intervals for implicit prices for forest service attributes resulting from the *Mikania* mitigation programme were estimated (Krinsky and Robb, 1986). The implicit prices and confidence intervals for the RPL models are reported in Table 7.9.

Table 7.9 Implicit Prices and Confidence Intervals (95% Level)

Attributes	WTC (days)	Value of WTC labour (NRs.)	WTC money (NRs.)
Forest product collection time	1.57 (1.29–1.85)	550.79 (453.07–648.51)	818.65 (649.03–988.27)
Visitors to community forest	6.92E-4 (6.01E-4 to 7.82E-4)	0.24 (0.21–0.27)	0.26 (0.21–0.31)
Plant species richness	0.19 (0.155–0.22)	66.68 (54.60–78.76)	81.10 (63.23–98.98)

Given that the forest management activities in BZCFUGs are carried out in a fixed period annually, forest users are familiar with the kind of work they have to do for a *Mikania* management programme. In addition, in rural areas of Nepal, daily worked hours (non-leisure activities) are between 8.5 and 10 hours (Abdulai and Regmi, 2000). Therefore, one might assume that time spent in a *Mikania* management programme would be at the expense of their work time. Therefore, the estimated WTC labour was monetised based on the local labour wage rate (NRs. 350/day). In addition, the majority of respondents had diverse livelihood options. Therefore, making trade-offs between leisure time and forestry activities were unlikely.

The estimated implicit prices show that the respondents electing to pay in monetary terms consistently had higher WTC than their neighbours who elected to contribute in labour terms. The socioeconomic determinants of selecting the mode of contribution for the *Mikania* mitigating programme suggest that respondents with higher levels of education and larger landholdings were more likely to select the monetary mode of contribution. Usually, in rural areas, wealthier families have more land and have a household head with a higher education level. This finding aligns

with previous CE surveys that suggest that WTP for non-market services is a function of respondents' incomes (Lehtonen et al., 2003; Wang et al., 2007).

The WTC estimates suggest that forestry activities to minimise the damages to forest ecosystems caused by the colonisation of *Mikania* can improve the welfare of BZ households. Based on the estimates derived from the RPL models, different combinations of the attributes (as outcomes of different management programmes) can be evaluated as changes in the welfare of individual households. The compensating surplus for each household as a household WTC for a change from the current situation has been calculated using equation 4.10. The status quo for this study was reported in Table 5.1. The change scenario for this estimation was that the average time to collect forest products for a day's requirement would be reduced to two hours, the number of plant species would be increased to 115, and annual visitors would be increased by 7,000. The change scenario was defined based on the BZCFUG operational plan, the BZCFUG record and the focus group discussions.

The estimated compensating surplus indicates that, on average, respondent households intending to contribute in monetary terms in the BZ of CNP were willing to pay NRs. 4,532 (US$63.84) for the predicted change scenarios, as an annual BZCFUG membership fee for five years. For those intending to contribute in labour terms, annual WTC labour was 10.46 days for the predicted scenario. The estimated equivalent monetary value of their labour contribution at market wage rate was NRs. 3,662 (US$51.58) annually. The estimated mean household WTP at 95 per cent confidence intervals for monetary terms was NRs. 3,679 to 5,386 (US$51.82 to

75.87), and for non-monetary terms was NRs. 3,026.92 to 3,919.76 (US$42.63 to 55.20) per year.

The estimated household WTC was a considerable amount, constituting 6.8 per cent and 5.5 per cent of the household annual income[10] for the labour and monetary groups, respectively. This was much higher than the existing estimates of WTP for environmental services in developing countries. The estimated values of WTP for water improvement in Latvia and the Philippines were around one per cent of household income (Choe et al., 1996; Ready et al., 2002). Greater WTP as a percentage of household income in low-income communities is expected. Usually, the income elasticity of WTP is less than unity (Kristrom and Riera, 1996; Aldy et al., 1999). This indicates that households' WTC as a percentage of income decreases with their income. The estimated WTP for watershed restoration in rural China was eight per cent of household income (Zhongmin et al., 2006).

7.2.3.4. Social Benefits of *Mikania* Management Programme

The total WTC for all households in the BZ for the predicted change scenario was estimated (equation 4.11) based on the percentage of respondents selecting the different modes of payment (Table 7.10). In the sample, 35.2 per cent of the total households selected monetary terms and 64.8 per cent of the total households did not wish to participate in monetary terms but showed their WTC labour terms. It was estimated that in the BZ, 15,811 households would elect to contribute monetary and 29,107 would participate in a *Mikania* management program if they are allowed to express their WTC in labour terms. The value of WTC of labour groups estimated

[10] Chakrabarty et al. (2011) estimated the average household income is NRs. 5,535, expenditure is NRs. 4,469, and savings is NRs. 665. The rest of the income is spent to repay a household loan per month.

here is usually overlooked in the conventional non-market valuations, as respondents are allowed to participate only in monetary terms. If respondents are allowed to choose either mode of contribution freely, then social benefits would be estimated by the total WTC in monetary terms, plus the value of the total WTC in labour terms, which equals NRs. 178.24 million (US$2.51 million).

Table 7.10 Estimated Total Annual WTC in NRs. (US$) (in '000)

Situation	Value of total WTC		Total WTC (money)	% of households contributing in money
	Scenario-I	Scenario-II		
Current sample (female – 60%)	106,589 (1,501)	71,040 (1,000)	71,656 (1,009)	35%
If female = 50%	103,654 (1,459)	69,084 (973)	75,287 (1,060)	37%
If female = 40%	100,778 (1,419)	67,167 (946)	78,847 (1,110)	39%
If female = 33%	98,860 (1,392)	65,888 (928)	81,211 (1,143)	40%

In agrarian communities, gender differences influence forest management in different ways (Fish et al., 2010). Total annual WTC for BZ households was estimated assuming different proportions of male and female respondents (Table 7.10). Two assumptions were made to estimate the value of total WTC in labour terms, particularly for the opportunity costs of participation in forest management. These assumptions were:

i. All respondent trade-off labour time was contributed from working time; and

ii. 50 per cent of respondents trade-off their contributed labour time with their working time, and 50 per cent trade-off with their leisure time. The

leisure rate of time used here is one-third of the value of work time (Cesario, 1976).

The estimated value of total WTC of the labour group when labour was priced under scenario (i) was approximately 1.5 times higher than the total WTC of the monetary group. This corroborates with O'Garra (2009), who stated that the value of WTC labour at the market wage rate outweighs the total WTC in monetary terms. If labour was priced as in scenario (ii), the estimated value of the total WTC of the labour group almost equalled the total WTC of the monetary group. This shows that elicitation of WTP only in dollar terms undervalues the total benefits of a *Mikania* management programme by at least 50 per cent of the total benefits.

The Master Plan for Forestry Sector in Nepal has acknowledged women as primary users of the forest and made a recommendation that at least one-third of executive committee members of forest user groups should be women (MPFS, 1988). Here, the estimated total WTC of the labour group—based on the assumption of having one-third of the total respondents being female as per scenario (i)—was approximately US$1.40 million. This value was higher than the estimated total WTC of the monetary group, of approximately US$1.14 million.

Generally, all members of the BZCFUGs have a requirement to participate in forestry activities planned by their forest user group. The absentees have to pay fines according to the forest user group's constitution, and usually this is equal to one day's market wage rate. Hence, it can be expected that all households would participate in a *Mikania* management programme if they were asked to participate in

labour terms. In this context, the estimated value of the total WTC would be NRs. 164 million (US$2.31 million) and NRs. 109 million (US$1.54 million) when labour is priced under scenario (i) and scenario (ii), respectively. These values are 2.29 and 1.53 times higher than the total benefits estimated in purely monetary terms. If this is converted according to the estimated social opportunity of labour (NRs. 165.72 per day, as reported in Table 7.13), the value of total WTC labour would be NRs. 77.86 million (US$1.09 million). This value also outbids the total WTC expressed in monetary terms.

Further estimations based on the different labour rates are reported in Appendix 7.3a, and in different discount rates in Appendix 7.3b. Despite the amount of the estimated WTC in different elicitation formats and the gender composition of respondents, the use of labour as the mode of contribution ensures the participation of the maximum number of farm households in environmental decision-making. This might help establish consensus and reduce the potential conflicts in IPS management programmes.

7.3. Choice Experiment-II

The results of CE-I concluded that allowing respondents to choose the mode of contribution—monetary or labour—increased the estimated value of forest ecosystem services. The value of total WTC in labour terms outbid the total WTC in monetary terms. The results show the appropriateness of using labour as a mode of contribution in eliciting WTC for non-market forest benefits in subsistence economies. However, the estimation of WTC in terms of labour created the challenge of converting this WTC to a monetary value. Theoretical complexity arose

when placing monetary values on the number of labour days declared by the respondents. This was confounded by the fact that the opportunity cost of time varied across individuals. In the context of using labour as a mode of contribution, CE-II was designed to estimate the shadow value of time based on the WTC labour that could be converted into dollar values. The findings of the CE-II survey are summarised in Rai and Scarborough (*Forthcoming*).

In this survey, to estimate the shadow value of time, two payment-attributes, 'labour contribution' and 'cost', were included in the choice sets. From CE-I, the attribute 'plant species richness' was omitted, but the other two attributes remained the same. Hence, four attributes, two payments and two policy outcomes were included in the choice sets in this CE.

7.3.1. Sample Characteristics

In this survey, 325 households were interviewed. Of this total, 56 per cent of respondents were male (Appendix 7.4). The socioeconomic characteristics of the sample respondents in terms of landholdings, education, whether they were native to the area, age, use of *Mikania* and the preferred mode of contribution were similar to the first survey. The livelihood effects of *Mikania* are presented in Appendix 7.5a. The descriptive statistics of this survey also confirmed that the invasion of *Mikania* has adverse effects on the livelihood activities of BZ households.

7.3.2. Model Specifications

Respondents were asked follow-up questions to understand their decision-making strategies and heuristics (Carlsson et al., 2010). Only three respondents

(approximately one per cent of the total sample) selected the option that the government should pay for the IPS management programme, rather than the citizens paying. These were considered 'protest' respondents. Of the remaining respondents, 36 per cent (117) showed their preference to participate in monetary terms, and 63 per cent (205) preferred to participate in labour terms.

The choice data were divided into two groups; however, the categorisation did not follow that of CE-I. Here, the first group included all respondents, except the protest respondents, and the second group included those who preferred to contribute in monetary terms. The choice data set from the second CE survey was also analysed using LIMDEP 9.0 NLOGIT 4.0. Different models were used to analyse the data and were estimated individually for each group (Table 7.11).

As previously indicated, the basic CL model (Model-I) included only attributes and the ASC. This model demonstrates the importance of attributes in explaining respondents' choices across three different alternatives. The second CL model (Model-II) included socioeconomic variables interacting with the ASC to capture observed heterogeneity. Some interesting observations were made here, particularly regarding the sign of the labour contribution attribute. Other attributes were as expected. Understanding the labour contribution attribute was more complex. It had a positive sign in Model-I and a negative sign in Model-II in both groups. This was probably due to the utility functions in the first model.

In Model-I, utility is the function of the attributes included in the alternatives and the ASC (equation 4.4). It stated that there was no preference heterogeneity across the

individuals. The respondents selected the alternative by making trade-offs between the payment attributes of 'labour contribution' and 'annual membership fee'. The majority of respondents showed their preference to contribute in labour, rather than monetary, terms. This may be the reason for the positive sign of 'labour contribution'. However, in Model-II (equation 4.5), where socioeconomic variables were included to capture the preference heterogeneity, the sign of 'labour contribution' was negative, as expected.

As the dataset 'protest respondents excluded' demonstrated the importance of the attributes in explaining respondents' choices better than the dataset 'WTC in monetary terms", the CL model was re-estimated for the former dataset for further analysis which was reported in Table 7.12. Only significant socioeconomic variables were included. Those selected variables were interacted with the ASC and attributes. A Hausman test was performed to confirm IIA/*iid* condition in the CL model. It was found that the data did not support the test, as the difference matrix was not positive definite. Hence, the RPL model was estimated, which relaxed the IIA assumptions (Appendix 7.6g).

The Swait-Louviere log-likelihood ratio test was carried out following equation 6.2. This test compares the superiority of CL and RPL models. The log-likelihood (LL) decreased from -598.54 in the CL model (LL_1) to -587.38 in the RPL model (LL_2). The value of the calculated statistics χ^2 of 22.32 was greater than a statistic χ^2 of 3.84 at one degree of freedom. This indicated that the RPL model provided a significant improvement in model fit over the CL model. In addition, the value of

the *pseudo* R^2 increased from 0.301 in the CL model to 0.315 in the RPL model. Hence, the latter model was used for further analysis and discussion.

