Influence of payment modes on farmers' contribution to climate change adaptation: understanding differences using a choice experiment in Nepal

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Abstract

Adaptation has become a key priority in dealing with the climate change issues. However, successful implementation of climate change adaptation entails substantial financial investment. This study examines differences in Nepalese farming households' willingness to contribute to the implementation of adaptation programs across monetary and non-monetary modes of payments. To this end, we undertake discrete choice experiments with monetary payment and labor contribution as the payment vehicles. We find that farmers are interested in participating in and financially supporting the implementation of climate change adaptation initiatives that increase the availability of climate adaptive crop varieties, improve soil quality, expand irrigation and build farmers' capacity in terms of climate adaptive farming. Factors influencing farmers' participation in adaptation programs include age, income, access to extension services, size of land holdings, number of farm parcels, climate change perception and climate change experience. Furthermore, the findings reveal significant heterogeneity in the farmers' preferences across three agro-ecological regions in Nepal. Our findings also strengthen the methodological validity of the results of the choice experiment, which indicated that farmers are willing to pay significantly more when asked to make a payment in terms of a labor contribution compared to a monetary payment for the implementation of adaptation programs. Overall, the findings of this study justify the relevance of implementing agricultural adaptation programs in rural areas of Nepal.

Keywords: agriculture, climate change adaptation, choice experiment, random parameter logit, willingness to pay

1. Introduction

Adaptation to the adverse impacts of climate change has become a key priority in climate change policy negotiations in recent years. A large number of studies have documented empirical evidence of the role of adaption in minimizing climate change impacts on agriculture (Dharmarathna et al., 2014; Di Falco et al., 2011; Finger et al., 2011; Huang et al., 2015). Over the past two decades, adaptation policies and programs have been developed around the globe in response to adverse impacts of climate change (UNFCCC, 2014). However, transforming this adaptation planning into action at the ground level requires large capital investment. Narain et al. (2011) estimate that the annual costs of adaptation in the agricultural sector in developing countries will be US$2.5-2.6 billion a year between 2010 and 2050. Comparing the overall resources available for adaptation and estimated costs shows a considerable financing gap (Smith, 2011).

This study examined farming households' ability and willingness to contribute to adaptation programs, using a discrete choice experiment (DCE) approach based on household level cross-sectional data from Nepal. The DCE is a useful tool for valuing multi-attribute goods or services (Hanley et al., 1998), which include climate change adaptation programs. The application of the DCE can capture both farming households' Willingness to pay (WTP) for climate change adaptation (CCA) programs and the marginal values for improving the adaptation attributes. These marginal values can then be used to derive values for specific adaptation strategies that best meet the needs of farming households.

In the DCE, a monetary attribute is usually included as a cost of the alternative in WTP estimates. Given the low income of poor households in least developed countries (LDCs) and the non-monetized nature of their economies (Rai et al., 2015), using only a monetary attribute as a cost of the alternative may increase the chance of respondents selecting the *status-quo* due to their limited ability to pay (Bennett & Birol, 2010). Among the cash-constrained households, survey-based studies that ask people to pay money for environmental services can produce a high ‘protest’ response (Bennett & Birol, 2010) and thereby understate the welfare estimate (Alam, 2006).

Research interest regarding the effect of using non-monetary forms of payments, such as in-kind payments (Asquith et al., 2008; Shyamsundar & Kramer, 1996) and labor time contributions (Abramson et al., 2011; Gibson et al., 2016; Karunarathna, 2012; O’Garra, 2009; Rai & Scarborough, 2013; Rai et al., 2015), have been growing in the literature on stated preferences methods. Although studies employing DCE pay significant attention to the selection of attributes and levels, experimental design, questionnaire development, survey mode and econometric estimation of welfare estimates, the impact of using a non-monetary instead of monetary value as a payment mode on welfare estimates has been given comparatively little consideration. This paper aims to contribute to this line of research by investigating how using labor as a medium of payment influences stated preferences and derived welfare measures for climate change adaptation benefits.

We used labor as a medium of payment because labor exchange is one of the major types of economic transactions in Nepal (Bhattarai et al., 2015; Ruben & Pender, 2004). Furthermore, for many development projects, local people work on projects to derive benefits from the project. For instance, in food-for-work programs implemented in many poor countries, including Nepal, people receive food assistance in exchange for providing labor for development projects (Clay, 1986).

This study was undertaken in rural areas of Nepal where most of the people are poor. Empirically, a number of studies find that farming household income is positively associated with adoption of climate change adaptation practices (Below et al., 2012; Deressa et al., 2009). It can be argued that poor farmers in LDCs who are deprived of entitlements and necessities of life are not willing to pay for adaptation implementation. Our assumption is that their unwillingness to pay is largely due to their inability to pay cash rather than an absence of demand.

One of the sources of differences between payment modes in DCE results is related to the method of sampling. Significant measurement errors occur when the same respondent places a different value to the choice alternative that has the same level of benefits across mediums of payment. Our objective is therefore to assess the possible measurement error due to the medium of payment. Are the preferences and the derived welfare measures expressed with monetary payments different or equivalent to labor contributions as the medium of payment? We requested that the same interviewees answer two choice sets in two different days, one set with a monetary contribution and the other set with a labor contribution as the payment modes, with all the attributes and levels remaining exactly the same. We assume that this approach provides a markedly better means to control sampling accuracy than in many previous studies that compared payment modes in DCE studies. We used the identical choice set format administered by the same enumerator during the same time period to ensure preference stability.

