Environment and Development Economics 18: 225–244 © Cambridge University Press 2012
doi:10.1017/S1355770X1200037X

Economic value of mitigation of plant invaders in a subsistence economy: incorporating labour as a mode of payment

RAJESH KUMAR RAI
School of Accounting, Economics and Finance, Deakin University, Melbourne Campus at Burwood, Australia. Tel: +61-421949632. Email: rkrai@deakin.edu.au; rjerung@gmail.com

HELEN SCARBOROUGH
School of Accounting, Economics and Finance, Warranmbool Campus, Deakin University, Australia. Email: helen.scarborough@deakin.edu.au

Submitted April 20, 2012; revised June 13, 2012; accepted August 4, 2012; first published online October 11, 2012

ABSTRACT. This paper presents the analysis of a choice experiment designed to estimate willingness-to-pay (WTP) to mitigate damages caused by invasive plant species in a rural community of Nepal. In order to address the cash constraints problem in a subsistence economy, two payment attributes, *labour contribution* and *membership fee*, were included in the choice sets. The results reveal that rural farmers have significant WTP for forest management activities, in terms of both cash and labour contributions. The results also suggest that rural farmers value their time in this context at a different rate from the current wage rate.

1. Introduction

The pace of the spread of invasive plant species (IPS) has increased with trade, travel and technology (Meyerson and Mooney, 2007). As spillovers of economic globalization, invasive plants are widely heralded as one of the greatest threats to native forest ecosystems and species richness (Wilcove *et al.*, 1998; Moore, 2000; D'Antonio and Kark, 2002). Undoubtedly, their introduction brings a change in the supply of

This research was supported by the South Asian Network for Development and Environmental Economics (SANDEE), Research Grant No. SANDEE/Dec 2010/001, as a part of the Ph.D. study of the corresponding author entitled 'Estimating the benefits of managing invasive plants in subsistence communities' at the School of Accounting, Economics and Finance, Deakin University, Melbourne. The authors thank Professor Jeffrey R. Vincent of Duke University for his valuable input during the proposal and analysis of this study.

ecosystem services through the modification of structure and functions of host ecosystems. An assessment of the economic impacts of IPS on ecosystem services is sought for the efficacy of invaded area management programmes, as ecosystem services approaches to conservation are central to environmental decision-making (Pejchar and Mooney, 2009).

A review of the literature on the economic impacts of invasive species highlights the need for non-market valuation to capture a comprehensive account of the impacts of IPS (Born *et al.*, 2005; Holmes *et al.*, 2009; Pejchar and Mooney, 2009). This is because most of the economic impact assessments are based on control costs, *ex post* evaluation and lost market products such as timber. These methods are criticized as estimates of the impacts associated with invasive species as they overlook the costs and benefits beyond the market system (Hoagland and Jin, 2006). For instance, many control strategies tend to fail or become ineffective when more effective alternatives become available and the impacts may be overestimated (Curnutt, 2000). On the other hand, imperfect assessment of the external effects is likely to undervalue the impacts of invasive species on invaded habitat (Born *et al.*, 2005).

Empirical studies have shown that invasive plants have both positive and negative externalities; management of an invaded forest is considered a challenging task (Shackleton *et al.*, 2007; García-Llorente *et al.*, 2011). In this context, public awareness regarding the costs and benefits of IPS management becomes an important tool in winning public support for the management process (Pimentel *et al.*, 2005; Xu *et al.*, 2006). There is also a risk of supporting flawed policies, if information regarding costs associated with IPS management is based on rough estimations. The level of social awareness has a strong association with the management of invasive species (Nuñez and Pauchard, 2010). In order to overcome such situations, empirical data is required to capture the full impacts of IPS on human wellbeing, including the magnitude of this impact on communities (Pejchar and Mooney, 2009).

Stated preference (SP) methods are considered viable tools for exploring social preferences and gauging public support related to IPS management (García-Llorente *et al.*, 2011). The contingent valuation method (CVM), one of the widely used SP methods, has been employed to estimate the value associated with invasive species (Jetter and Paine, 2004; Nunes and van Den Bergh, 2004; Nunes and Markandya, 2008; García-Llorente *et al.*, 2011). The choice experiment (CE) method of SP techniques poses several advantages relative to CVM, including facilitation of benefits transfer, estimation of the marginal values of attributes and avoidance of the 'yes-saying' problem (Hanley *et al.*, 1998; Rolfe *et al.*, 2000). The CE has received considerable attention from applied economists in SP studies (Hanley *et al.*, 1998; Lehtonen *et al.*, 2003; Wang *et al.*, 2007; Do and Bennett, 2009; Birol and Das, 2010).