Table 7.11 Results of CL Models (CE-II)

Variables	Protest respondents excluded		WTC in monetary terms	
	Model-I	Model-II	Model-I	Model-II
ASC	-0.370***	-0.289***	-0.197	-0.152
	(7.32E-2)	(7.27E-2)	(0.133)	(0.131)
FP collection time	-0.794***	-0.566***	-0.570***	-0.406***
	(4.91E-2)	(5.81E-2)	(8.02E-2)	(9.66E-2)
Visitors to forests	1.60E-4***	1.34E-4***	1.90E-4***	1.70E-4***
	(8.41E-6)	(8.74E-4)	(1.44E-5)	(1.54E-5)
Labour contribution	6.15E-2***	-6.69E-2**	5.54E-2	-5.50E-2
	(2.25E-2)	(3.27E-2)	(4.08E-2)	(6.04E-2)
Annual fee	-2.6-E-4***	-6.56E-4***	2.21E-5	-3.40E-4*
	(7.73E-5)	(1.07E-4)	(1.30E-4)	(2.22E-4)
Age ×ASC	-	4.16E-2***	-	1.54E-2
		(1,69E-2)		(4.16E-2)
Inc_ag ×ASC	-	1.49**	-	-
		(0.772)		
Edu × ASC	-	0.100	-	-0.233**
		(6.92E-2)		(0.117)
Off-farm × ASC	-	-9.17E-5	-	0.879
		(6.13E-5)		(0.574)
Land × ASC	-	-2.83E-2	-	0.147
		(3.43E-2)		(0.127)
Log-likelihood	-686.23	-666.61	-213.51	-205.99
pseudo R^2	0.258	0.278	0.349	0.369

Notes: Standard errors are in parentheses.

*, ** and *** denote statistical significance at 10 per cent, five per cent and one per cent, respectively.

As expected, the results of the RPL model demonstrated that respondents had a preference for less forest product collection time, and more visitors to community forests, as outcomes of *Mikania* management. In addition, they wanted to have less labour contribution and a lower annual membership fee. The negative sign of the

ASC, which was coded with zero for the status quo, indicated that there were some respondents who preferred to live with the current situation. This might be a consequence of having the provision of an annual contribution in the proposed IPS management programme; however, this requires further investigation.

Table 7.12 Results of CL and RPL Models (CE-II)

Variables	CL	RPL
ASC	-0.305***	-0.320***
	(7.72E-2)	(0.113)
Visitors to forests	1.38E-4***	2.16E-4***
	(9.28E-5)	(2.60E-5)
FP collection time	-0.399***	-0.496***
	(8.81E-2)	(0.135)
Labour contribution	-9.13E-2**	-0.152***
	(3.93E-2)	(5.87E-2)
Annual membership fee	-6.43E-4***	-9.17E-4***
	(1.10E-4)	(1.62E-4)
Fam × ASC	0.468***	0.559***
	(0.138)	(0.176)
Inc_ag × ASC	1.090*	1.330*
	(0.630)	(0.706)
LU × FP collection time	-0.156***	-0.254***
	(2.89E-2)	(5.30E-2)
Inc_ag × labour contribution	6.070*	8.75E-2*
	(3.17E-2)	(4.88E-2)
Land × FP collection time	1.19E-2**	2.27E-2***
	(4.74E-3)	(8.26E-2)
Female × FP collection time	-0.140**	-0.268**
	(6.64E-2)	(0.112)
Standard deviations of random parameters		
Visitors to forests	-	1.57E-4
		(0.3E-5)***

Note: *, ** and *** denote statistical significance at 10 per cent, five per cent and one per cent level, respectively. Standard errors are in parentheses.

Family size was positively associated with selecting the alternatives. In the study area, the indigenous *Tharu* community lives in a joint family. Hence, they have large land parcels. There was a positive correlation between family size and landholding size (Appendix 7.1). This relationship indicated that family size was also associated with household income. Households with more members preferred to contribute labour (Table 7.6).

Households with agriculture as their main source of income selected the alternatives more frequently than their neighbours whose main income source was off-farm activities. Generally, an infestation of *Mikania* decreases the availability of basic forest products. Therefore, it is likely that farmers will prefer improved forest conditions. In this study, they showed greater interest in labour contributions than their neighbours who had off-farm activities as their main income source. This supports the results of binary logistic that farm households preferred the labour contribution elicitation format (Table 7.6). About two-thirds of the sample households preferred to contribute in labour in this survey. Hence, a positive association of family size with selecting the alternatives was not surprising.

Households with more livestock were likely to prefer the options with less forest product collection time. This was expected, as they have high demand for fodder. In addition, these households were employing a greater number of coping strategies to meet their demand for fodder. Regarding gender preferences, women were more likely to choose the options with less forest product collection time and a lower annual membership fee. In rural areas, women are responsible for collecting basic forest products for their households. It is often assumed that they are experience the

main effects of environmental degradation, including the invasion of exotic plants (Fish et al., 2010). However, the alternatives with less forest product collection time were not preferred by the households that had larger sizes of landholdings. This was not unexpected, as those households with larger parcels of land can fulfil their requirements for forest products from their own land. They are less dependent on BZCFs for basic forest products (Sapkota and Oden, 2008).

7.3.3. Estimation of Willingness to Pay

Here, implicit prices for each non-random attribute (k) were calculated using equation 4.8 as a negative ratio between the coefficient of the attribute (k), and the payment attribute (c). The random parameter, visitors to community forests, was estimated based on equation 4.9. The implicit price for each attribute was estimated twice, using two payment-attributes individually as the denominator. The estimated implicit prices for each attribute reported in Table 7.13 are obtained after dropping the other mode of contribution. This means the implicit price in monetary terms (NRs) was estimated assuming the labour contribution is zero and vice-versa. The confidence intervals for implicit price are presented in Appendix 7.5b.

Table 7.13 Estimation of Implicit Price (NRs.)

Attributes	Implicit price (NRs.)	Implicit price (days)
Visitors to community forests	0.24	1.43E-3
Forest product collection time	541.43	3.26
Labour contribution	165.72	-

For the whole sample, the average WTP for a one-hour decrease in forest product collection time was NRs. 541 (US$7.62), and for an increase in 1,000 tourists was

NRs. 240 (US$3.38). Respondents valued the opportunity cost of their time at NRs. 166 (US$2.33) for every day involved in IPS management activities. The estimation of implicit price, if expressed in labour terms, was 1.4 days for an increase in 1,000 visitors, and 3.26 days for a decrease in one hour of collection time for a day's forest product requirement.

The estimated shadow value of time per day contributing to a *Mikania* management programme was less than half (47 per cent) of the market wage rate (NRs. 350 per day). This can also be compared with estimates that the leisure rate of time—one-third of the value of work time (Cesario, 1976). As explained earlier, forest management activities in BZCFUGs are carried out annually during a fixed period. It can be concluded that respondents were trading their work time for the outcomes of a *Mikania* management programme. Usually, farm households enjoy farm activities as a lifestyle. They make trade-offs between time and other benefits received from being involved in forestry activities (Ahearn et al., 2009). Thus, they have the shadow value of labour in the IPS management programme between the opportunity cost of leisure and market wage.

Here, the compensating surplus was the mean WTP to change from the current situation to the improved condition of the BZ ecosystem. This value included improvements in attributes, such as forest product collection time and annual visitors to community forests, and the ASC.

The current situation is indicated in Table 5.2. The change scenario for this estimation was based on the operational plan and records of the BZCFUGs. The predicted change scenario for this estimation was:

- The average time for forest product collection will reduce to two hours;
- The number of tourists will increase to 27,000; and
- No labour contribution will require for IPS management.

The mean annual household WTP for the expected outcome was NRs. 2,382 (US$33.55) or 14.4 labour days. The estimated annual household financial WTP was 3.6 per cent of the average annual household income (Chakrabarty et al., 2011).

The present values of the compensating surplus were calculated using a range of discount rates at three, five and seven per cent, as reported in Table 7.14. These rates were selected based on the previous valuation studies (For example; Harris et al. 1989; Kaiser and Roumasset, 2002; Liu et al. 2010). In 2011, the present value of the average WTP per BZ household for the specified forest improvement was NRs. 11,236 (US$158.25) at a three per cent discount rate.

These valuation results can be applied to a social CBA of a *Mikania* management programme. The social benefits can be estimated by aggregating the overall households' WTP from the survey results for the BZ community. Two approaches were used in the follow-up question, based on the preferred mode of contribution of the respondents:

i. Household numbers were based only on respondents who chose to contribute in monetary terms; and

ii. All respondents were included, except those who believed that the government should pay for the IPS management programme.

In the second estimations, an assumption was made that the average WTP was the same across all individuals, regardless of whether they preferred to contribute in money or labour. The annual social benefits for the BZ community of CNP, as total WTP, were calculated using equation 4.11. These are reported in Table 7.14.

Table 7.14 Estimates of Total WTP (NRs.)

		Household mean WTP	Aggregated for the BZ community (in'000)	
			Monetary terms only	Excluding protests
WTP per annum		2,382	38,518	106,007
Discounted	3%	11,236	181,693	500,045
household WTP	5%	10,828	175,101	481,902
for five years	7%	10,450	168,987	465,075

The first approach provided a lower bound and the second approach a higher bound of the social benefits of a *Mikania* management programme. The estimated benefit of a *Mikania* management programme was between NRs. 38.51 million (US$542,508) and NRs. 106 million (US$1.49 million), respectively. The difference between the two bounds was that the estimated benefits could be excluded if respondents were asked to participate in monetary terms only. Table 7.14 also presents the value of the total WTP for a five-year period, as respondents were asked to select the alternative IPS management outcomes for five years.

7.4. Hypotheses and Results

Table 7.15 presents a summary of the results of the analysis of the CE data, with respect to the hypotheses developed in Chapter Six. The first general hypothesis—

that the infestation of *Mikania* undermines the livelihoods of the BZ community of CNP, Nepal—was accepted. This was tested by three research hypotheses. Descriptive statistics were used to test the research hypotheses from one to three. All three research hypotheses were supported, as there was an increase in forest product collection time and, as a result, a number of local households decreased and downsized their livestock herd. The second general hypothesis will be tested in Chapter Eight. The estimated benefits of the *Mikania* mitigation programme will be compared with the costs of the programme. Here, the annual budget of the BZ management is considered as the cost of a *Mikania* management programme.

The third general hypothesis posited that the estimated WTP for a *Mikania* management programme is sensitive to the mode of contribution. This hypothesis was tested with research hypotheses five to 15. Research hypotheses five to 12 were tested by a binary logistic model. This found that only research hypothesis five was not supported, as the age of respondents was not a significant factor in selecting the mode of contribution. Hypotheses 13 to 15 were supported by the CE analysis. The significance of socioeconomic variables in selecting the mode of contribution indicated that households with higher incomes selected the monetary mode of contribution more frequently. The estimated mean WTC in monetary terms outweighed the value of mean WTC labour, even though labour was priced at the market rate. The market wage rate was the highest opportunity cost of time among the available estimations. This demonstrates that WTP/WTC are functions of individuals' incomes.

Therefore, in subsistence communities, providing an option to express WTC in labour terms ensures the participation of disadvantaged groups, including women, those with low incomes, and indigenous people, in the environmental decision-making process. In addition, it provides realistic estimates of the social benefits of environmental programmes, such as a *Mikania* management programme. The estimated benefits help demonstrate the importance of the invasive plants management programme. The estimated upper and lower bounds of social benefits in the analysis of the second CE data also supported this hypothesis, as the mode of contribution was the major determinant of the estimated WTP/WTC for a *Mikania* management programme.

The final general hypothesis related to the shadow value of time spent in a *Mikania* management programme—that BZ households value their time spent in the programme at a different rate to the current wage rate. This hypothesis was tested by research hypothesis 16, using the analysis of second CE data. The estimated value of the implicit price for labour as shadow value supported the research hypothesis.

7.5. Summary

This chapter presented the analyses of responses from the CE surveys. The results mainly focused on three issues. First, the livelihood effects of *Mikania* were explored using descriptive statistics and multiple regressions. Second, the CE responses were analysed with CL and RPL models. These models estimated the benefits of a *Mikania* management programme in two different modes of contribution. Third, this section examined the estimations of the social opportunity cost of labour spent in the proposed environmental programme using CE. In brief,

CE-I showed that the estimated WTP/WTC for a *Mikania* management programme was sensitive to the mode of contribution, and CE-II estimated the shadow value of labour people were willing to spend to manage the invaded area.