To the best of our knowledge, this is the first well-controlled comparison between payment modes in stated preferences in general and in DCE in particular, interviewing the same respondent at two different times. A limited number of studies incorporate labor as a medium of payment in a DCE (Karunarathna, 2012; Rai & Scarborough, 2013). However, these studies either used only labor as a mode of payment or included both labor and money payment in the same choice sets and did not assess the impact of payment modes on welfare estimates. These studies indicate that inclusion of a non-monetary payment attribute along with a monetary attribute is effective in eliciting rural farmers' WTP. Notable exceptions in terms of the means of assessing the impact of labor and monetary payment mode in welfare estimates employing DCE are Rai et al. (2015) and Gibson et al. (2016). However, these studies draw their samples from different populations for two different modes of payments.

Given the background, the following is the overarching research question of this study: how do farmers in LDCs respond to adaptation programs? The specific questions this study seeks to answer include the following: Are farmers willing to make a financial contribution to implement adaptation programs? What are the factors that influence farmers to take part in adaptation programs? Does demand for adaptation change when households are asked to make contributions in terms of labor rather than cash payments?

Nepal presents a compelling case for studying farmers' willingness to implement climate change adaptation for two reasons. First, visible impacts of climate change have been already observed in Nepalese agriculture, which is the country's dominant economic sector[1]. The contribution of Nepal to annual global greenhouse gas emissions is only 0.025 percent (MoE, 2010), but the country is one of the most vulnerable to the climate change impacts. According to MoE (2010), for Nepal, there is a trend of increased warming of 0.04-0.06°C per year and an unpredictable rainfall pattern. Prolonged droughts and unseasonal rains can

[1] In Nepal, agriculture is the dominant sector, contributing approximately 35% of total gross domestic product and employing 70% of the population (MoAD, 2012).

have a severe impact on Nepalese agriculture, where rain-fed farming accounts nearly for two-thirds of the cultivated area (MoAD, 2012). In the decades from 1983–2005, over 28 billion Nepalese rupees (US$ 288 million) were lost due to climate change-induced disasters in the country's agriculture sector (FAO, 2010).

Second, over the last few decades, Nepal has been active in developing climate change adaptation policies and programs. The government of Nepal prepared a National Adaptation Program of Action (NAPA) in 2010 that identified well-defined priorities for climate change action in important economic sectors, including agriculture (MoE, 2010). A Local Adaptation Plan of Action (LAPA) framework has also been developed, which provides opportunities to assess site-specific climate vulnerabilities, identify adaptation options, and implement urgent and immediate adaptation actions with the participation of local communities and households (MoE, 2011). In 2011, the government of Nepal established a climate change policy that had the goal of improving livelihoods by mitigating and adapting to the adverse impacts of climate change (MoE, 2011). In this context, an understanding of farmers' response to adaptation programs can assist in the effective planning and implementation of adaptation policies and programs.

2. Methodology

2.1 Choice experiment approach

We employ a discrete choice experiment (DCE) to analyze farmers' willingness to contribute to the implementation of climate change adaptation programs in the rural area of Nepal. The DCE methodology is based on Lancaster's theory of value (Lancaster, 1966) combined with random utility theory, which describes discrete choices in a utility-maximizing framework. Lancaster proposed that consumers derive utility from a good based on its characteristics and not from the good itself. Each alternative, *i*, in the choice set has an associated utility level for each individual represented by

$$U_i = V_i + \varepsilon_i \tag{1}$$

where V_i is the observable component of the utility function and ε_i is the unobservable component. Respondents choose the alternative that provides the maximum utility among the different alternatives that differ in terms of attribute levels (Hanley et al., 2001; Hensher et al., 2015). The probability that any particular respondent chooses alternative *i* in the choice set to any alternative *j* can be expressed as

$$\Pi\,(i) = Pr\,(V_i + \varepsilon_i > V_j + \varepsilon_j) \tag{2}$$

where *V* is the deterministic component of the utility function, assumed to be linear in parameters. There exist several models to analyze the data obtained from DCEs (for details, see Adamowicz et al., 1998; Colombo et al., 2009; Hensher et al., 2005). In this study, we analyzed the data by estimating a random parameter logit model (RPL), which is expressed as:

$$V_i = \alpha + \beta Z_i + \gamma Z_i \tag{3}$$

where α is the alternative specific constant (ASC), which captures the average effect of unobserved factors on utility. In this study, the adaptation alternatives were assigned the generic ASC. Z_i are the climate change adaptation program attributes and payment attribute. β is the vector of coefficients associated with these attributes, and γ is a vector of standard deviation parameters.

Since studies using the DCE method have a common utility theory base, welfare estimates of change in the attributes can be estimated and compared (Boxall et al., 1996). Once the parameter estimates have been obtained, a willingness to pay (WTP) can be derived for each attribute by dividing the estimated coefficient of the attribute of interest by the negative coefficient of the payment variable. In other words, the value of a marginal change in any of the attributes can be measured using the formula given below (Hanley et al., 2001).

$$WTP = - \beta_c / \beta_y \tag{4}$$

where β_c is the coefficient of any of the attributes and β_y is the coefficient for the cost attribute.