However, one of the limitations of SP methods including CE is the reliance on money as a mode of contribution and measure of willingness-to-pay (WTP). In many subsistence economies, where there are significant cash constraints, the use of money as a payment vehicle risks underestimating the willingness of communities to contribute towards the mitigation of invasive species. In part, labour has been used occasionally as a numéraire to address the problem of the cash constraints of households in subsistence economies and capture their concerns and preferences (Mekonnen, 2000; Alam, 2006; Hung *et al*., 2007). In this context of using a labour numéraire, the sum of labour days declared by respondents is an estimate of the social benefits of a *Mikania* management programme. However, the estimation of willingness to contribute (WTC) in terms of labour creates the challenge of converting this WTC to a monetary value. This theoretical complexity arises as placing monetary values on the number of labour days declared by the respondents is confounded by the fact that the opportunity cost of time varies across individuals. The issue is: which conversion rate for each labour hour should be used so that, based on the estimated shadow value of time, WTC labour can be converted into dollar values?

This paper focuses on the mitigation of invasive plants, particularly mile-a-minute (*Mikania micrantha*) in the buffer zone (BZ) of Chitwan National Park (CNP), Nepal. The research addresses the question of estimating the willingness of members of subsistence forest-based communities to contribute to invasive species mitigation. In exploring this question, value has also been placed on contributions in terms of labour as well as money. A CE was undertaken where respondents were provided with choice sets which included both a monetary contribution attribute and a labour contribution attribute.

The paper is structured as follows. Section 2 outlines the methodology of the research. The results are presented in section 3 and discussed in section 4. The paper concludes with a discussion of the policy implication of the findings in section 5.

2. Methodology

2.1. Study area

There are two reasons why this study was carried out in Nepal. Firstly, developing countries are in the front line of the invasion of exotic plants. With economic globalization and governments' priority to promote tourism, Nepal is hosting an increasing number of tourists annually. This is considered one of the major sources of the diffusion of exotic species. Lack of infrastructure to prevent the introduction of exotic species is resulting in developing countries being the hosts of unwanted guests (Nuñez and Pauchard, 2010). Once introduced, these plants are more likely to establish in disturbed and fragmented habitats (Moore, 2000). The phenomena of rapidly growing populations coupled with the increasing fragmentation of habitat resulting from land-use changes are pushing developing countries in general and rural areas in particular towards previously non-invaded habitats.

Admittedly, the control of IPS could be more beneficial in developing countries because these countries tend to have highly diverse habitats and low-cost labour is available (Myers *et al*., 2000; Nuñez and Pauchard, 2010). However, research on bio-invasion is primarily focused on developed countries (Pyšek *et al*., 2008). Usually, large non-market economic impacts of IPS can occur in forested landscapes close to population centres

(Holmes *et al.*, 2009). This indicates that rural populations in developing countries are the ultimate victims of IPS, as the rural area is attributed to scattered human settlements with forest patches and farmlands.

Secondly, non-market valuation has not received significant attention as a policy tool in developing countries. To the authors' knowledge, a handful of CE studies in developing economies are limited to urban areas (e.g., Wang *et al.*, 2007; Do and Bennett, 2009; Birol and Das, 2010). Rural communities, which constitute a large part of the population and have regular interaction with natural resources, are consistently being excluded from non-market valuation studies. In the absence of considered evaluation of the concerns and contributions of rural communities, the establishment of good environmental governance is unlikely (King, 2007). In this context, the environmental Kuznets curve can be interpreted, as environmental protection is the outcome of economic development, and this may overshadow environmental conservation (for details, see Bennett and Birol, 2010).

Our choice of the BZ of CNP for this study was motivated by three reasons: (i) the intensity of the colonization of *Mikania*, (ii) the importance of CNP as a biodiversity hotspot, and (iii) the reliance of the rural population on the forest as a source of income. The BZ covers 750 square kilometres, including 37 village development committees and the two municipalities of Chitwan and Nawalparasi districts (see appendix 1). A total of 21 user committees with 44,918 households manage the BZ (DNPWC, 2011). Forest patches in the BZ are managed by the residents of the BZ as members of buffer zone community forest user groups (BZCFUGs).

A programme or policy to constrain the spread of invasive plants has not been formulated in Nepal. An *ex ante* assessment of the possible measure for one target species can serve as an aid to decision making for policy advice (Born *et al.*, 2005). Since the BZ aims to reduce the local pressure on the core area of the national park, controlling the spread of *Mikania* is essential to facilitate a conservation programme inside the national park. BZCFUGs have shown their willingness to invest in the control and management of plant invaders (Rai *et al.*, 2012).

2.2. Choice experiments

In CE surveys, respondents are asked to select an option among the available alternatives in a choice set assuming that they prefer the alternative with maximum utility subject to the resource constraint (Ben-Akiva and Lerman, 1985). The alternatives are hypothetical scenarios which constitute a set of attributes. These attributes are outcomes of the proposed programme or policy under investigation, and alternatives are distinguished by the levels of the attributes. The choice is known as a function of the attributes, as CE is founded on Lancaster's theory of characteristics, stating that usefulness of goods for the consumer depends on their properties (Lancaster, 1966), and individuals implicitly make trade-offs between attributes (Alpizar *et al.*, 2001).