Table 7.15 Summary of Research Hypotheses Results

Research hypotheses	Results
H_1: The infestation of *Mikania* has led to a decrease in the number of households collecting forest products from the BZCF.	Supported
H_2: The infestation of *Mikania* has led to an increase in forest product collection time for a day's requirement.	Supported
H_3: The infestation of *Mikania* has led to a decrease in average livestock holding.	Supported
H_4: The benefits of a *Mikania* management programme were greater than the costs.	Supported (Chapter Eight)
H_5: An individual's age is a significant factor in selecting the mode of contribution.	Not supported
H_6: Education level is a significant factor in selecting the mode of contribution.	Supported
H_7: Gender is a significant factor in selecting the mode of contribution.	Supported
H_8: A households' proximity is a significant factor in selecting the mode of contribution.	Supported
H_9: A households' landholding is a significant factor in selecting the mode of contribution.	Supported
H_{10}: A households' main source of income is a significant factor in selecting the mode of contribution.	Supported
H_{11}: A households' size is a significant factor in selecting the mode of contribution.	Supported
H_{12}: A respondents' origin is a significant factor in selecting the mode of contribution.	Supported
H_{13}: The number of households choosing to contribute in terms of labour outnumbers the number of households choosing to contribute in monetary terms.	Supported
H_{14}: Households choosing to contribute in monetary terms are willing to contribute more than households choosing to contribute in labour terms.	Supported
H_{15}: The total WTC of households choosing to contribute in labour terms is greater than the total WTC of households choosing to contribute in monetary terms.	Supported
H_{16}: Forest product collection time is a significant attribute in the choice of invasive species management policy, and is negatively signed.	Supported
H_{17}: Visitors to community forests is a significant attribute in the choice of invasive species management policy, and is positively signed.	Supported
H_{18}: Plant species present is a significant attribute in the choice of invasive species management policy, and is positively signed.	Supported
H_{19}: Labour contribution is a significant attribute in the choice of invasive species management policy, and is negatively signed.	Supported
H_{20}: Annual membership fee is a significant attribute in the choice of invasive species management policy, and is negatively signed.	Supported
H_{21}: The market wage rate is higher than the estimated shadow value of time.	Supported

The major findings of this study are:

- *Mikania* is undermining the livelihoods of BZ communities;
- BZ households have significant WTP for the management of *Mikania*;
- The existing practice of eliciting WTP in dollar values excludes the concerns of two-thirds of the BZ population;
- Household and individual characteristics have significant influences on the selection of the mode of contribution;
- Households who elected to complete the choice task in monetary terms had consistently higher WTC for a *Mikania* management programme than households who elected to complete the task in labour terms;
- The social benefits of a *Mikania* management programme increase if BZ communities are allowed the option of expressing their contribution in labour terms; and
- BZ households value their time spent in a *Mikania* management programme at a different rate to the current wage rate.

The sample characteristics showed that agriculture was the main source of household income in the BZ of CNP. However, the majority of households were found to be increasingly involved in diversified livelihood strategies, including tourism and foreign employment. This could be the main reason behind the significant portion of immigrants in the area's population. Households' income attributes—such as landholdings and level of education—were disproportionately distributed among households. This indicates a gap between 'haves' and 'have-nots'. Such heterogeneity is an attribute of rural communities in developing countries.

Respondents observed that there had been a rapid increase in the abundance of the vine during the last five years. As a result, the availability of basic forest products, such as fuelwood and fodder, was declining. Many households had subsequently decreased their dependence on community forests and downsized their livestock holdings. In addition, they had employed different coping strategies to sustain their livelihoods. Households unable to afford the cost of alternatives were either using the vines or were exploring larger areas in the core area of CNP. With a decrease in BZCF-dependent households, the demand for products from the forest has also decreased. As a result, a small portion of the population who were continuing their previous activities were benefitting from this situation. The results also showed that farm households close to the forest with large livestock herds and older household heads were employing more coping strategies than other households were. This indicated that *Mikania* disproportionately affects rural households.

Respondents were overwhelmingly willing to participate in a *Mikania* management programme if they were asked to contribute in labour terms. Income-related variables—such as having a large land parcel, having a higher level of education, being an immigrant, and being a male—had positive associations with contributing in monetary terms. These variables might also influence the expressed WTP. The results showed that mean household WTP of the monetary group was consistently higher than the mean value of household WTC of the labour group. On the contrary, the value of total WTC expressed in labour terms exceeded the total WTC expressed in monetary terms.

In the context of using labour as a mode of contribution, the sum of labour days declared by respondents provided an estimate of the social benefits of a *Mikania* management programme. However, the estimation of WTC labour raised the challenge of placing monetary values on the number of labour days declared by the respondents. This was confounded by the fact that the opportunity cost of time varies across individuals. In this study, for the first time, a CE was undertaken to estimate the social opportunity cost of time spent in a *Mikania* management programme. It was found that the estimated shadow value of time was less than half of the market wage rate.

Chapter 8 : Discussion of Results

8.0. Introduction

This chapter discusses the results of this thesis. The results support an intervention to control the spread of *Mikania*. The development of a *Mikania* management programme following an integrated approach that includes gender and education sensitivity is vital. These aspects are important for the development of environmental policy and natural resource management in developing countries. This research shows the potential of CE to elicit WTP/WTC for non-market benefits in low-income communities. This is enhanced if respondents are also given the opportunity to express their WTC in non-monetary terms. This chapter also discusses several ways to reduce the complexity of this task in a heterogeneous community.

This chapter is structured as follows. The first section discusses the livelihood effects of *Mikania*. These effects were assessed in terms of different household activities and the coping strategies employed. The second section discusses the policy implication of the CE results. This section also addresses the second research question, which relates to the potential to improve the social welfare of the BZ community through the implementation of a *Mikania* management programme. The third section explores the potential of a CE to elicit the preferences of low-income households by using labour mode of payment. This section also discusses the socioeconomic determinants in selecting the mode of contribution. The fourth section presents the estimation of the shadow value of time spent in public forestry activities, using a CE. The methodological issues surrounding implementing a CE survey in a subsistence economy are discussed in the fifth section.

8.1. Livelihood Effects of *Mikania*

BZ households believe that local river floods introduced *Mikania* to their landscape. Regardless of the means of transportation, it can be confirmed that the vines were accidentally transported to the BZ. The results of the household survey have clearly illustrated that the invasion of *Mikania* has caused a substantial reduction in the dependence of local communities on their community forests, despite the efforts of BZCFUGs to regularise forest product collection and impose a ban on cattle grazing to improve the condition of the community forests. In Nepal, community forestry practices have been successful in improving forest product supply to local users but this is not the case in this study (Pandit and Bevilacqua, 2011a). This may be due to the invasion of *Mikania* in the BZCFs.

The infestation of *Mikania* influences the supply of forest products in two ways. First, its abundance reduces the availability of native species. Second, *Mikania* itself does not offer any of the forest products required for rural livelihoods. Nevertheless, a small portion of BZ households used the vines as goat fodder. This was used during the dry season, when other plant species were unavailable. Therefore, the use of *Mikania* is more obligatory than preferential (Siwakoti, 2007; Rai et al., 2012b). Accidentally transported exotic plants challenge the ability of ecosystems to prosper and be farmed (McWilliam, 2000; McNeely et al., 2001).

This variation in households coping strategies indicates that the invasion of *Mikania* disproportionately affects BZ households. Older respondents were practising more coping methods than their younger neighbours. Usually, a high proportion of farmers in developing countries are older, and farm households are the most

vulnerable victims of invasive plants (McWilliam, 2000; Mwangi and Swallow, 2008; Rai et al., 2012b). In addition, older people have comparatively lower levels of education (Appendix 7.1), which means they may have limited alternative employment opportunities. In this context, they may feel compelled to make efforts to continue their existing livelihood strategies. Hence, they may use more coping strategies to fulfil their demand for forest products.

Households' dependence on the forest increases with their proximity to the forest (Sapkota and Oden, 2008). This means that distant villagers are less affected by a change in the supply of forest products from BZCFs than households in close proximity. In general, distant populations do not consider the invasion of exotic plants as their problem, which raises the prospect of a significant distance-decay effect in values (Kerr and Sharp, 2007). A response of distant households to a change in the availability of forest products in the BZCF is unlikely. Indeed, households close to the forest respond to invasive species as both victims and beneficiaries (Rai et al., 2012b). Hence, these households are also the major beneficiaries of an IPS management programme. Likewise, households having larger livestock holdings are likely to have more coping strategies, as they must find ways to feed their animals.

It is interesting that a strategy employed as an alternative for one product has led to increasing demand for other products. For example, biogas plants were installed as an alternative to fuelwood. For this, households have to keep livestock—particularly buffalo and cattle—to ensure the production of the dung required to operate the biogas plants. However, more livestock means more demand for fodder. The

connection between biogas plants and fodder indicates that the idea of biogas installation as an alternative to fuelwood was introduced without considering the limitations of households to address uncertainties in their livelihoods. It can be concluded that the effects BZ households are experiencing and their response to these effects demonstrate that *Mikania* is imposing costs on the BZ community.

8.2. Policy Implications: Application of Choice Experiment in Social Cost-Benefit Analysis of *Mikania* Management

In general, those impacted by invasive plants have a common will to invest in the control activities. In the BZ of CNP, the execution of coping strategies is after the failure of control activities initiated by BZCFUGs. As control strategy is the first priority, BZCFUGs may expect more benefits from the control of *Mikania* than from the implementation of a coping strategy. However, they need external supports to develop and implement the appropriate *Mikania* management programme (Shackleton et al., 2007). In the absence of external support, they think the control of *Mikania* is an unattainable mission (Rai et al., 2012b). In addition, most of the coping strategies may have a short horizon. In the long run, they may be ineffective compared to the control strategy. Hence, estimations of their expected benefits from the control programme can be helpful in decision-making. This is estimated analysing CE responses.

The estimated WTP indicates that the benefits from the management of the BZ of CNP can be increased by implementing a *Mikania* management programme. The benefits resulting from the proposed programme were estimated to be between NRs. 169 million (US$2.38) million and NRs. 500 million (US$7.04 million). These

values were net present values at a seven per cent discount rate of the lower bound aggregate WTC, and at three per cent of the upper bound aggregate WTC (Table 7.14). The estimated total WTC can be translated as the BZ community being better off after mitigating the invasion of *Mikania*. The community are experiencing a shortage of forest products, and fewer visitors to their community forests. This suggests that, if more resources are allocated to the IPS management programme, social welfare would improve by up to 1.2 times the current benefits from CNP in terms of royalties. Revenue from CNP in the fiscal year of 2010-11 was NRs. 83.14 million (DNPWC, 2011).

In comparison, the annual budget for BZ management in CNP was NRs. 80 million in the fiscal year 2011-12[11]. However, the allocated budget amount did not include any specific programme for *Mikania* management. Hence, the gap between the estimated social benefits and the annual budget indicates that there is potential to improve the welfare of the BZ community through a *Mikania* management programme. The social benefits could be higher if the global WTP for *Mikania* management was also taken into account (Do and Bennett, 2009). This is because CNP is listed as a World Heritage Site.

This study estimates the benefits based on the BZ community population and their preferences. The estimated WTP/WTC values and an increasing trend in the abundance of *Mikania* suggest that the government should respond to the problem as soon as possible. If not, the cost associated with IPS will increase over time as the

[11] This information was received from the Department of National Park and Wildlife Conservation (DNPWC), Nepal.

plant abundance increases (Shackleton et al., 2007). As a result of this increase, the living standards of the BZ community will also further decline.

The estimated values of WTC in different modes of contribution suggest that a *Mikania* management programme should follow the integrated approach. The mean WTC of households who elected to contribute in monetary terms was consistently higher than the mean WTC of households who elected to contribute in labour terms. This means that the benefits of the programme do not solely depend on its effectiveness; it can also be enhanced by increasing the number of households in the monetary group. This can be increased by educating BZ communities, empowering women and diversifying livelihood strategies, as male respondents with high levels of education and off-farm activities as their major source of income preferred to contribute in monetary terms. Therefore, gender awareness and income generating activities should be included to enhance the effectiveness of a *Mikania* management programme (CFD, 2004).

Respondents observed that *Mikania* was spreading rapidly in the BZ of CNP during the past five years. It can be postulated that *Mikania* may severely undermine the livelihoods of the BZ community into the future. Livelihood vulnerability and control costs increase with the abundance of undesirable and highly competitive plants such as *Mikania* (Shackleton et al., 2007). These findings warrant an immediate intervention to control the spread of *Mikania* in the BZ of CNP.