The first step in carrying out a DCE is to define the good to be valued in terms of its attributes and levels. The good to be valued in this study is climate change adaptation programs. We selected five attributes (see Table 1 for detail attributes, their definition, and levels) through a process that involved four steps. First, we reviewed the literature related to agriculture and the environment, which employed DCEs (Akter et al., 2012; Colombo et al., 2005; Goibov et al., 2012; Rai & Scarborough, 2013). We also reviewed literature relating to the agricultural and environmental policies of Nepal. Second, we reviewed adaptation strategies identified by LDCs in their NAPAs as submitted to the UNFCCC. Out of 43 NAPAs[2] submitted to the UNFCCC, development of resistant crop varieties, reduction of soil erosion and diversification and improvement of irrigation are identified explicitly as adaptation strategies in 35, 34, 24 and 37 NAPAs, respectively. Notably, the need for building farmers' capacity around climate change adaptation is highlighted in all 43 NAPAs. In the next step, three focus group discussions (FGDs) with farmers were carried out to supplement the literature review information with feedback from farmers. We assessed farmers' perception of the benefits of adaptation and their interest and capacity to contribute to deriving such benefits on their farmlands. Finally, we conducted three stakeholder workshops with local agricultural and environmental experts to further refine the identified

[2]Fifty NAPAs have been submitted to UNFCCC. Seven NAPAs (Benin, Burundi, Congo, Equatorial Guinea, Guinea, Djibouti, and Togo) were not reviewed because they were submitted in languages other than English.

attributes and levels. In the workshop, we assessed the benefits of implementing climate change adaptation practices and determined how much these benefits could increase in 10 years’ time. We thus determined the final attributes and the levels, which were the most important and meaningful to farmers in the study area.

A cost attribute should be defined and included in the choice set to estimate welfare changes. A one-time per month payment for the period of program implementation was chosen as the payment vehicle. Furthermore, to assess whether the mode of payment affects WTP, respondents were asked about using two different payment attributes: one in the form of a monetary contribution in local currency per month for the household and another in the form of a labor contribution per month in number of days. The number of days was converted into a monetary value during the analysis. We hypothesize that having a labor contribution as the mode of payment in the choice set increases the response rate and a household’s WTP for the CCA program implementation. Assessing WTP in terms of a labor contribution will generate important policy implications, which are expected to be of interest to researchers and policy makers considering applying this DCE study to poor economies of developing countries and LDCs.

We then used an orthogonal fractional experimental design technique to generate 36 choice scenarios, which were further blocked into 6 sets containing 6 choice scenarios. Each choice set contained three alternatives and an option to select neither scenario, i.e., the status quo. The status quo represented the existing farming condition: that is, no increase in the availability of climate-adaptive crops and species, no improvement in soil quality, no training on climate-adaptive farming, and irrigation water availability for 6, 5, 5, 3, 4 and 6 months in Chitwan, Dhading, Kaski, Mustang, Rasuwa and Rupandehi districts, respectively. An example of a choice set is presented in Figure 1. Two versions of the choice sets were prepared with two different modes of payment, with all other attributes and levels remaining the same. Pictures and diagrams to illustrate the attributes and levels were added in the choice sets to facilitate understanding of the choices.

2.2 Study site and data collection

Nepal comprises three distinct agro-ecological regions: mountain, hill and Terai. Each represents a well-defined geographic area with distinct altitude, socioeconomic and climatic characteristics. The climate varies from subtropical in the lower elevations of the Terai region to alpine conditions in the higher hill and mountain regions. The wide range of altitude and climate has given rise to different agricultural land types and associated ecosystems. The impact of climate change has been observed differently in different regions, demanding location-specific climate adaptation strategies. Administratively, the country is divided into 75 districts. For this study, we selected two districts from each ecological region to consider the distinctiveness across regions – Mustang and Rusuwa from the mountain region, Dhading and Kaski from the hill region, and Chitwan and Rupandehi from the Terai region. The field study was conducted through two village development committees (VDCs)[3] in each district. We selected 60 households from each VDC, producing a total sample size of 720.

The survey was conducted from October 2015 to January 2016. The data were collected from the head of the household by means of face-to-face interviews using a pretested, semi-structured questionnaire. The questionnaire consisted of two sections: household socio-economic characteristics and a choice experiment. Before respondents participated in the choice experiment, they were given a detailed explanation of adaptation

[3]A VDC is an administrative unit in Nepal, which is further divided into nine wards.

program scenarios, including attributes and the levels they were offered. To minimize hypothetical bias in selecting adaptation alternatives, they were reminded to report what they would actually pay if this were, in fact, a real decision and informed that the adaptation program was going to be implemented in the near future. Then, they were presented with six choice sets, one at a time, which asked them to choose the option they preferred among three options in each choice set or no program at all, i.e., the *status quo*. The interview was conducted in the Nepali language and took approximately one hour to complete. To assess whether the mode of payment affects WTP, first, each respondent was asked to make their choice for all six choice sets with monetary values as the mode of payment. Then, the next day, the same respondent was asked to make choices for the same choice sets but with labor contribution as the mode of payment.

Our target was to conduct a DCE with 720 farming households, which involved interviewing 795 households. That is, 75 households did not agree to participate in the survey. Of the 720 households who were interviewed, 4 and 7 respondents showed a zero WTP by always choosing the *status quo* option in labor and monetary payment modes, respectively. Since a respondent received 6 choice sets, the total number of *status quo* options was 4320. Of the 4320, 348 were selected using the monetary mode, and 295 were chosen with labor as the mode of payment.