The alternative j will be chosen over some option g, if 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

https://doi.org/10.1017/S1355770X1200037X Published online by Cambridge University Press

with utility from the option and the probability (P) that individual i will choose option j over other options g in a complete choice set R is given by

$$P(j|R) = P\{(U_{ij} > U_{ig}, \text{s.t.} \forall g \in R, \text{ and } j \neq g)\}. \tag{1}$$

In general, the likelihood of selecting an alternative increases with the level of the desired attributes and vice versa. A change in the level of an attribute can lead to a discrete switch from one alternative to another; therefore CE links Lancaster's theory with the model for consumers' demand for discrete choices (Hanemann, 1984). The utility derived from the alternatives is not restricted to the presented attributes and it is considered that unobservable components unknown to the analysts lead to inconsistency (Hanemann and Kanninen, 1999). The choices made in CE are analyzed based on random utility theory and the framework links the deterministic model with a statistical model of human behaviour to address those inconsistencies (McFadden, 1974).

The utility of a choice is comprised of two components: a deterministic component (βx), and an error component (ε). The former component is related to the attributes, x, included in the choice sets. A random model with the utility function that individual i is associated with alternative j (e.g., IPS management programme option) models the consumer choice behaviour as

$$U_{ijt} = V(x_{ijt}) + \varepsilon_{ijt} \tag{2}$$

where individual $\underline{i}(i = 1, \ldots, N)$ obtains utility (U) from choosing alternative j (j = alternative I, alternative II, status-quo) in each of the choice sets t $(t = 1, \ldots, n)$ presented to them. Following Lancaster's theory, the utility derived from any alternative depends on its attributes, x, such as *forest products collection time*. The error terms, ε, are assumed to have identical and independent distribution (IID), and relationships between utility and attributes are linear in the parameters and variables function. Therefore, equation (2) is usually estimated with a conditional logit (CL) model (McFadden, 1974).

The indirect utility function for estimation is

$$V_{ijt} = ASC + \beta_i x_{ijt} \tag{3}$$

where alternative specific constant (ASC) captures the effects on utility of variables not included in the choice set, and β is the coefficient of attributes x presented in table 1.

The CL model based on IID error terms implies a number of restrictions including the property of independence of irrelevant alternatives (IIA), and limitation in modelling variation in taste among respondents. The IIA property states that the choice probability ratio for any two alternatives in any choice set is constant for an individual, which is considered too restrictive in many practical situations. The CL model can be generalized into a random parameter logit (RPL) model, which relaxes the IIA constraints (Train, 1998).

In an RPL model, the observed component $(\beta_i x_{ijt})$ given in equation (3) is expressed as the sum of the population mean (β') and individual deviation $(\acute{\eta})$. The coefficient vector captures a random, unconditional and

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Table 1. *Attributes and levels used in choice sets*

Attributes	*Description*	*Levels*
Forest products collection time	The time needed to collect forest products, mainly fodder and firewood, for daily requirements after arriving at the forest and therefore excluding travel time to and from the forest (hours)	4 hours[a]; 2 hours; 1 hour
Visitors to community forests	Number of tourists visiting community forests annually	The same number as now[a]; one-and-a-half times as many as now; twice as many as now
Labour contribution[b]	Annual volunteer involvement of forest users in forest management activities	0[a] day; 3 days; 5 days; 7 days
Annual membership fee[b]	Annual membership fee in each BZCFUG (NRs.)	NRs. 0[a]; NRs. 1,050; NRs. 1,750; NRs. 2,450

Notes: [a]Levels use in status-quo. Annual visitors in status-quo are 20,000. NRs. is Nepalese currency, US$1 ~ NRs. 71.00.
[b]Contribution for a five-year period.

unobserved type of taste heterogeneity of each random parameter β'. The utility is:

$$V_{ij} = \text{ASC} + \beta'_i x_{ijt} + \acute{\eta}_i x_{ijt}. \tag{4}$$

In order to explain the sources of heterogeneity, socioeconomic characteristics, s, enter into the utility function. After including socioeconomic variables, the indirect utility function estimated becomes:

$$V_{ij} = \text{ASC} + \beta'_i x_{ijt} + \acute{\eta}_i x_{ijt} + \gamma S_i \tag{5}$$

where γ is the coefficient of socioeconomic variables (s). The respondents' characteristics do not vary over choices and capture conditional type of preference heterogeneity by interacting with given attributes. Socioeconomic variables enter as interaction terms with the attributes and ASC. These interaction terms examine the impacts of individual specific characteristics on participation in the IPS management programme.