8.3. Using Labour as a Mode of Contribution

The estimated values of WTP/WTC show that respondents overwhelmingly supported a forest improvement programme through the management of *Mikania*. However, the existing practice of eliciting WTP and using money as the only mode of contribution substantially downplays the benefits of a *Mikania* management programme. A substantial portion of low-income respondents were unwilling to commit a monetary contribution. As a consequence, agricultural households may be portrayed as forest free-riders and the proposed programme may not receive sufficient attention from policy-makers. This finding is similar to other contingent valuation studies carried out in the developing countries (Alam, 2006; Hung et al., 2007).

Results of the two CE surveys confirmed that, in subsistence communities such as the BZ of CNP, the majority of respondents cannot express their preferences in cash. There is no difference in their preference for the mode of contribution when asked to select before or after the choice task. In both cases, approximately two-thirds of respondents elected labour terms as their preferred mode of contribution.

In addition, it is also interesting that the estimated annual household WTC for the defined scenario of labour groups in CE-I (value based on the estimated shadow value) was comparatively lower than the estimated value of CE-II in labour terms. The analysis of CE-I clearly indicated that households in the monetary groups had higher WTC/WTP than households in the labour group. In the estimation of CE-II, preferences of both the monetary and labour groups were included; hence, a higher average household WTC than that of the labour groups was expected.

There was a positive association between income-related variables, including landholding size and education, when selecting the monetary format. In rural areas, the size of land holdings was often used as a proxy for family income. Theories of human capital and endogenous growth suggest that education has a substantial economic effect at both the micro and macro levels. The more education people have, the higher their income. Additionally, people with more education may consider it easier to place a value in dollar terms, and are more aware of the potential benefits to be derived from the forest. Hence, they are more willing to participate in economic participation than less educated farmers (Dolisca et al., 2006).

It is widely accepted that wealthier and more educated households have higher WTP for improved environmental conditions. The estimated mean WTC supports this argument, as the mean WTC of the monetary group was greater than the mean WTC of the labour group. However, eliciting preferences in dollar terms undervalues the benefits of a *Mikania* management programme, as it excludes the benefits of two-thirds of BZ households. The estimated value of total WTC in labour terms consistently outbid the total WTC in monetary terms.

Gender was signed as expected, suggesting that male respondents were more likely to choose to pay in monetary terms. Usually, women in rural areas have less decision-making power in regard to household expenditure (Angel-Urdinola and Wodon, 2010). They mostly engage in non-monetary activities, such as farm work and domestic activities (Abdulai and Regmi, 2000). Those studies have found that women have less leisure time than men do. Thus, they may consider participating in public activities such as a *Mikania* management programme as an opportunity to

socialise. If respondents are asked to express preferences only in monetary terms, the participation of women is less likely. Needless to say, women are key actors in natural resource management in agrarian communities (Agrawal, 2001).

Typically, economic agents make decisions to ensure the best possible outcomes. While making a trade-off between private good consumption and public good consumption, people relinquish the option that offers the least utility. The law of diminishing marginal returns says that marginal benefits decrease with additional goods and services. This means that a household will more willingly relinquish those things that they have in greater quantities. Large families have more labour for farming; thus, households with large families preferred to contribute labour to forest management (Dolisca et al., 2006; Tilahun et al., 2011).

Respondents native to the BZ were less likely to choose a monetary contribution. This is consistent with the findings of Tilahun et al. (2011). This study observed that, in forest conservation programmes, respondents living in the area before resettlement programmes had a negative association with monetary contribution. They frequently selected to participate in labour contribution. This highlights the role that migration can play in improving livelihoods by diversifying livelihood options (de Haan, 1999). In addition, farmers with varied sources of income were more likely to invest in forest management (Dolisca et al., 2006). Therefore, the selection of a monetary mode of contribution by a household with only an agricultural income is less likely. The probability of selecting money as a mode of contribution also depends on whether the respondent is a farmer or not (Hung et al., 2007).

A household's forest product collection pattern cannot be interlinked with their preferred mode of contribution for forest improvements. For example, distant households collect less forest products, while frequent visitors collect more forest products in the Terai region of Nepal (Sapkota and Oden, 2008). Both these variables are negatively associated with the choice of money as the mode of contribution. This is probably due to the perceived effects resulting from a change in the availability of forest products following infestation. Distant users have lower dependency on community forests. Hence, they are perceived as being comparatively less affected by the invasion of exotic plants. On the other hand, frequent visitors can collect their required products by increasing their frequency of visits or exploring more forest areas inside the CNP. These frequent visitors are probably among those collecting more forest products than earlier, as the majority of households decreased their dependency on community forests.

In brief, the socioeconomic determinants of selecting the mode of contribution generate important information for forest policy development. The effects of eliciting public preferences in dollar terms are likely to underestimate the value of environmental decisions. This also excludes certain groups of society who have a significant role in improving forest management, including women, native people and farmers with small land holdings. As the primary users of forest resources, these social groups are widely recognised as active managers and caretakers of the forests in subsistence communities. They have shown their willingness to participate through labour contributions. Thus, the provisioning of a labour mode of contribution not only provides a realistic estimate of non-market environmental values, but also enhances the participation of the disadvantaged groups in society.

The involvement of these groups in equitable sharing of both rights and responsibilities helps strengthen participatory forestry practices (CFD, 2004; Pandit and Bevilacqua, 2011b).

8.4. The Shadow Value of Time

This study and previous contingent valuation studies have demonstrated the importance of including a labour numéraire for gauging the social preferences of low-income households (Alam, 2006; Hung et al., 2007; Saxena et al., 2008; O'Garra, 2009). However, a theoretical complexity exists in estimating social benefits as an aggregation of individuals' WTC in labour terms. This is mainly due to the different opportunity costs of time across individuals and situations (Ahlheim et al., 2010).

Various studies have employed different techniques to measure the opportunity cost of time. For example, the shadow value of time was estimated by linking WTC time and WTP through the value of saving time using contingent valuation method (Eom and Larson, 2006). The estimated value of housework time was 70 to 80 per cent of the market wage. Jacoby (1993) estimated the shadow value from an agricultural production function. A CE of travel mode choice was used to estimate the value of travel time in different travel modes, and their opportunity costs (Truong and Hensher, 1985).

This thesis estimated the shadow value of time spent in forestry activities by using a CE survey. This showed that an individuals' value of time spent in public activities can be estimated by eliciting WTP for non-market goods. Both labour contribution

and monetary contribution were included as attributes to create hypothetical scenarios. Survey respondents were allowed to make trade-offs between these attributes. The shadow value of time was estimated as the marginal rate of substitution with an annual membership fee.

The estimated social opportunity cost of time indicated that farm households would have a shadow value of family labour that was less than the market wage rate. The estimated shadow value of time was 47 per cent of the market wage rate. The existing methods of converting the WTC labour in public work using either the market wage rate or one-third of the wage rate may not produce reliable results (O'Garra, 2009). However, these included the concerns of disadvantaged groups, such as women, farmers and those with low incomes. The use of market wage as a conversion rate overestimates the benefits, while the assumption of one-third of the market wage underestimates the value.

In an agrarian community, the shadow value of time considers its marginal worth to the household, rather than as an opportunity cost derived from a market wage rate (Edmeades et al., 2006). While participating in community forestry activities, forest users can collect forest products—such as fodder and fuelwood—that are required for their daily life. The binary logistic results show that female participants prefer labour contribution. Their involvement in public activities in rural areas is unlikely. Hence, they may enjoy meeting with neighbours and feel positive about participating in public activities. The results demonstrate that, in a CE survey, inclusion of the two payment attributes of monetary and labour can address the

problem of estimating an appropriate rate of conversion of time spent in public activities.

8.5. Methodological Issues

The implementation of CEs in the subsistence communities, particularly to elicit WTP for environmental services, is in its early stages of development. This study provides an important foundation for further implementation of non-market valuation studies, particularly CEs, in subsistence economies. The experience gained during the survey should be helpful for CE practitioners. Other than the suggestions made by previous studies regarding the implementation of stated preference surveys in the developing country context (including number of choice sets, attributes and focus groups), two main issues are drawn from this study to further the development of CEs in rural communities (Whittington, 2002; Bennett and Birol, 2010). These are the recruitment of local enumerators and the inclusion of a non-monetary contribution.

In CEs, personal interviews are considered an appropriate mode of survey in developing countries (Bennett and Birol, 2010). In order to improve the quality of data in household surveys in developing countries, several strategies were employed. These included entering and verifying data in the field, training enumerators, and recruiting a local interview team that consisted of male and female enumerators (Puetz, 1993). In addition, ethnicity was also considered when recruiting enumerators because respondents in the study area have diverse ethnicity and their own dialects. Typically, talking to people in their native language can improve their

understanding of the study. This can also help reduce task complexity in low literacy communities.

8.6. Summary

In general, accidentally transported non-woody plants are not suitable to produce the wide variety of forest products required for local communities. Their abundance reduces the availability of native plant species and the supply of forest products. Hence, households that are highly dependent on forest products are likely to be the most affected parties from the invasion of *Mikania*. In order to minimise the effects of this invasion, BZ households use different coping strategies. This indicates that the invasion of *Mikania* imposes costs on the BZ community.

In general, the BZ community expected to benefit more from the control of the spread of *Mikania* than from using coping strategies. Hence, they had a common will to invest in control activities. The estimated WTP/WTC indicated that the implementation of a *Mikania* management programme would improve the social welfare of the BZ community. The estimated expected benefits and trends of the growth of *Mikania* recommend the immediate implementation of a *Mikania* management programme, as control costs will continue to increase with the increased abundance of the invasive plants (Shackleton et al., 2007). The findings of the study help policy-makers in allocating available resources for the purpose of improving the ecological conditions of BZ community forests by controlling the further spread of *Mikania*.

The discussion of CE responses indicates that only eliciting WTP for non-market forest benefits in subsistence economies not only understates the value, but also ignores the concerns of disadvantaged groups who are the primary users of natural resources. If respondents' income levels are not taken into consideration when developing hypothetical scenarios, non-market valuation techniques cannot be effective in establishing forest governance in developing economies. Determining WTP of low-income households in labour terms can help minimise the controversy surrounding IPS programs maximising the participation of the local community. There are also other socioeconomic variables that influence the selection of mode of contribution. This indicates that forest management programmes should follow an integrated approach in developing countries.

An interesting finding of this thesis is that the estimated social opportunity cost of time is less than the market wage rate. Forest users receive benefits being involved in forest activities, such as collecting fuelwood and fodder for domestic use and socialising with others. Hence, farmers value their time based on its marginal worth to their household. This study progresses the implementation of a CE to estimate the shadow value of time. The survey strategies for low-income communities were also discussed. The next chapter presents the limitations and conclusions of this thesis.

Chapter 9 : Limitations and Conclusions

9.0. Introduction

This is the concluding chapter of this thesis. This chapter is divided into three parts. The first section outlines the limitations of this study. The limitations presented here are mainly specific to this study. The need for further research to address the limitations of this study and to provide further insight into the implementation of CE surveys in subsistence economies is addressed in the second section. The third section is the final conclusion. This chapter supplies valuable information for further research in general, and for policy-makers in particular.

9.1. Limitations of the Study

Stated preferences methods have been criticised on the grounds that hypothetical settings may lead respondents to overstate their WTP, as the commitment is not binding (Blumenschein et al., 2001; Lusk and Schroeder, 2004). This study attempted to minimise this by having respondents select the appropriate range of levels of payment attributes during the experimental design, as per the suggestion of focus groups. Several studies have underlined the limitations of CE in general (Wills, 1997; Adamowicz et al., 1998; Alpizar et al., 2001; Hanley et al., 2001). These authors suggested that design constraints can limit the validity of the results. In addition, there is no consensus in the literature on the best econometric model to analyse CE responses (Greene and Hensher, 2003). However, despite these limitations, this research illustrates that a CE can be effective in informing policy-makers in developing countries (Lagarde and Blaauw, 2009).

In general, invasive plants exhibit different ecological dominance in different phases of the invasion process (Cousens and Mortimer, 1995). Therefore, postulating the long-term effects of invasive plants is a complex task. Most species exhibit unpredictable behaviour in different locales, and sometimes even under similar conditions in the same locale (Abbott et al., 2007). The livelihood effects of IPS and the cost of control may vary across the different phase of the invasion. This may increase the uncertainty for human welfare over time. Ultimately, this limits the effectiveness of many tools of economic analysis (Perrings et al., 2000). This study did not assess the effects of different stages of the *Mikania* invasion in the BZCFUGs. Despite this, several findings emerged from this study.