Table 2 presents descriptive statistics for the surveyed households. It shows that the average age of the household was 45.8 and that the average level of education was 7.6 years. The average family size was 6.1, with a landholding size of 0.55 ha, and the average number of farm parcels was 2.9. On average, approximately 68% of the farming households had multiple sources of income, 69% had at least one member associated with agriculturally related groups, and 35% of the farming households were affected by drought and/or flood in the last five years. On average, the households were located 13 km away from the nearest government extension service. Regarding the farmers perceptions on the trends of attributes selected for this study, the numbers of respondents who perceived a decrease in specific attributes over the years are as follows: the number of climate adaptive crops (17.3% of respondents), soil quality (48% of respondents), irrigation water availability (47% of respondents) and farmers knowledge of farming (18% of respondents). We found various significant differences between the three agro-ecological regions in terms of household characteristics, except for education level.

3. Results and discussions

Household preferences – monetary versus labor contribution

We analyzed the choice data using random parameter logit (RPL) models. We also estimated multinomial logit models, but the results were similar to those of the RPL models. In the RPL model, we included a number of households' social, economic and attitudinal characteristics in the estimation. The main objective was to examine the effect of households' characteristics on preferences for adaptation programs compared with preferences for the status quo. These variables cannot enter the model on their own, as they do not change over choice sets. Hence, these variables all interacted with the ASC. Following Alvarez-Farizo et al. (2007) and Nguyen et al. (2013), the ASC is coded 1 for the adaptation alternatives and 0 for the *status quo.* By doing so, we identified the sources of heterogeneity in respondents' decisions. The estimation results are shown in Table 3. In estimating the RPL model, we specified all the parameters as random parameters with a normal distribution[4] except the parameter for the payment attribute. Distribution simulations were based on 500 draws. The choice data were analyzed separately for the monetary and labor cohorts.

The estimated parameters of all attributes included in the model are statistically significant, thus indicating that they all affected individual scenario choice. Analyzing the coefficients' direction and significance, both monetary and labor models yielded very similar results. All parameters have the expected signs. The coefficient of climate adaptive crop varieties is positive, implying that farmers are more likely to choose alternatives with a higher number of climate adaptive crop species/varieties for their farmlands. This is also the case for the coefficients on soil quality, irrigation and training, indicating that farmers prefer the alternatives that delivered improved soil quality, increased irrigation months and training for farmers. Finally, the coefficient of the monetary payment attribute is negative, conforming to the economic theory indicating that higher payment rates decrease the probability that farmers choose the respective alternative. The overall fit of the model as measured by pseudo-R^2 is reasonable by conventional standards that are used to describe probabilistic discrete choice models (Hensher et al., 2005). The RPL model with the monetary payment mode produced a significant standard deviation only for the moderate improvement in soil quality. However, using labor as a payment mode is significant for all the attributes. This finding indicates that the data support the presence of choice-specific unconditional unobserved heterogeneity in the preferences for attributes.

[4] To test whether the assumption of normal distribution is appropriate, we tried other distributional assumptions, uniform and triangular. However, the results indicate that there is no significant difference across distributions. The likelihood values for the specifications across distributions are not statistically different.

The positive and significant coefficient of the ASC X age in both the labor and monetary scenarios show that older respondents chose the improved climate adaptation program more frequently than younger respondents. This result is in line with previous findings that farming experience increases the likelihood of adopting climate change adaptation measures (Deressa et al., 2009; Seo & Mendelsohn, 2008). Households with multiple sources of income are also shown to be inclined to choose adaptation alternatives. However, this likelihood is not significant in the labor scenario. Access to extension services also plays a major role in determining a farmer's decisions to choose adaptation alternatives. Moreover, in both scenarios, households with larger land holdings and higher numbers of farm parcels showed a higher likelihood of choosing the adaptation alternatives than the *status quo*. Thus, the households' utility for the adaptation alternative increases with the increase in land holdings and farm parcels. In both labor and monetary scenarios, households experiencing drought and/or flood problems are more willing to move away from the existing condition and are likely to choose the adaptation alternatives. Similarly, the ASC X perception of climate change is positive and significant in both scenarios. This result implies a greater expectation that households that foresaw that heightened changes in climate would favor the adaptation program compared to the expectation of those who perceived no or fewer changes. Contrary to our expectation, the results show that households that are involved in agriculturally related organizations are likely to choose the *status quo* option more frequently than the adaptation alternatives. However, this likelihood is not significant in the monetary scenario. The impact of household head education and family size was found to be nonsignificant in the estimation.

WTP measurement

The WTP was calculated using the Wald procedure (Hensher et al., 2005). Table 4 shows the WTP for the improvement in climate change adaptation attributes and the respective 95% confidence intervals. The WTP for all the attributes are positive, indicating that respondents have a positive WTP for improvement in quality and quantity of each attribute. For the quantitative attributes – climate adaptive crops and irrigation months – this price represents the WTP to obtain an extra unit. In the case of qualitative attributes – soil quality improvement and training – this price represents the WTP for a discrete change in the attribute's level. For example, this could represent a change in soil quality from no improvement (the base level) to moderate improvement or high improvement or to achieving regular training in comparison to no training.

The results suggest significant differences in the WTP between labor and monetary scenarios. The estimated WTP for an additional climate adaptive crop is NRs 164 (~USD 1.55)[5] for the labor scenario, which is significantly higher than that for the monetary scenario. Similarly, the WTP for high improvement in soil quality, an increased number of irrigation months and training on climate adaptive farming is significantly higher for the labor scenario than for the monetary scenario (Table 4).