2.3. Questionnaire development

The CE requires two separate components to capture the preferences of respondents, a statistical design plan to create the hypothetical scenarios and a statistical method to analyze the responses (Louviere *et al.*, 2000).

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The first step is to define the attributes and their levels. In this study this was finalized after thorough discussions with the local villagers in five focus group discussions, consultation with local experts, and reviewing community forest user groups' records, reports and literature. Focus group participants were asked to prepare a list of the impacts of *Mikania* on the forest and their livelihoods and to rank the impacts in terms of severity. Based on majority voting, the top four impacts were selected as attributes for the study (Bergmann *et al.*, 2006). In addition, a draft questionnaire was tested and a payment vehicle was selected.

The selected attributes (table 1) are similar to the motivational factors influencing individuals to pay in a hypothetical market and support IPS management-related factors such as impacts on ecosystems, native species, ecosystem services and tourism (García-Llorente *et al.* 2011). In CE, the implicit price (IP) of a particular attribute can be directly obtained from the ratio between the coefficients in a logit regression of the individuals' binary response for accepting/rejecting offers with given costs (Hanemann, 1984). The social opportunity cost of labour in terms of the IP is the negative ratio of the labour attribute coefficient and the coefficient of the monetary attribute. Hence, two-payment attributes, *labour contribution* and *annual membership fee*, were included in the choice set.

An efficient design created the unlabelled CE with three alternatives: *status-quo*, *Option A* and *Option B*. The D-efficient design strategies are considered to be efficient in the context of discrete CEs, as responses are analyzed in logistic models (Ferrini and Scarpa, 2007; Scarpa and Rose, 2008; Bliemer and Rose, 2010). An efficient design was generated using Ngene (1.0.2) and the 24 choice situations were blocked into six versions of the questionnaire (see appendix 2 for an example of choice set). The number of attributes and choice sets in each version were determined based on the observation of piloting. The number of alternatives, their levels and choice sets are important considerations in reducing task complexity, particularly in the context of developing countries (Bennett and Birol, 2010). In addition, visualization of the choice cards enhances the efficacy of the choice task in low-literate communities (Jae and Delvecchio, 2004; Brouwer *et al.*, 2010).

The questionnaire included the following three sections. Firstly, it introduced IPS and the existing situation in the BZ. In addition, this section described the proposed plan to manage the invaded forest, the need to raise funds to implement mitigation policies, and asked respondents to select their preferred option from policy alternatives presented in the choice sets. Each option presented two policy attributes with *labour contribution* and *an annual membership fee* in each BZCFUG for the next five years. Follow-up questions were asked in order to understand how individuals become aware of the need to make the decision, search information on alternatives and attributes, construct choice sets and make decisions (Do and Bennett, 2009). Secondly, the questionnaire asked respondents what changes they were experiencing following the colonization of *Mikania*. Finally, the questionnaire also collected information about the sociodemographic characteristics of respondents.

2.4. Survey implementation

A face-to-face survey and the appropriate training of enumerators are crucial in ensuring the success of a CE in developing settings (Bennett and Birol, 2010). Recruitment of local enumerators was beneficial as approaching female respondents by outsiders is not socially acceptable and the local ethnic community has its own dialects. The team of enumerators were given intensive training and monitored by the research team. In addition, each enumerator was given a folder containing choice sets on coloured sheets so that they could show them while describing the scenarios. A plain language statement was read before the respondent was asked whether s/he would like to participate in the research.

Considering the relationships between households' dependency on forest products and distance to the forest (Sapkota and Oden, 2008), the households were stratified into three strata based on their proximity to the forest: less than 1 km, 1–2 km and more than 2 km. A systematic random sampling was employed to select households and every 10th household was interviewed. To establish a consensus about the species to be discussed, a photograph and a specimen of the vines were shown to the respondents before the interview. The household heads of either gender were interviewed because they hold decision-making power in household expenditure. The interviews were conducted in *Nepali* and *Tharu* (local dialects).

3. Results

3.1. Sample characteristics

Of the total (325) households interviewed, two-thirds were farmers (table 2). This indicates that the study area is agro-based and rural households are diversifying their livelihood strategies due to tourism, a trend of going abroad for employment, and access to education. The average education level of the interviewed household heads was not above the

Table 2. *Sociodemographic characteristics of the sampled households*

Variables	*Agriculture*	*Agri. + Off-farm*	*Off-farm*	*Total*
Respondents	214	10	101	325
Male	101	5	77	183
Female	113	5	24	142
Native	105	3	51	159
Education (in years)[a]	3.00	5.40	7.86	4.59
Landholding size (in katha)[a]	11.83	9.40	9.91	11.16
Age[a]	48.22	45.30	42.71	46.42
Households using *Mikania*	13	1	8	22
Prefer to contribute in labour	140	7	61	208

Notes: [a] Average of the variables. A katha is a unit of area approximately equal to 67 square meters.