9.1.1. Livelihood Effects of Invasive Plants

This study illustrated that accidentally transported non-woody plant species undermine rural livelihoods. Hence, the mode of introduction of the IPS (accidental or deliberate) and its life-form (woody or non-woody) can determine its effect on rural livelihoods. This conclusion was drawn from the literature review and findings of this study. The investigated accidentally transported plants were non-woody. This analysis excluded the assessment of the effects of accidently transported woody species on rural livelihoods. Besides, the effects of invasive plants on rural livelihoods are often evaluated based on the provisioning of basic forest products (timber, fuelwood and fodder) by the particular species, which excludes the assessment of other ecosystem services.

The assessments of the livelihood effects of *Mikania* were based on the respondents' perceptions. There were two facts to support the farmers' responses:

i. The number of visitors to the CNP was increasing; and

ii. There was a ban on cattle grazing.

Hence, a conclusion was made that *Mikania* was entirely responsible for the reduced availability of forest products and the fewer tourists visiting the BZCFs. However, other factors may also have influenced the dependency of respondents on the forest and the number of visitors to the forest. These factors may include a voluntary change in livelihood options involving tourism, access to contemporary facilities (such as liquefied petroleum gas for cooking), and improvement of facilities by the national park authority inside the CNP.

Several coping strategies used by farmers, such as agroforestry, may bring positive changes in the long term. These strategies were not assessed. Currently, the depletion of forest resources is imposing social costs. In addition, the likelihood of an infestation of *Mikania* occurring in an agroforestry system will increase if the vines are not managed properly.

9.1.2. Survey Implementation

Developing choice scenarios that are clear for respondents is one of the major challenges of CEs. In this study, several strategies were undertaken to improve content validity, including focus groups and questionnaire pre-testing. This included selection of appropriate attributes and their levels to ensure the clarity and appropriateness of choice scenarios could be improved. Typically, CEs allow respondents repeated choices by presenting a number of choice scenarios. This study limited the number of attributes and choice scenarios to minimise the cognitive burden on the survey respondents.

In general, estimates in a hypothetical context should be compared with results from the actual market to ensure criterion validity (Carlsson and Martinsson, 2001). As non-market services do not have a price, a comparison between the estimated values and actual values was not possible. The use of stated preference and revealed preference methods in combination partly allowed an estimation of values (Brooks and Lusk, 2010). These stated preference and revealed preference data sets shared complementary strengths to overcome weaknesses (Hensher et al., 1998). This study mainly focused on the application of non-market valuation in a subsistence economy.

It was observed that using face-to-face surveys led to an effective response rate. In the presence of enumerators, respondents may have felt pressure to complete the questionnaire however there was no time limit in which the surveys had to be completed. This might be due to the situation that respondents have had to maintain eye contact with the enumerator while describing choice scenarios. In order to avoid the possible effect of presence of others during the interview, the drop off–pick up method of data collection can be used. However, there is a risk that respondents may fill out the questionnaire by discussing it with their neighbours. In this context, village elites can influence policy choices (Whittington, 1998).

This research was limited by selecting BZCFUGs in the clusters that were close to national park authorities and were receiving comparatively more visitors. However, the majority of community members were farmers. The sampling strategy was designed to capture the effects of the different intensities of *Mikania* in the BZCFs, as the abundance of invasive plants was considered a major determinant of control

costs and livelihood vulnerability (Shackleton et al., 2007). Nevertheless, the research yielded some interesting findings to inform policy and raise awareness in local communities about the infestation of *Mikania* and the development of non-market valuation surveys in low-income communities.

9.1.3. Using Labour as a Mode of Contribution

Household income levels are often considered the major hindrance to undertaking stated preference surveys in subsistence economies (Whittington, 1998). This study indicated that estimated WTP/WTC are sensitive to the mode of contribution. The use of labour contribution as an alternative mode of contribution was found effective in addressing the cash constraints of people with low incomes. However, the elicitation of WTC in labour terms may not be suitable for all programmes and communities. Hence, CE practitioners have to identify the appropriate form of non-monetary contributions prior to the experimental design. Focus groups could be an appropriate forum for this purpose. Labour was shown to be a viable alternative to money to elicit the preferences of rural communities involved in participatory resource management.

A question may arise regarding how respondents can handle both labour and money attributes in one choice set. The reasons for including two payment attributes and their appropriateness in the context of this study were discussed in an earlier section of this thesis (Section 5.4). Paying a fixed amount of an annual fee and participating in forest management activities are common practices among community forest users. If respondents were not familiar with these types of contribution, the inclusion of two payment attributes (labour and money) in the choice set could make the

choice task more complex. In this context, instead of including two payment attributes, the shadow value of labour time that was estimated in this study (47 per cent of the market wage rate) could be used as a conversion rate.

In CE-II, the estimated WTP/WTC values were based on a single payment attribute that considered the value of another payment attribute equal to zero. In this CE, respondents considered two cost attributes in each choice set. This may limit the interpretation of results. Nevertheless, the main aim of CE-II was to estimate the shadow value of labour that respondents were willing to contribute to a *Mikania* management programme.

9.2. Suggestions for Future Research

Professionals and the general public have different perceptions regarding the invasion of exotic plant species (Selge et al., 2011). An assessment of the livelihood effects of invasive species is an important question, considering that the majority of research on invasive species has previously focused on the ecological effects. As described in earlier chapters, the effects of invasive plants on rural livelihoods are ambiguous. This study attempted to clarify this ambiguity by categorising the species based on the mode of introduction and their life-form. This study concluded that the invasion of accidently introduced non-woody species undermines rural livelihoods. However, this distinction is not always clear, as virtually all woody plants can produce basic forest products, such as timber, fuelwood and fodder. Further research to assess the livelihood effects of accidently introduced woody plants would be valuable to broaden the understanding of the interface between rural livelihoods and invasive plants.

Time lag effects in different phases of the invasion process add complexity to predicting the effects of invasive species. A conceptual framework to interpret the effects of IPS on rural livelihoods has been developed by Shackleton et al. (2007). This framework is helpful in understanding the livelihood effects of IPS in different phases. The responses of farmers and their WTC for managing invasive plants may also vary over time. Hence, a further study to elicit public preferences for the IPS management programme in rural areas using different phases of the invasion of a particular plant species would be interesting. For this, the infested landscape could be divided into three strata based on the phases of invasion: introduction, colonisation and naturalisation.

This study also indicated the problem of comparing the estimated values with the actual market. Conducting a valuation study, as recommended in the previous paragraph, would be valuable to combine CE with a revealed preference method. In the BZ of protected areas, a travel cost method with the CE survey would be the best fit. In addition, this thesis demonstrated the potential for the application of stated preference surveys in forest management decision-making in subsistence communities. Further valuation studies using a CE survey in subsistence communities would be helpful to improve non-market valuation surveys and develop them as environmental decision-making tools.

This study progresses the use of labour as a mode of contribution as an alternative to monetary terms and opens the door to elicit the preferences of natural resource management programmes of low-income households. Further research regarding how to measure WTC in labour terms and convert to actual work hours would be

helpful to facilitate the use of CE in developing countries as an environmental decision-making tool. The estimation of WTP/WTC for a specific environmental programme is not a panacea to promote good environmental governance. Hence, research that seeks ways to harness this estimated WTC would translate information into action to implement the IPS management program.

As discussed in previous sections of this thesis, the likelihood of introducing new exotic plants increases with economic globalisation. The effects of these plants on ecosystem services and rural livelihoods are ambiguous. Therefore, future research that focuses on raising the profile of the invasive problem and gaining supports for the public sector and the community would be helpful. In developing countries, CBF practices are acknowledged for contributing to improving local environmental conditions and forest product supply (Pandit and Bevilacqua, 2011a). Hence, future studies on the development of forestry policy to build on the established structure of community movement in forest management would also be valuable.

The previous subsection highlighted the limitations associated with the computation of WTP/WTC by using two payment attributes. As the inclusion of two payments increases the complexity of results analysis, this deserves further analysis to explore the relationship between these two payment-attributes in more detail. In addition, the relationship between two attributes “forest product collection time” and “labour contribution” calls for a future extension.

9.3. Final Conclusions

This thesis answered the research questions raised in the first chapter and justified these questions in Chapters Two and Three through the analysis of CE data that was collected in the two household surveys. The livelihood effects of *Mikania* were examined by assessing changes in the household activities of BZ communities. The CE survey was extended to be suitable for subsistence communities. This survey concluded that the lower estimations of social benefits that were derived from previous non-market valuation surveys were a consequence of bias in the valuation question framing. This research clearly showed that the use of a labour mode of contribution has a strong influence on non-market valuation surveys undertaken with low-income households. The results also suggest that rural farmers value their time in this context at a different rate to the current wage rate.

The categorisation of IPS based on the plants' mode of introduction and their life-form may help identify the direction (positive or negative) of these plants' effects on rural livelihoods. Unintentionally introduced invasive plants—particularly non-woody species—largely degenerate ecosystem services and exert a huge social cost. For example, the use of *Mikania* is likely to reduce household productivity, as it contributes to adverse effects on animal health and reduces the availability of forest products (Siwakoti, 2007). Households unable to afford coping strategies may make unauthorised entry into the core area of national parks to collect forest products. As a result, conflicts between the park and people are likely to resume.

Livelihood vulnerability and management costs increase with the abundance of unwanted and aggressive species such as *Mikania* (Shackleton et al., 2007). Coping

strategies often do not offer a satisfactory resolution. For example, the installation of biogas as an alternative of fuelwood increases the demand for fodder. These interventions focus on short-term benefits, without considering the limitations of households to address uncertainties in their livelihoods. This indicates that such strategies are unsuitable to minimise the effects of invasive plants. In this context, either a further investigation is required to determine the possibility of transforming *Mikania* into an economic good, or an immediate intervention is required to constrain the growth of *Mikania*. The second option is preferable, as most respondents were using different coping strategies to continue their existing livelihood strategy. In addition, they exhibited their WTC to control the spread of *Mikania*.

This study contributes to the existing literature on issues around biological invasion. In addition, it also sheds light on the implementation of CE surveys to elicit the preferences of low-income households. The estimated value of a *Mikania* management programme not only focused on the overall value of mitigating invasive plants, but also on the implicit price of each attribute. Based on this, an array of strategies can be evaluated. The findings of the study help policy-makers in allocating available resources for the purpose of improving the ecological conditions of forests by controlling the growth of *Mikania* in the BZ of CNP. The results of the CE surveys also demonstrated the effect of socioeconomic factors on the IPS management programme. In addition, the analysis of the CE responses provides information about the important socio-economic characteristics of respondents that influence the decision regarding the management of the invaded area.

The CE survey concluded that the use of labour as a numéraire provides an opportunity to include the preferences of an increasing number of community members in subsistence economies. Without including labour, these members' concerns may be overlooked in forest management programs. Three advantages were observed from including labour as a mode of contribution. First, it can increase the social benefits of forestry activities by including the values of low-income households. Second, it provides opportunities for marginalised groups to participate in environmental decision-making. These groups include women, farmers, frequent forest visitors, indigenous people and people with low incomes. These are all primary forest users and knowledgeable forest managers. Inclusion of these disadvantaged groups is strategic in establishing good forest governance in CBF programmes (CFD, 2004). Third, it can help minimise the controversy surrounding IPS programmes and maximise the participation of the community in IPS programmes.

The extension of CE surveys is not only limited to expressing WTC in non-monetary terms, but also provides the opportunity to estimate the shadow value of time spent in public activities. In this study, two payment-attributes—monetary and labour—were included to create choice scenarios. In addition to estimates of the social opportunity cost of labour, this reduced the choice task complexity providing an opportunity to express preferences in more familiar mode of contribution i.e. labour terms. It also addressed the theoretical issue associated with the discrepancy in opportunity cost of time across individuals. This research opens the door to extend the application of stated preference surveys, particularly CEs, in subsistence economies.

The estimated total WTC based on the extended CE surveys proves that rural people in subsistence economies support environmental sustainability despite their low-incomes. The value of total WTC in labour terms outbid the total WTC in monetary terms. In the long-term, this estimation could reverse, as household respondents committed in monetary terms had consistently higher WTC than their neighbours who elected the labour mode of contribution. The number of households in the monetary group is likely to increase with improvements in education, livelihood diversification and the empowerment of women. Governments' existing concerns regarding education and the empowerment of women may bring positive changes in the future. However, for the time being, the inclusion of non-monetary contributions indicates the significance of environmental policies and programmes. This is likely to increase the acceptance of non-market valuation surveys as policy tools in developing economies.