As mentioned in the methodology, the same respondents were requested to answer two choices sets on two different days to assess whether using labor instead of money as a medium of payment influence farmers' preferences and its welfare estimates. This approach of asking same respondents with two different payment vehicles at two different point of time could suffer from an anchoring bias where the WTP elicited from the second interview could be correlated with the WTP from the first interview (Tversky & Kahneman, 1974). Another

[5] 1 USD = NRs 106.07 (from the website of the Nepal Rastra Bank, accessed on 12/01/2016).

approach of comparing WTP between two modes of payment is by randomly choosing respondents for two modes of payment and comparing the results between samples[6]. We conducted a separate survey in four districts namely Dhading and Kaski from the Hill region, and Chitwan and Rupandehi from the Terai region. We used the same set of questionnaires and choice sets as in the previous survey. The study was conducted in two randomly selected VDCs in each districts. From each VDCs, 50 households were randomly selected, among which 25 households answered the choice sets with money as the payment vehicle and the remaining 25 with labor contribution. In the annexes 1 and 2, we present the results of a split sample DCEs using money and labour contributions as payment vehicles. The results are consistent with that of previous findings. The RPL results show that the estimated parameters of all attributes in both monetary and labor models are statistically significant, thus indicating that they all affected individual scenario choice (Annex 1). The WTP results show that for all the attributes, the WTP amount is consistently higher in the labor model compared to monetary model (Annex 2), thus validating the results from previous findings.

Regional comparison

There are wide spatial variations in regional climatic and socio-economic conditions and therefore considerable differences in farmers' vulnerability to and adaptive capacity to meet the impacts of climate change. In the next stage of the analysis, we therefore tested whether farmers' preferences for adaptation alternatives across Nepal are uniform throughout the country or whether there is any divergence on the basis of agro-ecological regions. We estimated separate RPL models for each of the regions. The RPL model results for the three regions are presented in Table 5. All the attributes' coefficients are significant except for the

[6] We thank an anonymous reviewer for raising this issue of anchoring bias and suggesting alternative method of comparing the results between two samples.

moderate improvement in soil quality in the hill region. We conducted the Swait-Louviere log-likelihood ratio test and found that the null hypothesis that the separate effects of regions are equal to zero was rejected at the 5% significance level. This result suggests that there is heterogeneity in farmers' preferences depending on the agro-ecological region. This finding further implies that farmers' preferences across agro-ecological regions cannot be pooled together.

The socioeconomic variables that influenced the selection of an adaptation alternative were shown to vary across regions. The results also revealed that households with older decision makers and respondents with larger land holdings were statistically more likely to support the adaptation program in all the regions. In the Terai region, those households experiencing drought and/or flood, having multiple sources of income, living closer to extension services and having awareness of climate change were found to be more likely to support adaptation programs. In the hill region, respondents with a higher education level and households with a larger family size, a higher number of farmland parcels and no members involved in organizations were more likely to choose adaptation alternatives. Likewise, in the mountain region, respondents with a lower education level, households closer to extension services and respondents that were more aware of climate issues were more likely to support adaptation programs.

Regional analysis of the welfare estimates also shows a significant difference in measured WTP across agro-ecological regions (Table 6). We find that farmers in the Terai region were willing to pay significantly more than those in the hill and the mountain regions for the increase in the number of climate adaptive crops. This result may be due to the lower crop diversity in the Terai region. A study by Bajracharya et al. (2010) indicated the presence of higher rice landrace diversity in the hill regions compared to that in the Terai regions of Nepal. Furthermore, farmers in the mountain region were willing to pay significantly more than those in the hill region for a high level of improvement in soil quality. The reason for this result may be the lower soil nutrient content associated with the high rate of soil erosion from the sloping agricultural lands in the mountain region compared to that in the hill and Terai regions (Bajracharya & Sherchan, 2009). Similarly, farmers in the hill region were willing to pay significantly more for the increase in the number of irrigated months. To consider this result in context, the hill region is more affected by drought impacts, and s there are poor irrigation facilities due to the difficult geography compared to the facilities in the Terai region (MoE, 2010). We did not find a significant difference in the WTP across the regions for training in climate adaptive farming. Thus, farmers in all regions are affected by climatic variability and are equally interested in training related to climate adaptive farming.

4. Conclusions and policy implications

More adverse impacts of climate change have been felt by farmers living in poor countries such as Nepal. Given that climate change risks are becoming increasingly severe, there is a need to implement adaptation strategies to lessen the harmful climate change impacts and to increase the resilience of agricultural systems. In response to the negative impact of climate change, different adaptation policies and programs have been developed. Much of the research has focused on assessing the impacts of climate change on livelihood resources, but somewhat less has been written about the willingness and preparedness of farming communities to implement adaptation programs. Ultimately, adaptation to the impacts of climate change depends not only on how the adaptation programs are designed but also on how individual farmers and the farming communities respond to the programs. Using the DCE approach, this study assessed farming households' willingness to participate in climate change adaptation programs and their financial capacity to support the implementation of such programs. The adaptation strategies included as attributes in the DCE were an increase in climate adaptive crop species/varieties, improvements in soil quality, an increase in irrigation water availability and training for farmers on climate adaptive farming. The study used random parameter logit models to analyze the data.

The results of this study highlight the positive and significant economic benefits associated with different climate change adaptation strategies. Farmers in the study areas are willing to pay to move away from existing agricultural practices toward a new direction that could improve their productivity over the longer term by means of appropriate climate change adaptation measures. It is found that farming communities are consistently willing to adapt to climate change and are prepared to contribute financially to execute climate change adaptation programs. Furthermore, an understanding of the observed influence of household characteristics on choice preferences can be a basis on which to develop an optimal climate change adaptation program for the agricultural sector as a whole. A further important finding of this study is that rural farming households have a strong preference for payment in labor. This finding implies that contributions to climate change adaptation program implementation would drop significantly if households were asked to make payments for adaptation benefits in monetary terms.