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primary level. Respondents having agriculture as their main income source have higher average *land-holdings* and *age* compared to their neighbours who depend on off-farm income. As expected, *farmers* have a lower average educational level and annual income.

Unlike the focus group participants, a small fraction of respondents (∼7%) were using *Mikania*, particularly for goat fodder during the dry season, when other grass and fodder were not available. To compensate for a reduction in forest products availability, the households were executing different strategies whether they were using *Mikania* or not. Such compensating strategies included: plantation in private land; exploring more areas, particularly core areas of the national park, to collect forest products; using alternative energy such as bio-gas, liquefied petroleum gas, and purchasing firewood and fodder from the local market.

3.2. Model selection

The choice data set was analyzed using LIMDEP 9.0 NLOGIT 4.0. Follow-up questions are helpful to understand respondents' decision-making strategies and heuristics (Carlsson *et al.*, 2010). Only three respondents (∼1% of total respondents) selected the option that the government should pay for the invasive plant management programme, not citizens. They were considered as protest respondents. Out of the remaining respondents, 36 per cent (117) showed their preference for participating in monetary terms, and 63 per cent (205) preferred to participate in labour contribution. Sociodemographic variables used in the models and their coding are specified in table 3. These variables are introduced to investigate the source of preference heterogeneity by interacting with the ASC and attributes.

Individual specific characteristics including age, gender, income and occupation of respondents have a significant influence on selecting alternatives for forest management programmes (Lehtonen *et al.*, 2003; Wang *et al.*,

Table 3. *Definition of variables*

Variables	*Description*
Age	Age of the respondents (years)
Sex	Gender of the respondents: male (0); female (1)
Education	Number of years attended school
Inc_source	Income source of respondents: agriculture (1); off-farm (0)
Off-farm income	Annual family income from off-farm activities including business, job, foreign employment and cottage industry in NRs.
Landholdings	The area of the parcel of land owned by households in Katha.
Livestock	Livestock unit per household
ASC	Alternative specific constant: status-quo (0); alternatives (1)

Note: A katha equals approximately 67 square meters.

2007). In addition, household characteristics including proximity to forests, landholding size, education, livestock holdings and wealth status are crucial determinants for forest products collection in rural parts of Nepal (Adhikari *et al.*, 2004; Sapkota and Oden, 2008).

The CL model was estimated including the selected socioeconomic variables interacting with the ASC and attributes to examine the variations in effects of the IPS management programme (table 4). Only the significant interactions between sociodemographic variables and the attributes have been included. The Hausman test was performed to confirm the IIA/IID condition. It was found that the data did not support the test, as the difference matrix was not positive definite. Further analysis was conducted to address the limitations of the CL model including the IID assumption and absence of preference heterogeneity. To this end, the RPL model was estimated to relax the IID assumption and investigate heterogeneity in respondents' preferences.

The CL and RPL models were compared to determine the superiority between these two. A Swait–Louviere log-likelihood ratio test was carried out following Rolfe *et al.* (2000) for the test of the significance of log-likelihood values and *pseudo* R^2 change. The log-likelihood (LL) decreased from −598.54 in the CL model (LL_1) to −587.38 in the RPL model (LL_2). The calculated statistics $\chi^2 = -2(LL_1 - LL_2) = 22.32$, was greater than a statistic χ^2 of 3.84 at one degree of freedom. The degrees of freedom are given

Table 4. *Results of conditional logit and random parameter logit models*

Variables	*CL*		*RPL*	
ASC	−0.305***	(0.077)	−0.320***	(0.113)
Visitors to forests	0.0001***	(0.9D-05)	0.0002***	(0.2D-04)
Forest products collection time	−0.398***	(0.088)	−0.496***	(0.135)
Labour contribution	−0.091**	(0.039)	−0.152***	(0.058)
Annual membership fee	−0.0006***	(0.0001)	−0.0009***	(0.0001)
Family size × ASC	0.468***	(0.138)	0.559***	(0.176)
Income_agr × ASC	1.090*	(0.630)	1.330*	(0.706)
Livestock × FP collection time	−0.156***	(0.028)	−0.254***	(0.053)
Income_agr × Labour contribution	0.060*	(0.031)	0.087*	(0.048)
Landholdings × FP collection time	0.011**	(0.004)	0.022***	(0.008)
Female × FP collection time	−0.140**	(0.066)	−0.268**	(0.112)
Standard deviations of random parameters				
Visitors to forests	–		0.0001***	(0.3D-04)

Notes: *, **, *** denote statistical significance at 10%, 5% and 1% level, respectively. Standard errors in parentheses.

by the difference in the numbers of parameters estimated in the two models. This indicates that the RPL model provides a significant improvement in model fit over the CL model. Hence, this model was used for further analysis and discussion.