This study also progresses the development of survey implementation strategies in heterogeneous communities. In these communities, local cultures and socioeconomic conditions play a significant role in eliciting meaningful estimates of community preferences. This study strongly recommends the formation of a team of local enumerators to consider the social and cultural issues of the study area. These enumerators will require intensive training and monitoring. Furthermore, a set of colourful pictorial choice scenarios helps enhance the efficiency of the choice task.

For the first time, the non-market values of an IPS management programme have been quantified in a subsistence economy by analysing CE responses. The results of this can be used to justify an IPS management programme in Nepal. It can be

concluded that, if a *Mikania* management programme is implemented, the BZ community will benefit. This study demonstrates that CEs can be applied in low-income communities to estimate the non-market values of forest ecosystems. The inclusion of non-market values and the information these provide for policy-makers may make a significant contribution to sustainable development in subsistence communities.

The results from this study are likely to:

i. Contribute to an increased awareness of environmental problems, such as the colonisation of invasive species;
ii. Provide policy-makers with valuable information regarding community preferences; and
iii. Enhance the application of non-market valuation as a tool in environmental decision-making.

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Appendices

Appendix 5.1: Focus Group Discussions

Focus Group One

Date: 20 November 2010 Place: Baghmara BZCFUG

Gender: Five males, two females Time: Two hours

This BZCFUG was established in 1989. The total area of the community forest is 400 hectares, comprising 779 households of Bachhauli village development committee—ward numbers one, two, three and four of Chitwan District. The major income source of the BZCFUG is tourism. The age of participants ranged from 28 to 70 years old. Their main income source was agriculture and two of them were partially involved in tourism.

The focus group participants had a consensus that the effects of *Mikania micrantha* were absolutely negative both ecologically and socioeconomically. They did not see any benefits from the species and wished for its eradication. For them, it served no purpose. According to them, the most significant effects of *Mikania* were in the following order:

i. Decreased quantity of grass (previously took one hour for one sack, now takes up to four hours);
ii. Decreased number of wild animals (previously were 12 to 13 rhinoceroses in one place, now hardly one or two);
iii. Increased crop raiding by wild animals;
iv. Decreased natural regeneration (is now sparse); and
v. Reduced density of the forests (is now medium).

Most participants regularly collected forest products—particularly fodder and fuelwood. They estimated that it previously took approximately one hour to collect fodder and fuelwood for their daily requirements. At the time of the study, it took up to four hours to collect the same amount, as they had to search further. *Mikania* had adversely affected the availability of fodder and natural regeneration. In response, respondents had reduced their number of livestock, such as cattle and buffalo.

The main income source of the forest user group was tourism. The group had invested in forest management. The BZCFUG had carried out *Mikania* management activities, including uprooting and cutting the *Mikania* vines; however, the results were not as expected. As a result of this, they suspect that only uprooting can control the spread of *Mikania*. Some participants thought that grazing in the forest could decrease the population of *Mikania*. However, grazing is prohibited inside the forest according to the community forest rule. The participants were concerned about their own income source (agriculture) and the community's income source (tourism). They believed that the population of rhinoceroses decreases with the increasing abundance of *Mikania*, which will have negative effects on tourism.

The community people readily agreed to contribute to forest improvement to control the colonisation of *Mikania*. However, they wanted to contribute in terms of labour—up to three days each year—because they had insufficient cash income. As they perceived the species had numerous negatives, they wanted to contribute consistently until the plant was eradicated. The provision of *Mikania* control in their user group's operational plan and the provision of labour contributions to their forest management would be an effective payment vehicle. They did not think a common

fund would be effective because the contribution would be limited to their community forest, and they suspected that would be mobilised according to the plan.

They suggested that the questionnaire be presented in a large font. In addition, they believed a choice set in pictorial form would be preferable; however, they thought that levels of the attributes in pictorial form may be confusing. They felt that presenting both attributes and their levels in pictures would require more time to differentiate. Besides, it was clearly observed that participants had difficulties in choosing the alternative, and the researcher had to clarify aspects of the choice set. Sometimes, it was felt that participants considered that more contribution would help to improve situations. Therefore, it was likely to take more time to ensure they were clear regarding the choice set.

Focus Group Two

Date: 22 November 2010 Place: Kumroj BZCFUG, Chitwan

Gender: 12 males, two females Time: Two hours and 30 minutes

This BZCFUG was established in 1996 and is situated in Kumroj village development committee, Chitwan. The community forest covers 679 hectares, comprising 1,682 households. The main income source of the BZCFUG is tourism, including *Machan* (a post to observe wildlife and scenery), entrance fees for the elephant rides and jungle walk, and concession for sand and gravel from the Rapti River. The group has an annual income of approximately NRs. 1.6 million, and has invested approximately NRs. one million into forest management activities, including the removal of *Mikania*. The group has 12 employees.

Participants had a consensus that *Mikania* has negative effects on the forest. They wanted to eradicate the species because of its long-term environmental and economic effects. They wanted to contribute in terms of labour. They listed the following effects:

i. Reduced habitat for wildlife (grassland);
ii. Adverse effects on plant species;
iii. Reduced forest products by three-quarters;
iv. Adverse effects on natural regeneration;
v. Increased animal raiding; and
vi. Adverse effects on jungle walk route.

They noticed that wild animals were shifting their habitats towards the core area of the national park. They were not sure about the wild animal raiding. Domestic animals, particularly goats, had started to graze on *Mikania*. According to the respondents, *Mikania* has two species, which can be distinguished by their leaf colours. The vines that have black leaves are preferred by animals, but those that have yellow leaves are not. They mixed the vines with other fodder and grass, with up to 50 per cent *Mikania*. However, they mentioned that they do not harvest vines intentionally. As they cannot detach the vines while cutting the grass, they offer it to their animals. The shortage of fodder was compensated with rice straw. The fuelwood deficiency was compensated by biogas installation.

At the individual level, they had not yet started to mitigate *Mikania* damages. The BZCFUG had cut the vine with no positive results. They estimated that it would take 150 man-days to clear 0.8 hectares of forest. They ensured that they contributed up

to 10 days annually to mitigate the *Mikania* infestation. They realised that *Mikania* kills other species and may create a monoculture. As vines become monocultures, other species will disappear after some years. The participants believed that *Mikania* was transported by a flood in 2003, from the mid-hills.

Forest product collection time had increased from one hour to three hours. For these respondents, a decrease in *Mikania* density was the most important characteristic. They believed that uprooting the vines can eradicate the species, while burning and cutting the vines were not effective. They believed that regular grazing could control the species, and had subsequently planned to allow rotational grazing.

Regarding the questionnaire, they suggested conducting a household survey, rather than providing questionnaire to the participants. They believed this would ensure clarity. They were also confused by the way the pictures presented both alternatives and attributes.

Focus Group Three

Date: 23 November 2010 Place: Janakauli BZCFUG, Chitwan

Gender: 10 males and one female Time: Two hours

This BZCFUG manages 59.5 hectares of forest with 1,300 households. The BZCFUG was handed over as a BZCF in 2004. It has 11 staff, and tourism—particularly boating—is the main source of income. The group has an annual income of approximately NRs. 150,000 and spends NRs. 65,000 on salaries.

Participants had the consensus that *Mikania* has absolute negatives. They listed its effects as follows:

i. Decrease in forest density;
ii. Decrease in grassland and, subsequently, wild animal populations;
iii. Decrease in forest product availability;
iv. Decrease in regeneration;
v. Decrease in domestic animals; and
vi. Jungle walk route negatively affected.

Participants observed that wild animals were migrating to other habitats. They were afraid that this may cause a decrease in their group's income, as tourists cannot see the animals. There was a reduction in the number of livestock owned by households. Villagers had realised that domestic animals—particularly goats—were grazing on the vines, which led to abdominal disorders. Additionally, they realised that, due to the shortage of forest products, there was competition among the villagers, which was likely to enhance conflicts. *Mikania* has also led to an increase in forest product collection time, from one hour to four or five hours.

Villagers managed the shortage of forest products such as fuelwood by using biogas. They have to keep buffaloes or cattle to install bio-gas plants as the plants require animal dung. They are buying rice straw to feed their cattle as the availability of fodder was not sufficient. They spent around NRs. 10,000 for a buffalo to buy straw annually. Hence, they were concerned about the sustainability of the operation of biogas plants, as the decrease in availability of forest products meant the number of domestic animals was declining and animal husbandry becoming more expensive.

The BZCFUG allocated land to its members to clear areas affected by vines and cultivate turmeric. However, the results were not as expected. They estimated that 50 to 60 man-days were required per hectare to uproot the vines. As the vines were dispersed rapidly by wind, this site-specific management did not help mitigate the problem. Doing this would require a landscape level approach, and they were ready to contribute up to six days to mitigate the damages caused by *Mikania*.

Focus Group Four

Date: 24 November 2010 Place: Chitrasen BZCFUG

Gender: 28 males and one female Time: Two hours and 30 minutes

This BZCFUG was handed over in 1995 by the District Forest Office and was brought under the jurisdiction of a national park in 2002. The group comprises 1,112 households and manages 483 hectares of forest. Tourism is the main source of income, with an annual income of approximately NRs. 7.4 million. The group employs 20 staff for administrative, forest protection and tourism.

As these community forests are mainly dominated by Sal (*Shorea robusta*), the effects of *Mikania* are not so serious; however, approximately 14 hectares of forest have been affected, particularly along the river. This group did not experience any severe effects; however, they had observed several effects of the species:

i. Decrease in forest density;
ii. Disturbance to wildlife habitats;
iii. Decrease in forest products (grass, fodder and timber); and
iv. *Mikania* growing on farmland.

They believed that rotational grazing would help reduce the infestation of *Mikania*. They stated that site-specific efforts were unlikely to mitigate the damages because the vine can spread from anywhere. Therefore, they strongly suggested extensive implication. For this, they had committed five days of labour per year to mitigate the damages according to the BZCFUG operational plan.

Focus Group Five

Date: 25 November 2010 Place: Ghailaghari BZCFUG, Chitwan

Gender: Eight males and four females Time: Two hours and 15 minutes

This BZCFUG consists of 942 households, which manage 161 hectares of forest patch. The collection and sale of forest products (timber, fuelwood and fodder) to their members, and tourism are the main sources of income for this user group. Most of its members depend upon traditional agriculture and day labour.

The participants had a consensus that *Mikania* has environmental and socioeconomic negatives in terms of:

i. Reduced forest density;
ii. Reduced forest products;
iii. Decreased number of wildlife;
iv. Decreased number of domestic animals; and
v. Decreased regeneration.

In addition, they found that the presence of the vine makes the land dry. Akin to other BZCFUGs, they had also observed that *Mikania* affects Veldar (*Trewia*

nudiflora) adversely, which is the main food of the rhinoceros. As a result of this, the rhinoceros was shifting its habitat to other places. Previously, it was easy to find five or six rhinoceroses in the forest. Now, the community rarely sees one or two.

The time required for forest product collection has increased significantly from half an hour to four hours for one day's requirement. Households who used to have 14 or 15 goats now have no more than two. Sometimes, the goats grazed on *Mikania*, which causes abdominal problems. The community were coping with the loss of forest products by buying straw, which costs approximately NRs. 7,000 to 10,000 per year for one buffalo. They used liquefied petroleum gas as an expensive alternative to fuelwood for cooking.

The community believed that the vines can be reduced by uprooting and burning. They attempted to uproot the vines by using a tractor in one hectare of forest. This took approximately 12 hours and cost NRs. 10,800, and the results were not as expected. Participants expressed that they could contribute up to NRs. 1,000 in cash or five days labour contribution. They wanted to regularise this labour contribution through a BZCFUG fund.

Appendix 5.2: Plain Language Statement (Focus group discussion)

To: Potential Participants

Project Title: Estimating the benefits of managing invasive plants in subsistence economies

Principal Researcher: Prof. Nejat Anbarci

Project No: 2010-213

You are invited to take part in this research project. Please note that your participation is entirely voluntary and can be withdrawn at any time. Deciding not to participate will not affect your relationship to the researchers or to Deakin University. Once you have read this form and agreed to participate, please sign the attached consent form. You may keep this copy of the Plain Language Statement.

You have been selected as a member of a *Buffer Zone Community Forest User Group*, whose community forest is facing the problem of Mile-a-minute *(Milkania micrantha)* infestation. The purpose of this research is to investigate the effects of Mile-a-minute infestation on the livelihoods of rural communities and to estimate respondents' willingness-to-pay to avoid the damages caused by the infestation and to improve the condition the forest. This research aims to raise awareness about the problem of colonization of invasive species such as mile-a-minute and, to provide valuable information to policy-makers seeking to manage forests in a sustainable way. It also investigates the preparedness for forest dwellers to adapt to changing conditions.