The findings of this study can assist agricultural policymakers at the local and national levels in integrating effective adaptation measures into their agricultural development plans and programs. The high economic value associated with the attributes in this study suggests that the development of climate adaptive crop varieties, improvement in soil quality, expansion of irrigation and farmer capacity-building activities should be prioritized in a country's agricultural development plans and programs. In brief, this study justifies the relevance of the development and implementation of climate change adaptation programs in the agricultural sector in the rural areas of Nepal and in other LDCs experiencing similar climate change trends and the resulting impacts in the agriculture sector.

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Table 1. Attributes, their definition, and levels

Attribute	**Definition**	**Attribute levels**	**Coded using**
Climate adaptive crops	Increase in the number of drought/flood tolerant crop species/varieties available in the local market	No increase, Increase by 5, Increase by 10	Actual levels
Soil quality	Improvement in soil quality (improvement in soil fertility and water holding capacity and reduction in soil erosion) due to implementation of climate adaptive farming	No improvement, Moderate improvement, High improvement	Effect coding
Irrigation	Number of months with irrigation water availability	6, 9, 12	Actual levels
Farmers' capacity building	Regular training (at least one training per month) for farmers in climate adaptive farming	Yes, No	Effect coding
Payment	Required payment (money or labour) per household per month for climate change adaptation program.	400 (1 days), 1200 (3 days), 2000 (5 days)	Actual levels

Table 2. Definition and means of the variables included in the model

Variables	Definitions	Terai	Hill	Mountain	Pooled	Sig.
Age	Age of the household head in years	45.04	51.94	40.40	45.79	a,b,c
Education	Education of the household head in number of years	8.08	7.46	7.42	7.65	
Family size	Total number of family members in the household	5.78	5.80	6.60	6.06	b,c
Income source	Income source diversification in the household, coded 1 if multiple sources of income and 0 if single source	0.75	0.75	0.55	0.68	b,c
Extension	Distance from home to extension service in kilometres	8.52	20.96	10.53	13.33	a,b,c
Land holding	Land holdings of the household in hectares	0.76	0.54	0.36	0.55	a,b,c
Farm parcel	Total number of farm parcels	3.10	2.41	3.22	2.91	a,c
Membership	Membership of one or more members of the household in an agricultural related organization or group. Coded 1 if member and 0 otherwise	0.86	0.43	0.79	0.69	a,b,c
Perception of climate change	Average number of weather-related changes perceived by the household within the last 15 years[d].	0.25	0.31	0.13	0.23	a,b,c
Drought and/or flood experience	Affected by drought and/or flood in the last five years, coded 1 for yes and 0 for no.	0.42	0.29	0.34	0.35	a,b
Farmers perception on trends of attributes						
Climate adaptive crops	Trends of climate adaptive crops in their farm lands in the last 10 years, coded 1 for decreasing and 0 otherwise	0.24	0.12	0.14	0.17	a,b
Soil quality	Soil quality conditions in their farms over the last 10 years, coded 1 for deteriorating and 0 otherwise	0.65	0.26	0.25	0.48	a,b
Irrigation	Trends of irrigation water availability over the last 10 years, coded 1 for decreasing and 0 otherwise	0.07	0.30	0.76	0.47	a,b,c
Farming knowledge	Farmers knowledge on farming over the last 10 years, coded 1 for decreasing and 0 otherwise	0.22	0.12	0.11	0.18	a,b

a Significant difference between Terai and Hill at less than 5% level of significance
b Significant difference between Terai and Mountain at less than 5% level of significance
c Significant difference between Hill and Mountain at less than 5% level of significance

[d]We collected respondent’s perceptions on six indicators of changes in weather parameters, summer season temperature, winter season temperature, summer season period, winter season period, overall precipitation and weather unpredictability. The respondents were asked whether they have experienced or noticed changes in given indicators. Three options were provided: ‘increase’, ‘stable’ and ‘decrease’. If the answer is increase or decrease, the value is “1” and “0” if stable.

Table 3. RPL estimates with household characteristics and ASC interaction

Attribute	Money		Labour	
	Coefficient (s.e.)	Coeff. std. (s.e.)	Coefficient (s.e.)	Coeff. std. (s.e.)
ASC	2.994*** (0.315)	0.016 (0.316)	4.704*** (0.487)	0.052 (0.257)
Climate adaptive crop	0.108*** (0.007)	0.038 (0.052)	0.217*** (0.015)	0.147*** (0.022)
Soil quality (high improvement)	0.705*** (0.048)	0.311 (0.191)	1.251*** (0.088)	0.363** (0.156)
Soil quality (moderate improvement)	0.154*** (0.040)	0.595*** (0.165)	0.153*** (0.052)	0.557*** (0.170)
Irrigation	0.239*** (0.012)	0.008 (0.044)	0.436*** (0.026)	0.085*** (0.022)
Trainings	0.636*** (0.035)	0.274 (0.202)	1.057*** (0.066)	0.310** (0.127)
Payment	-0.00098*** (0.493×10^{-4})		-0.00122*** (0.797×10^{-4})	
ASC X Age	0.019*** (0.004)		0.018*** (0.005)	
ASC X Education	0.012 (0.011)		0.001 (0.021)	
ASC X Family size	0.002 (0.019)		-0.013 (0.025)	
ASC X Income source	0.234** (0.094)		0.155 (0.147)	
ASC X Extension	-0.018*** (0.004)		-0.014*** (0.005)	
ASC X Land holding	0.900*** (0.241)		1.574*** (0.456)	
ASC X Farm parcel	0.060* (0.032)		0.138** (0.053)	
ASC X Membership	-0.021 (0.099)		-0.385*** (0.142)	
ASC X Perception	2.003** (0.844)		2.845** (1.371)	
ASC X Drought/flood	0.216** (0.095)		0.647*** (0.154)	
Number of observations	4320		4320	
Pseudo-R^2	0.244		0.394	
Log likelihood	-4526.35		-3630.520	
Replications for simulated probability	500		500	