In RPL models, taste parameters are considered to have statistical distributions arising from potentially different parameters for each individual (Hensher *et al.*, 2005). Usually, random parameters are assumed to have log-normal and normal distributions, and these distributes are used for estimation (Carlsson *et al.*, 2003). Following Hensher *et al.* (2005), firstly, all attributes except payment attributes were estimated as random parameters. Then random parameters having insignificant standard deviations were re-estimated as non-random parameters. Different distributions were used to estimate the model and resulted in minimal differences. The results reported in table 4 are estimated with a normal distribution as the normal distribution sets no constraints on the signs of the parameters (Train, 2003).

The model is statistically significant overall with Chi-square statistics of 1,459.69 with 12 degrees of freedom and p-value equal to zero. The overall model fits with *pseudo* R^2 of 0.31. Values of *pseudo* R^2 between 0.2 and 0.4 are considered extremely good fits (Hensher and Johnson, 1981). The RPL model with 1,000 random draws and random parameters with normal distributions shows that respondents have heterogeneous preferences over the *visitors to forest* attributes, significant at the 1 per cent level (table 4).

As expected, the results of both models show that respondents have a preference towards less *forest products collection time*, more *visitors*, and as outcomes of the *Mikania* management operation, which they want to have less *labour contribution* and *a lower annual membership fee*. The negative sign of the ASC, which is coded with 0 for the status quo, indicates that there are still some respondents who prefer to live with the current situation. This needs further investigation to be understood.

Family size is positively associated with selecting the alternatives. Households with more livestock and female respondents are likely to prefer the options with less forest products collection time. On the contrary, less forest product collection time is not the preferred attribute for households with larger parcels of land. Likewise, households with agriculture as the main source of income selected the policy alternatives more frequently. In addition, these farm households have shown interest in more labour contribution. However, these variables are significant only at 10 per cent levels.

3.3. Estimation of willingness-to-pay

The marginal value of a change in an invasive species management attribute can be estimated as a ratio of the coefficients between IPS management attributes in the choice set.If it is estimated as a ratio with the monetary attribute (in this case, *annual membership fee*), then it is known as marginal WTP or IP for a change in that attribute. Confidence intervals for IP for attributes resulting from a *Mikania* mitigation programme were calculated from both CL and RPL models using the Krinsky and Robb (1986) bootstrapping procedure. A vector of 1,000 sets of parameters is drawn for

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Table 5. *Estimated implicit price and confidence intervals (in NRs./year)*

Attributes	*Implicit price CL (NRs.)*	*Implicit price RPL (NRs.)*
Forest products collection time	619.52 (422.78–816.52)	541.44 (334.27–748.60)
Visitors to community forests	0.21 (0.17–0.25)	0.24 (0.18–0.29)
Labour contribution	141.81 (92.49–191.13)	165.72 (114.51–216.91)

Notes: Confidence intervals at 95% in brackets.

each model to re-estimate the welfare changes. These results are reported in table 5.

Across the whole sample, an average WTP for an hour's decrease in forest products collection time was NRs. 541.44 (US$7.62) and for an increase of 1,000 tourists was NRs. 240 (US$4.78). However, the opportunity cost of labour is estimated to be NRs. 165.72 (US$2.33) for every day involved in IPS management activities. The estimated value of labour contribution is about 47 per cent of the local agriculture labour wage, which was NRs. 350 per labour-day during the interview period.

Welfare measures for changes in IPS management attributes can be calculated by using the following formula (Hanemann, 1984):

$$CS = (V_1 - V_0)/\beta_c \tag{6}$$

where CS is the compensating surplus welfare measure, V_1 is the utility of the change scenario, V_0 is the utility from the *status-quo*, and β_c is the coefficient of *annual membership fee*. The value includes improvement in forest products collection time and annual visitors to community forests, and the ASC.

The status quo is indicated in table 1 and the change scenario for this estimation was based on the operational plan and records of BZCFUGs. The change scenario for this estimation was considered as the average time for forest products collection being reduced to two hours, the number of tourists increasing to 27,000 and no labour contribution for IPS management. The annual household WTP for the expected outcome is NRs. 2,382 (US$33.55). The estimated annual household WTP is 3.6 per cent of the average annual household income (Chakrabarty *et al.*, 2011). Greater WTP as a percentage of households' income is expected in low-income communities. Generally, income elasticity of WTP is less than unity, indicating that WTP as a percentage of income decreases with income (Kristrom and Riera, 1996; Khan, 2009). The estimated WTP for watershed restoration in rural China was 8 per cent of household income (Zhongmin *et al.*, 2006).