The objectives of the discussions are to define good and bad aspects of the infestation of Mile-a-minute and test the draft questionnaire that is designed for the interview. First, we will discuss about changes you have observed in your community forest and select 5 major changes. Secondly, we ask you to fill up the draft questionnaire. Afterwards, we would like to know your opinion about complexity in understanding and answering the questionnaire and your suggestions to improve the questionnaire in order to make it more users friendly. There are no correct answers- we are interested in your opinion. The feedback and information gained during the discussions is a key to improve and complete the final questionnaire which will be used for the interview.

The discussion will take about 2 hours and 15 minutes. You may of course decide to quit the discussion at any point. In accordance with Deakin University's ethics requirements, the following information and assurances are provided in relation to the questionnaire and its results;

Your response during the discussions will be completely anonymous and nobody identifies you.

1. The completed draft questionnaires during the discussions will be secured in accordance with *the Deakin Code of Good Practice in Research Procedure*. They will be stored for the minimum period of 6 years and they will be destroyed.
2. Only aggregated results of the discussions will be published in a PhD dissertation and in refereed journals, and presented at relevant academic conferences.

If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact: The Manager, Office of Research Integrity, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, Facsimile: 9244 6581; research-ethics@deakin.edu.au

If you need any further information about the outcome of the project please contact either of the researchers. The researchers responsible for this project are:
Prof. Nejat Anbarci, School of Accounting, Economics and Finance, Deakin University , 221 Burwood Highway, Burwood, VIC 3125, Australia. Email- nejat.anbarci@deakin.edu.au. Or, Rajesh K Rai, PhD Student, School of Accounting, Economics and Finance, Deakin University, 221 Burwood Highway, Burwood VIC 3125, Australia, Email- rkrai@deakin.edu.au.
Or you can contact through;
Ganesh Pant, Assistant Warden, Chitwan National Park, Sauraha, Chitwan, Nepal.
Phone- +977-9841283953, Email- ganesh.mfsc@gmail.com

Appendix 5.3: Plain Language Statement (Interview)

TO: Potential Participants

Project Title: Valuing Damages Caused by Invasive Alien Species in a Low Income Community

Principal Researcher: Prof. Nejat Anbarci

Project No: 2010-213

You are invited to take part in this research project. Please note that your participation is entirely voluntary and can be withdrawn at any time. Deciding not to participate will not affect your relationship to the researchers or to Deakin University. Once you have read this form and agreed to participate, you will be interviewed using a questionnaire. The interview will take approximately one hour and you may of course decide to stop the interview at any point. You may keep this copy of the Plain Language Statement.

You have been selected as a member of a *Buffer Zone Community Forest User Group*, whose community forest is facing the problem of Mile-a-minute *(Milkania micrantha)* infestation. The purpose of this research is to investigate the effects of Mile-a-minute infestation on the livelihoods of rural communities and, to estimate respondent's willingness-to-pay to avoid the damages caused by the infestation and improve the condition of the forest. This research aims to raise awareness about the problem of colonization of invasive species such as mile-a minute and, to provide valuable information to policy-makers seeking to manage forests in a sustainable way. It also investigates the preparedness for forest dwellers to adapt to changing conditions.

The questionnaire mainly contains:

- Hypothetical policy options which would have different effects on forest conditions,
- Your household information (income sources, dependency on forests),
- Changes in forest products collection (time, amount, type of the products) before and after the arrival of Mile-a-minute in your forests,

There is no right or wrong answers and the choices you are going to make are non-binding. We are interested in your opinion. We will take the handwritten notes of the interview on a questionnaire sheet.

In accordance with Deakin University's ethics requirements, the following information and assurances are provided in relation to the questionnaire and its results;

- Your response to the questionnaire will be completely anonymous.
- The completed questionnaires will be secured in accordance with *the Deakin Code of Good Practice in Research Procedure*. They will be stored for the minimum period of 6 years and they will be destroyed.
- Only aggregated results of the questionnaires will be published in a PhD dissertation and in refereed journals, and presented at relevant academic conferences.

If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Manager, Office of Research Integrity, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, Facsimile: 9244 6581; research-ethics@deakin.edu.au.

If you need any further information about the outcome of the project please contact either of the researchers. The researchers responsible for this project are:

Prof. Nejat Anbarci, School of Accounting, Economics and Finance, Deakin University, 221 Burwood Highway, Burwood, VIC 3125, Australia. Email- nejat.anbarci@deakin.edu.au.

Or, Rajesh K Rai, PhD Student, School of Accounting, Economics and Finance, Deakin University, 221 Burwood Highway, Burwood VIC 3125, Australia. Email- rkrai@deakin.edu.au.

Or you can contact through a local contact;

Ganesh Pant, Assistant Warden, Chitwan National Park, Sauraha, Chitwan, Nepal. Phone- +977-9841283953, Email- ganesh.mfsc@gmail.com.

Appendix 5.4: The Design Matrix (Choice Experiment- I)

Version	Choice Situation	FP collection time	Plant Species	Visitor (‘000)	Annual Membership Fee
1	1.1	4	126	27	1,750
		1	115	35	1,750
		4	102	20	0
	1.2	1	102	35	350
		4	115	20	1,750
		4	102	20	0
	1.3	4	115	27	1,750
		1	115	20	1,050
		4	102	20	0
	1.4	1	115	20	350
		4	115	35	2,450
		4	102	20	0
2	2.1	2	126	20	350
		4	102	35	2,450
		4	102	20	0
	2.2	1	102	27	1,750
		4	126	27	1,050
		4	102	20	0
	2.3	1	102	27	2,450
		4	126	27	350
		4	102	20	0
	2.4	2	115	35	2,450
		2	126	20	350
		4	102	20	0
3	3.1	2	126	35	1,050
		1	102	27	1,050
		4	102	20	0
	3.2	1	102	20	1,050
		4	126	35	1,750
		4	102	20	0
	3.3	2	126	27	1,750
		1	115	27	350
		4	102	20	0
	3.4	1	126	27	2,450
		2	102	35	350
		4	102	20	0
4	4.1	4	102	35	1,050
		2	126	20	1,750
		4	102	20	0
	4.2	4	102	35	1,050
		2	126	20	2,450
		4	102	20	0
	4.3	2	126	20	2,450
		4	102	35	1,050
		4	102	20	0
	4.4	2	126	20	350
		2	102	35	2,450
		4	102	20	0
5	5.1	1	102	20	1,750
		4	126	35	1,750
		4	102	20	0
	5.2	4	115	35	1,050
		1	115	20	1,050
		4	102	20	0
	5.3	2	115	20	2,450
		2	115	27	1,050
		4	102	20	0
	5.4	4	126	27	350
		1	102	27	2,450
		4	102	20	0
6	6.1	2	115	35	1,050
		2	126	20	2,450
		4	102	20	0
	6.2	1	126	20	2,450
		4	102	35	350
		4	102	20	0
	6.3	4	115	35	1,750
		1	115	20	350
		4	102	20	0
	6.4	1	102	27	350
		2	115	27	1,750
		4	102	20	0

D error	0.057313	A error	0.066797
B estimate	30.098914	S estimate	5.754234

Appendix 5.5: Questionnaire

Part I: State of the Area

Invasive species refer to exotic species that have a distribution beyond their natural habitat and that threaten biological diversity. Mile-a-Minute (*Mikania micrantha*), a fast growing South American climber vine, is colonising rapidly in your community forests. This species is displacing native vegetation, as it carpets forest and grassland.

We are interested in your opinions about Mile-a-Minute in the forest areas that your household has used during the past five years. We are interested in only your household's use of the forest, not use by other households in your village or other villages.

1. When do you think *M. micrantha* first arrived in the forest?

   ……

2. Where do you think it came from?

……

3. How do you think it came to the forest?

……

4. Has its abundance changed over the last five years?

   (a) Increased (b) Decreased (c) Not at all (d) Can't say

5. How do you describe the effects on your life of the *M. micrantha* invasion?

   (a) Positive (b) Negative (c) Not at all (d) Can't say

6. In your opinion, what is the current condition of your community forests in general?

   (a) Good (b) Okay (c) Bad (d) Very bad (e) Can't say

7. Do you prefer the current situation or do you want to improve it?

   ……

8. There are many ways to sustainably manage forests in order to enhance the availability of forest products that are useful to your households. The condition of your community forest is likely to depend upon which forest management activities are adopted. Based on the available research findings, periodic cuttings of *M. Micrantha* before its flowering can control their further spread. Since forest management activities require costs, your household may need to contribute to forestry activities for the next five years. What do you think of the idea that costs of forest management should be shared among households, with households being able to decide whether or not to contribute?

   (a) Very good (b) Good (c) Bad (d) Can't say

9. Would you be willing to share the cost?

(a) Yes (b) No

9.1.1 If no, in would you like to contribute in labour terms?

(a) Yes (b) No

9.1.2 If no, why don't you want to contribute?

……

10. In this section, we want your opinion about the improvement of the conditions of your community forests from now until 2015. There are three alternatives in each 'choice situation'. The choice situation consists of two policy alternatives and one option in which there is no change from the current policy. Alternatives will be labelled 'Alternative A', 'Alternative B' and 'No change to intervention levels (C)'.

In the present condition, there are no specific forest management activities that focus on the colonisation of *M. micrantha.* Periodic cuttings of the vines would be an appropriate strategy to control the further spread of *Mikania*. To implement a *Mikania* management plan to change environmental conditions, your user group requires a fund. We propose an increase in the annual membership fee of the community forest to implement the specific policy for each household. This would be undertaken for a five-year period. This option is included in Alternative 'A' and 'B'. In 'No intervention', no additional cost is imposed for the household. The alternative conditions are described by the attributes listed in the following table.

Attributes	Description	No intervention
Forest product collection time	Time required for each trip (in hours) for one day's requirement, excluding travel time. There are three levels: four hours, two hours and one hour.	**Four hours**
Plant species present	A number of plant species occurring in the community forests. There are three levels: 102, 115 and 126 species.	**102 species**
Visitors to community forests	The number of tourists visiting community forests annually. There are three levels: 20,000, 27,000 and 35,000.	**20,000**
Cost	An annual membership fee in each BZCFUG that users are required to pay in local Nepali currency. There are four levels: In cash (NRs.): 350, 1,050, 1,750 and 2,450. In labour (days): one, three, five and seven.	**No contribution**

In each situation, please choose the alternative that best describes your expectation. Please consider what you think is best. When you make a selection, please consider your income or available time after your necessary expenses (such as food, housing and clothing) have been met.

Please check one box in each situation (this section varies in each version—see Appendix 5.4).

(Here enumerators show choice card to respondents as shown in Figure 5.1 to describe the scenarios).

Choice Situation-1

Attributes	Alternative A	Alternative B	No intervention (C)
FP Collection time	4	1	1
Plant species present	126	115	102
Visitors to CF	27,000	35,000	20,000
Annual membership fee	1,750	1,750	0
Please tick one box	☐	☐	☐

Choice Situation-2

Attributes	Alternative A	Alternative B	No intervention (C)
FP Collection time	1	4	1
Plant species present	102	115	102
Visitors to CF	35,000	20,000	20,000
Annual membership fee	0	1,750	0
Please tick one box	☐	☐	☐

Choice Situation-3

Attributes	Alternative A	Alternative B	No intervention (C)
FP Collection time	4	1	1
Plant species present	115	115	102
Visitors to CF	27,000	20,000	20,000
Annual membership fee	1,750	1,050	0
Please tick one box	☐	☐	☐

Choice Situation-4

Attributes	Alternative A	Alternative B	No intervention (C)
FP Collection time	1	4	1
Plant species present	115	115	102
Visitors to CF	20,000	35,000	20,000
Annual membership fee	0	2,450	0
Please tick one box	☐	☐	☐

Background information about answering the question

11. While choosing the preferred alternative did you consider every part of each alternative?

    (a) Yes (b) No

12. Were some characteristics more important than others?

    (a) Yes (b) No

    20.1 If yes, what are they?

    a.

    b.