***, **, * = 1%, 5%, 10% Significance level. Standard errors in parentheses.

Table 4. WTP and confidence intervals, in Nepalese Rupees

Attribute	Money			Labour		
	WTP	95% lower bound	95% upper bound	WTP	95% lower bound	95% upper bound
Climate adaptive crop species/varieties	107.465***	92.958	121.972	164.610***	146.268	182.953
Soil quality (high improvement)	675.961***	598.013	753.909	949.178***	855.961	1042.396
Soil quality (moderate improvement)	145.627***	75.182	216.071	141.938***	68.624	215.252
Irrigation	243.376***	218.600	268.151	352.371***	320.345	384.398
Training	650.400***	586.213	714.588	859.536***	781.732	937.339

*** = 1% significance level.

Table 5. RPL estimates by ecological regions

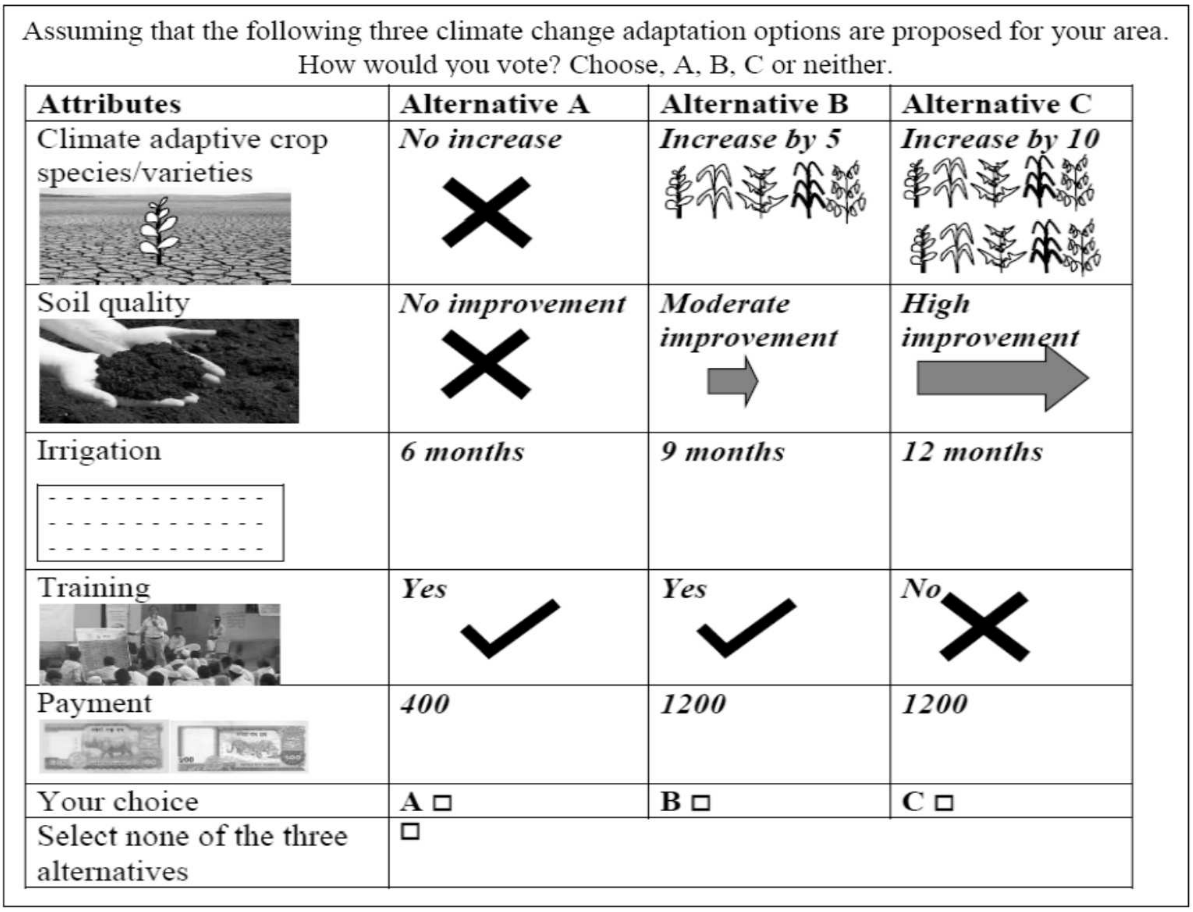
Attribute	Terai	Hill	Mountain
	Coeff (s.e.)	Coeff (s.e.)	Coeff (s.e.)
ASC	5.945***	8.119**	2.685***
	(1.642)	(1.287)	(0.800)
Climate adaptive crop	1.372***	0.241***	0.0738***
	(0.153)	(0.034)	(0.017)
Soil quality (high improvement)	9.136***	1.273***	0.996***
	(1.116)	(0.179)	(0.179)
Soil quality (moderate improvement)	1.843***	0.107	0.287**
	(0.663)	(0.099)	(0.119)
Irrigation	1.800***	0.656***	0.207***
	(0.203)	(0.081)	(0.033)
Trainings	4.486***	1.627***	0.784***
	(0.557)	(0.216)	(0.135)
Payment	-0.01023***	-0.00232***	-0.00121***
	(0.0012)	(0.000)	(0.000)
ASC X Age	0.220*	0.024**	0.028***
	(0.128)	(0.010)	(0.010)
ASC X Education	0.326	0.078**	-0.057*
	(0.416)	(0.035)	(0.031)
ASC X Family size	0.546	0.106*	0.019
	(0.746)	(0.055)	(0.045)
ASC X Income source	8.967***	0.239**	0.286
	(2.889)	(0.106)	(0.239)
ASC X Extension	-0.396**	-0.001	-0.031**
	(0.175)	(0.010)	(0.016)
ASC X Land holding	6.489*	2.579***	1.941**
	(3.905)	(0.820)	(0.799)
ASC X Farm parcel	0.122	0.383**	0.006
	(0.941)	(0.192)	(0.083)
ASC X Membership	4.515	-0.707***	-0.001
	(3.227)	(0.268)	(0.281)
ASC X Perception	9.639*	1.482	8.347***
	(7.365)	(1.182)	(2.771)
ASC X Drought/flood	6.532**	0.517	-0.336
	(2.804)	(0.387)	(0.261)
Observations	1440	1440	1440
Pseudo-R^2	0.299	0.402	0.165
Log likelihood	-1398.176	-1193.0263	-1667.654
Replications for simulated probability	500	500	500