Table 6 reports the present values of the CS, calculated using a range of discount rates. 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 3 per cent discount rate. The lower bound is total benefits of households who expressed their WTP in monetary terms, and the upper bound is only respondents who believed that the government should pay for the

Table 6. *Estimates of WTP (NRs.)*

		Household mean and confidence intervals at 95%	Aggregated for BZ community (in '000)	
			Lower bound	Upper bound
WTP per annum		2,382 (1,778–2,985)	38,518	106,007
Discounted household	3%	11,236 (8,390–14,082)	181,693	500,045
WTP for 5 years	5%	10,828 (8,086–13,571)	175,101	481,902
	7%	10,450 (7,803–13,097)	168,987	465,075

IPS management programme. These results clearly illustrate the underestimation of the value of mitigation of IPS to the forest dependent community if WTP estimation does not include the opportunity to contribute in terms of labour.

4. Discussion

4.1. Invasive species management

The abundance of *Mikania* is likely to reduce the availability of indigenous plant species. However, *Mikania* is not a preferred resource, as the vines used during the dry season are only suitable for goats (Rai *et al.*, 2012). In order to maintain daily livelihoods, respondents of the BZ of CNP are implementing different coping strategies. The situation clearly indicates that colonization of *Mikania* is imposing costs to the BZ households. Therefore, respondents are willing to pay in monetary terms and, if not, are willing to contribute labour for improved forest conditions resulting from an invasive species management programme.

The family size is positively associated with selecting the alternatives. In general, large family size means more labour for farming and can supply more labour in forest management (Dolisca *et al.*, 2006). In this case, this is expected as a majority of the respondents have shown their willingness to contribute labour for the proposed programme. The households with more livestock and female respondents have high demand for fodder. In developing countries like Nepal, women tend to have more responsibility for household chores including small livestock production. Hence, they showed their preference for less forest products collection time. On the contrary, households with larger parcels of land do not value the alternatives with less forest products collection time. Literally, these households can fulfil their demand for forest products from their own land. They are less dependent on community forests for basic forest products (Sapkota and Oden, 2008).

The number of farm households using *Mikania*, however not preferred, indicates their dependency on forest products, so they are more sensitive to a change in the availability of forest products (Nuñez and Pauchard, 2010). In this context, higher WTP of farmers to control the spread of plant invaders is expected. Usually, users of forest ecosystem services have higher valuations for forest ecosystem services than non-users (Hanley *et al.*, 1998).

The main aim of non-market valuation is to estimate social benefits. This can be derived by aggregating households' WTP. The social benefits of the IPS management programme were calculated using the following equation:

$$WTP_{total} = \Sigma WTP^{*} H^{*} R, \qquad (7)$$

where WTP_{total} is total social benefits, WTP is the mean household WTP, H is households in BZ and R is proportion of respondents willing to pay.

The estimated WTP for the BZ community was between NRs. 38.51 million (US$542,508) and NRs. 106 million (US$1.49 million). The present value of total WTP for a five-year period, as respondents were asked to select the alternative IPS management outcomes that would happen in five years, is reported in table 6.

In comparison, the annual budget for BZ management in CNP was NRs. 80 million[1] in the fiscal year 2011/2012. However, the allocated budget amount does not include any specific programme for *Mikania* management. Hence, the gap between estimated social benefits and the annual budget indicates that there is potential to improve the social welfare of the BZ community through the IPS management programme. The social benefits could be higher if global WTP for IPS management is also taken into account; this is because CNP is listed as a World Heritage Site (Do and Bennett, 2009). The estimated WTP suggests that governments should respond to the problem associated with invasive plants, particularly *Mikania*, as soon as possible. If not the cost associated with IPS increases over time (Shackleton *et al.*, 2007).

4.2. Choice experiments in a subsistence economy

The majority of the respondents were subsistence farmers who have a willingness to contribute labour so that they can minimize any cash payment. Their estimated value for IPS management programmes, therefore, depended not only on outcomes of forestry operations but also on the number of days they were willing to be personally involved in the implementation phase. Providing only a monetary attribute as a cost of the bundle of outcomes may increase the chance of respondents selecting the status quo. Using a non-monetary term can address the cash constraints problem in a subsistence economy which potentially impacts the valuation of non-market benefits (Mekonnen, 2000; Alam, 2006; Hung *et al.*, 2007). If not, a high protest rate is likely as respondents have limited ability to pay due to budget constraints (Bennett and Birol, 2010).

The implementation of CEs in the rural communities of developing countries, particularly to elicit WTP for environmental services, is in its infancy. The results show that the inclusion in the choice sets of a non-monetary payment attribute along with a monetary attribute is effective in

[1] This information was received from the Department of National Park and Wildlife Conservation, Nepal.

eliciting rural farmers' WTP for IPS management activities. In addition, this also addresses – with the variance of the opportunity cost of time across individuals – the associated challenges of aggregating individual preferences elicited in labour terms to derive social benefits (Ahlheim *et al.*, 2010). Hence, the extension of CE using two different payment attributes facilitates the participation of the rural poor with budget constraints in environmental decision making.