13. If you chose alternative C (status quo) in all choice situations, which of the following describes your reasons? (you can tick many)

    a. I don't care about the invasion in the forest,
    b. It's not my responsibility to pay for improving forest condition ,
    c. I don't believe in any response will that brings any improvement to the condition of the forest,
    d. Government should take care of it ,
    e. Contribution is too high,
    f. Other (specify) --------

Part II: Role of *M. micrantha* in livelihoods

14. Do you think there is a change in forest product availability since the introduction of *mile-a-minute*?
    (a) Yes (b) No

15. If yes, how do you evaluate the change in forest products?
    (a) Increasing (b) Decreasing (c) Cannot say

16. Which forest products are they?

    ---

17. How do you evaluate the condition five years before and after the arrival of *Mikania?*

	Before	After
Forest product availability (Enough or Scarce)		
Forest products harvested (e.g. Fodder, firewood, grass)		
Plant species used to harvest		
Time required to collect forest products for a trip		
The number of forest visit to collect forest products weekly		
Forest products collected per trip	Fodder: Firewood:	Fodder: Firewood:
Domestic animals	Buffalo: Cattle: Goat:	Buffalo: Cattle: Goat:

18. How do you compensate for the reduction in forest products?

(a) Reducing consumption (b) Accessing more area (c) Agro-forestry

(d) Buying (e) others ……

19. Are there any conflicts due to the scarcity of forest product availability? If yes, please describe.

……

……

20. Do you use the species (*mile-a-minute)*?

(a) Yes (b) No

20.1 If yes, what do you use for? (For example: fodder, compost, mulching etc).

……

……

20.2 How often do you collect?

……. Month

20.3 What months of the year do you collect it and why?

……..

21. Are there any impacts in your household activities due to invasion?

(a) Positive (b) Negative (c) not at all

21.1 If yes, what are they?

(a) ……..

(b) ……

(c) …….

(d) ……

PART III: Personal Information

22. Individual (Code No# ……..)

22.1 Age: ……. Yrs.

22.2 Gender:

22.3 Distance to the forests……. min walk

22.4 Education: ……..Years

22.5 Income source (Tick as many)

(a) Agriculture:

(b) Business (specify):

(c) Job (specify):

(d) Other (Specify):

22.6 Land holdings (Katha):

22.7 Number of Family members:

22.8 For how long are you living in the area?

(a) Born here (b)--------- years

22.9 House type:

(a) Concrete (b) General

Thank you.

Appendix 5.6: The Design Matrix (Choice Experiment- II)

Version	Choice Task	FP collection time	visitors ('000)	Labour contribution	Cost (NRs)	Version	Choice Task	FP collection time	visitors ('000)	Labour contribution	Cost (NRs)
1	1.1	1	20	3	1,050	4	4.1	2	30	3	2450
		4	40	3	2,450			2	30	7	1050
		4	20	0	0			4	20	0	0
		4	40	0	1,750			4	40	7	0
	1.2	1	30	7	0		4.2	2	20	0	1750
		4	20	0	0			4	20	0	0
		4	40	7	0			2	20	3	1750
	1.3	1	30	3	1,050		4.3	2	30	7	1050
		4	20	0	0			4	20	0	0
		1	30	5	1,750			1	30	3	1750
	1.4	2	20	5	1,750		4.4	2	30	5	1750
		4	20	0	0			4	20	0	0
2	2.1	1	40	0	2450	5	5.1	1	30	5	1050
		4	30	5	1050			4	30	3	2450
		4	20	0	0			4	20	0	0
		1	20	0	1050			1	30	5	1050
	2.2	4	40	7	0		5.2	4	30	3	1750
		4	20	0	0			4	20	0	0
		2	20	7	1050			2	30	0	2450
	2.3	4	40	0	2450		5.3	4	40	7	0
		4	20	0	0			4	20	0	0
		4	40	0	2450			2	20	0	1750
	2.4	2	20	7	1050		5.4	1	40	5	0
		4	20	0	0			4	20	0	0
3	3.1	2	30	7	0	6	6.1	2	20	5	1050
		2	30	0	2450			4	40	3	2450
		4	20	0	0			4	20	0	0
		2	30	5	1750			1	40	3	0
	3.2	1	30	3	1050		6.2	4	30	5	2450
		4	20	0	0			4	20	0	0
		4	40	0	2450			1	30	3	1050
	3.3	1	20	5	0		6.3	2	20	5	1750
		4	20	0	0			4	20	0	0
		4	40	7	0			4	40	0	2450
	3.4	1	20	0	1750		6.4	1	20	5	0
		4	20	0	0			4	20	0	0

Appendix 7.1: Correlation between variables

	Sex	Edu	Land	Visit	Dist	Inc_agr	Native	Age
Education	0.287	-	-	-	-	-	-	-
Landholding	0.052	0.058	-	-	-	-	-	-
Visit forest	0.0169	-0.066	-0.067	-	-	-	-	-
Distance	-0.081	-0.125	-0.004	-0.281	-	-	-	-
Inc_agr	-0.004	-0.115	-0.015	0.0536	-0.03	-	-	-
Native	-0.229	-0.149	-0.054	0.0176	-0.106	-0.014	-	-
Age	0.104	-0.465	0.044	0.032	0.001	-0.016	0.261	-
Family size	0.024	0.030	0.360	-0.023	0.049	-0.060	-0.046	0.010

Appendix 7.2: Socio-economic characteristics of sample households by mode of payments (Choice Experiment-I)

Characteristics	Mode of payment	
	Monetary	Labour
Respondents	176	324
Female	85	216
Male	91	108
Income (Agriculture)	35	112
Income (Agri+Off-farm)	135	201
Income (Off-farm)	6	11
Native	73	148
Immigrant	103	176
Age (Years)	43.40 (12.40)	43.35 (12.57)
Education (Years)	5.03 (5.02)	3.08 (3.61)
Landholdings	18.43(15.65)	8.78(9.48)
Family size	6.34 (2.80)	6.18 (2.59)

* Standard errors in parentheses.

Appendix 7.3a: The value of total WTC based on different wage rates and Gender compositions (NRs.)

Gender Composition in sample	Market Wage	One-third of the Market Wage	Estimated Shadow value*	Number of Household having WTC Labour (%)
Current Sample	106,589,336	35,520,076	50,454,746	29,107 (65%)
50% Female	103,654,966	34,542,220	49,065,743	28,306 (63%)
40% Female	100,778,133	33,583,538	47,703,976	27,520 (61%)
One-third Female	98,860,244	32,944,416	46,796,131	26,996 (60%)
All in Labour	164,489,716	54,814,933	77,862,263	44,918 (100)

*Estimated shadow value is NRs. 165.72 is based on the Choice Experiment-II.

Appendix 7.3b Estimates of total WTC (NRs) based on the estimated shadow value of Time (all respondents have WTC in labour terms)

		Household Mean WTC labour (10.46 days) in NRs	Aggregated value for the BZ Community (in '000)
WTC per annum		1,733 (24.41)	77,862 (1,096)
Discounted household	3%	8,177 (115)	367,283 (5,173)
WTC for five years	5%	7,880 (111)	353,957 (4,985)
	7%	7,605 (107)	341,598 (4,811)

* US $ in parentheses

Appendix 7.4: Sample characteristics (Choice Experiment –II)

	Male	Female	Total
Respondents	183	142	325
Age	49.79(12.80) [a]	42.08(11.53)	46.42(12.83)
Edu	5.02(4.89)	4.03(3.94)	4.59(4.52)
Land (Katha)	11.90 (8.02)	10.21 (5.73)	11.16(7.15)
Native	93 (50.8%)	66(46.5%)	159 (49%)
Mikania users	14 (7.7%)	8(5.6%)	22 (7%)
Inc_ag	101(55.2%)	113(79.6%)	214(66%)
Monetary contribution	57 (31%)	60(42.3%)	117*36%)

[a] Standard error in parentheses not followed by percentage.

Appendix 7.5a: Effects of *Mikania* invasion on household activities

Activities	Increasing	No-change	Decreasing
Change in CF Visit	3	117	205
Change in fodder	14	112	199
Change in Fuelwood	70	119	136
Change in Animal	56	60	209

Appendix 7.5b: Implicit Prices and 95% Confidence Intervals (CE-II)

Attributes	Monetary terms (NRs)	Labour Terms (day)
Forest products collection time (per hour decrease)	541.43 ±195.43	3.26 ± 1.57
Visitors to BZCFUG (per visitor)	0.24±0.05	1.43E-3±5.5E-4
Labour contribution (per day)	165.72±47.97	-

Appendix 7.6: Utility functions used (extended version of equations)

a. CL **-I (CE-I)**

V_{sq} = β_1*fp+β_2*PS+β_3*vi+β_4*con

$V_{(Alt1, Alt2)}$= ASC+β_1*fp+β_2*PS+β_3*vi+β_4*con

b. CL **-II (CE-I)**

V_{sq} = β_1*fp+β_2*PS+β_3*vi+β_4*con+ γ_1*(Age×ASC)+ γ_2*(edu×ASC) + γ_3*(fam×ASC) +γ_4*(ma×fp)+γ_5*(ma×ps)+ γ_6*(ma×vi)+ γ_7*(ma×con)

$V_{(Alt1, Alt2)}$= ASC+β_1*fp+β_2*PS+β_3*vi+β_4*con+γ_1*(Age×ASC)+γ_2*(edu×ASC) +γ_3*(fam×ASC) +γ_4*(ma×fp)+γ_5*(ma×ps)+ γ_6*(ma×vi)+γ_7*(ma×con)

c. RPL Models (CE-I)

V_{sq} = β_1*fp+β_2*PS+β_3*vi+β_4*con+ η*vi+γ_1*(Age×ASC)+ γ_2*(edu×ASC) + γ_3*(fam×ASC) +γ_4*(ma×fp)+γ_5*(ma×ps)+ γ_6*(ma×vi)+ γ_7*(ma×con)

$V_{(Alt1, Alt2)}$= ASC+β_1*fp+β_2*PS+β_3*vi+β_4*con+ η*vi +γ_1*(Age×ASC)+γ_2*(edu×ASC) +γ_3*(fam×ASC) +γ_4*(ma×fp)+γ_5*(ma×ps)+ γ_6*(ma×vi)+ γ_7*(ma×con)

d. Basic Model (CE-I)

V_{sq} = β_1*fp+β_2*vi+β_3*la+β_4*fee

$V_{(Alt1, Alt2)}$= ASC+β_1*fp+β_2*vi+β_3*la+β_4*fee

e. CL **Model II (CE-II)**

V_{sq} = β_1*fp+β_2*vi+β_3*la+β_4*fee + γ_1*(Age×ASC)+ γ_2*(Inc× ASC)+ γ_3*(edu×ASC) + γ_4*(AI×ASC)+γ_5*(Land×ASC)

$V_{(Alt1, Alt2)}$= ASC+β_1*fp+β_2*vi+β_3*la+β_4*fee + γ_1*(Age×ASC)+ γ_2*(Inc×ASC)+ γ_3*(edu×ASC) + γ_4*(AI×ASC)+γ_5*(Land×ASC)

f. CL **(CE-II)**

V_{sq} = β_1*fp+β_2*vi+β_3*la+β_4*fee + γ_1*(fam×ASC)+ γ_2*(Inc× ASC)+ γ_3*(LU×FP) + γ_4*(Inc×la)+γ_5*(Land×fp) +γ_6*(Fe×FP)

$V_{(Alt1, Alt2)}$= ASC+β_1*fp+β_2*vi+β_3*la+β_4*fee + γ_1*(fam×ASC)+ γ_2*(Inc× ASC)+ γ_3*(LU×FP) + γ_4*(Inc×la)+γ_5*(Land×fp) +γ_6*(Fe×FP)

g. RPL (CE-II)

V_{sq} = β_1*fp+β_2*vi+β_3*la+β_4*fee + η*vi + γ_1*(fam×ASC)+ γ_2*(Inc× ASC)+ γ_3*(LU×FP) + γ_4*(Inc×la)+γ_5*(Land×fp) +γ_6*(Fe×FP)

$V_{(Alt1, Alt2)}$= ASC+β_1*fp+β_2*vi+β_3*la+β_4*fee+ η*vi + γ_1*(fam×ASC)+ γ_2*(Inc× ASC)+ γ_3*(LU×FP) + γ_4*(Inc×la)+γ_5*(Land×fp) +γ_6*(Fe×FP)

h. Multiple regression

Cope = α+β_1×Age+ β_2×Male+ β_3×Inc_ag+ β_4×LU+ β_5×Land+ β_6×Dist

Notations:

Fp = forest products collection time

PS = Plant species presents

Vi = visitors to forests

Con = Contribution

Edu = Education

Fam = family size

Ma = Male

La = labour contribution

Fee = annual membership fee

Inc = Income agriculture

AI = Annual income

LU= Livestock unit

Land = Landholding size

Fe = Female