***, **, * = 1%, 5%, 10% Significance level. Standard errors in parentheses. Standard deviation estimates are not shown in the Table for space purpose.

Table 6. WTP and confidence intervals, in Nepalese Rupees by ecological regions

Attribute	Terai		Hill		Mountain	
	WTP	95% Conf. interval	WTP	95% Conf. interval	WTP	95% Conf. interval
Climate adaptive crops	139.01 ***	110.94- 167.07	98.52 ***	81.02- 116.02	77.36 ***	46.02 – 108.72
Soil quality (high improvement)	681.19 ***	543.97- 818.42	536.36 ***	448.88- 623.83	844.82 ***	636.25- 1053.38
Soil quality (mod improvement)	222.41 ***	95.32-349.51	69.13	18.03- 156.28	209.84 **	43.02- 376.69-
Irrigation	212.06 ***	170.38- 253.75	288.31 ***	254.93- 321.67	222.53 ***	165.84- 279.24
Training	534.33 ***	430.27- 638.38	692.21 ***	612.63- 771.77	742.92 ***	575.07 - 910.78

***, ** = 1%, 5% Significance level



Assuming that the following three climate change adaptation options are proposed for your area. How would you vote? Choose, A, B, C or neither.

Attributes	Alternative A	Alternative B	Alternative C
Climate adaptive crop species/varieties	***No increase***	***Increase by 5***	***Increase by 10***
Soil quality	***No improvement***	***Moderate improvement***	***High improvement***
Irrigation	***6 months***	***9 months***	***12 months***
Training	***Yes***	***Yes***	***No***
Payment	***400***	***1200***	***1200***
Your choice	**A** ☐	**B** ☐	**C** ☐
Select none of the three alternatives	☐		

Figure 1. An example of a choice set

Annex 1. RPL estimates with split samples

Attribute	Money		Labour	
	Coefficient (s.e.)	Coeff. std. (s.e.)	Coefficient (s.e.)	Coeff. std. (s.e.)
ASC	4.256***	0.083	5.149***	0.024
	(0.639)	(0.742)	0.916	0.977
Climate adaptive crop	0.214***	0.161***	0.241***	0.223***
	(0.034)	(0.047)	0.046	0.064
Soil quality (high improvement)	1.161***	0.326	1.556***	0.531
	(0.189)	(0.422)	0.273	0.384
Soil quality (moderate improvement)	0.102	1.527***	0.281**	1.020***
	(0.132)	0.412	(0.113)	(0.327)
Irrigation	0.518***	0.070	0.700***	0.146***
	(0.073)	(0.065)	0.114	0.054
Trainings	1.182***	0.228	1.425***	0.773**
	(0.165)	(0.644)	0.242	0.336
Payment	-0.002***		-0.002***	
	(0.0003)		0.0003	
Number of observations	1200		1200	
Pseudo-R2	0.373		0.389	
Log likelihood	-1024.992		-1015.241	
Replications for simulated probability	500		500	

***, **, * = 1%, 5%, 10% Significance level. Standard errors in parentheses.

Annex 2. WTP and confidence intervals with split samples, in Nepalese Rupees

Attribute	Money			Labour		
	WTP	95% lower bound	95% upper bound	WTP	95% lower bound	95% upper bound
Climate adaptive crop species/varieties	95.961***	79.119	112.803	107.514***	84.539	130.490
Soil quality (high improvement)	530.922***	444.967	603.409	725.881***	616.877	848.354
Soil quality (moderate improvement)	85.112	24.544	194.768	141.120***	54.069	228.171
Irrigation	247.770***	216.943	278.596	345.863***	298.603	393.123
Training	585.545***	512.871	621.193	725.277***	638.220	829.361

*** = 1% significance level.