The estimated value of the labour contribution of respondents indicates that farm households would have a shadow value of family labour that is less than the market wage rate. This could be because farm households may enjoy farm activities as a lifestyle, and they make trade-offs between time and other benefits received from being involving in forestry activities (Ahearn *et al.*, 2009). In addition, in agricultural households labour is valued by its marginal worth to the household rather than as an opportunity cost derived from a market wage rate (Edmeades *et al.*, 2006). Therefore, the marginal rate of labour involvement in forestry activities can be used to pragmatically estimate the cost and benefits of forestry programmes in the context of rural economies of developing countries.

5. Conclusions

The benefits from the management of the BZ of CNP can be increased by implementing a *Mikania* management programme. The benefits resulting from the *Mikania* management programme in the BZ of CNP were estimated to be between US$2.38 million and US$7.04 million. This range is the net present value at 7 per cent of lower-bound aggregate WTP and at 3 per cent of upper-bound aggregate WTP. This suggests that, if more resources were allocated to an IPS management programme in the BZ of CNP, social welfare would improve by up to 1.2 times the current benefits from CNP in terms of royalty. Revenue from CNP in the fiscal year 2010/2011 was NRs. 83.14 million (DNPWC, 2011).

This study sheds light on the implementation of CE surveys in developing countries, particularly in rural areas. The estimated value of the IPS management programme not only focuses on the overall value of the forest ecosystem but also on the WTP for each attribute. This informs policy in allocating available resources in forest improvement by controlling the growth of *Mikania* in the BZ of CNP. The results of the CE survey have also demonstrated the impact of socioeconomic factors on the IPS management programme. This can help to minimize controversy surrounding the IPS management programme, particularly as the impacts of IPS on rural livelihoods are ambiguous (Pasiecznik, 1999; Shackleton *et al.*, 2011; Rai *et al.*, 2012).

In addition, provisioning of participation in the IPS management programme in labour contribution can increase the socioeconomic benefits. This also includes the concerns of approximately two-thirds of the rural population, whose values may otherwise be overlooked, in forest management. The inclusion of a non-monetary payment attribute with a monetary attribute not only reduces the task complexity but also estimates the social opportunity cost of time in a subsistence economy. This is helpful in converting the value of contributed labour into monetary terms, which facilitates social benefit-cost analysis of environmental programme in low-income areas.

In conclusion, for the first time, the non-market values of the IPS management programme have been quantified and can be used to justify the IPS management programme in Nepal. This study shows that a CE can be applied in a low-income community to estimate the non-market values of the forest ecosystem. The application of CE in rural areas of developing economies may have a significant contribution to sustainable development. The use of CE to estimate the value associated with invasive species not only focuses on ecosystem services but also informs policy about the impacts on rural livelihoods.

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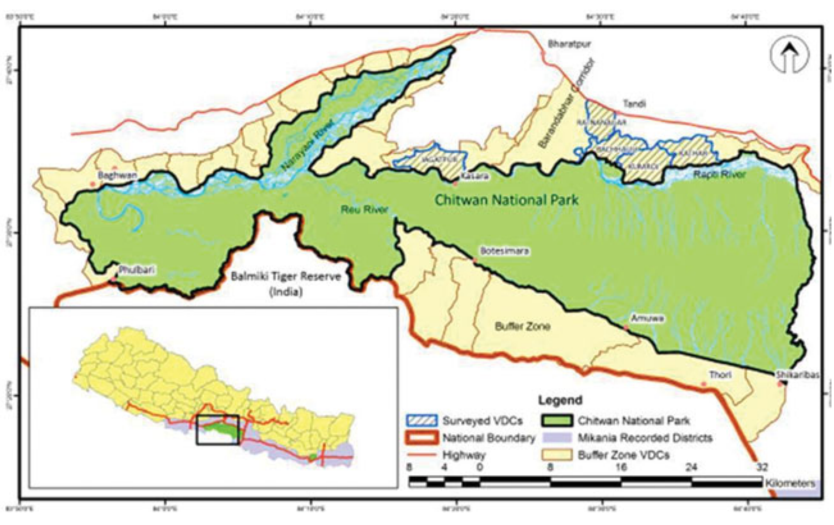
Appendix 1. Study area



https://doi.org/10.1017/S1355770X1200037X Published online by Cambridge University Press

Appendix 2. Example of choice set

Choice Situation 1.1	Alternative 1	Alternative 2	Current Situation
Forest Products Availability 	1 hour	4 hours	4 hours
Visitors to Forests 	The same number as now	Twice as many tourists as now	The same number as now
Labor Contribution 	3 days	3 days	0
Annual Membership 	NRs. 1,050	NRs. 2,450	0
Select one (√)			

https://doi.org/10.1017/S1355770X1200037X Published online by Cambridge University Press