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RESEARCH PAPER

Estimating the willingness to pay for regulating and cultural ecosystem services from forested *Siwalik* landscapes: perspectives of disaggregated users

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Abstract

Key message **We assessed forest users' willingness to pay (WTP) for regulating and cultural forest services based on their socio-economic status (rich vs. poor), proximity to forests (nearby vs. distant), and forest management modalities (community forestry vs. collaborative forest management). As expected, a huge variation was found in WTP among these sub-groups. The wealthier households (HH) preferred 'cash' whereas poor HHs preferred 'labour' as a payment option.**

• ***Context*** Forest's ecosystem services (FES) research have largely concentrated on aggregated economic valuation, while minimal consideration has been paid to distributional issues of willingness to pay (WTP) of many regulating and cultural services such as water quality improvement (WQI), flood control (FC), and bequest and aesthetic values.

• ***Aims*** We assessed WTP of high-priority FES to the various sub-groups (nearby/distant, rich/poor and community/collaborative forest users) and explored the preferred payment options among the sub-groups in the Siwalik landscape of Nepal.

• ***Methods*** We carried out contingent valuation survey of 253 households (ranging from 31 to 33 households from each of the sub-groups). We performed the generalised linear mixed model (GLMM) to analyse the data in RStudio.

• ***Results*** Spatial distance and wealth levels of the respondents play a crucial role in WTP of FES. GLMM analysis indicated that WTP of non-marketed FES differed in terms of cash and labour format. Generally, the WTP is higher in wealthier sub-groups as a cash option. WTP in-terms of labour is a better option for poor HH.

• ***Conclusion*** Disaggregated WTP should be considered while designing future forest management interventions.

Keywords Valuation · Economic contribution · Flood control · Water quality improvement · Bequest value · Aesthetic value

1 Introduction

1.1 Background of the study

Forest ecosystem services (FES) play critical roles in people's daily lives, their environments and national income. Forest ecosystem services contribute to livelihoods in both high-income and low-income countries, although the contributions from the services often vary widely. The contribution to resource-poor rural people, particularly those in low-income countries, is critically important (Christie and Rayment 2012; Bhatta et al. 2014), as about 75% of poor people in low-income countries are primarily dependent on forest ecosystem services. Recent statistics show that forest ecosystems provide approximately 20% of the income for rural households in low-income countries, both through cash and by meeting subsistence needs (FAO 2018). However,

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despite the significant contribution made by the ecosystem to the population, the actual contributions of forest ecosystem services to different categories of forest users have not been assessed adequately.

While research on the valuation of forest ecosystem services has increased at an exponential rate, most of these studies are constrained by their disproportionate focus on aggregated economic valuation such as biophysical quantification through modelling and mapping (Verkerk et al. 2014; Akujärvi et al. 2016; Forsius et al. 2016; Langner et al. 2017) or purely aggregated monetary valuation of the FES (Kubiszewski et al. 2013; Parthum et al. 2017; Turpie et al. 2017; Verma et al. 2017). There exists little research that demonstrates how these contributions, for example the economic benefits of forest ecosystem services, are distributed among different sub-groups in community forest-based ecosystems, although some studies have called for urgent action to demonstrate the economic values of various sub-groups while performing forest-based ecosystem services valuation research (Vihervaara et al. 2010; Daw et al. 2011; Nieto-Romero et al. 2014; Fagerholm et al. 2016; Garrido et al. 2017; Chaudhary et al. 2018; Acharya et al. 2020b).

Some researchers have attempted to fill this gap, but they have mostly focused on forests on government-managed/public land (de la Torre-Castro et al. 2017; Murali et al. 2017; Queiroz et al. 2017), private forests (Nordén et al. 2017), protected area systems (Cuni-Sanchez et al. 2016; Peh et al. 2016; Shoyama and Yamagata 2016; Affek and Kowalska 2017; Delgado-Aguilar et al. 2017; Vauhkonen and Ruotsalainen 2017; Adhikari et al. 2018), and community forests (Lakerveld et al. 2015; Paudyal et al. 2015; Bhandari et al. 2016). Similarly, researchers have explored regulating services including insurance values of forests and wetlands (Brander et al. 2013; Ninan and Inoue 2013; Acharya et al. 2019b; Dallimer et al. 2020) or analysed various functions, values, demand and supply and management implications of forests (Olschewski 2013; Müller et al. 2020; Unterberger and Olschewski 2021). However, these studies have not comprehensively assessed the economic contribution of the forest ecosystem services or compared the different community-based management modalities among groups with different socio-economic rankings when focusing on regulating and cultural services. Community-based forest management (CBFM) is a management model which places people at the forefront of planning, decision-making, implementation and benefit-sharing (Maraseni et al. 2005). This model is applied to around 511 million hectares of global forests (almost 15.5% of global forests) and has been gaining popularity in recent years. The adoption of these systems is an increasing trend in developing countries (2006, 22%; 2010, 27%; 2015: > 30%) (Maraseni et al. 2014, 2019; Paudyal et al. 2017). This model comprises different users living close to and far away from a forest area and includes people of different economic and social backgrounds (Rai et al. 2017). Such differences imply diverse needs and demands on forest ecosystem services. Therefore, the benefits derived from these regulating and cultural forest ecosystem services vary significantly based on their livelihood outcomes.

The users, who are not only the key stakeholders and the real managers but also the victims of ecosystem degradation, need to understand the real economic contribution of regulating and cultural forest services for effective implementation of policy and management plans (Muhamad et al. 2014). Knowing local people's needs, their demands and the distribution patterns of economic benefits to different segments of the societies is imperative and can create threefold benefits. First, such knowledge can create awareness among different sub-groups at the local level of the real economic contributions of critical but non-marketed forest ecosystem services. Second, the monetary valuation of those forest ecosystem services in a disaggregated manner will help policymakers and managers understand the needs and inspirations of the different sub-groups so that they can formulate practical and applicable forest ecosystem management plans. This also helps to prioritize the use of scarce capital for the effective implementation of forest management plans. Third, the global community will gain insights into how the economic contribution of forest ecosystem services varies among the sub-groups involved in community-based forest management, which has become a world-renowned model of forest management.

In this paper, we quantify the economic contribution of high-priority regulating (flood control and water quality improvement) and cultural (bequest and aesthetic value) forest ecosystem services disaggregated according to proximity (nearby/distant forest users), economic status (rich/poor users) and forest management modalities (community forestry (CF)/collaborative forestry management (CFM)) in the fragile mountain area of the *Siwalik* of Nepal.

2 Methodology

2.1 Description of study sites

This study was carried out in *Sarlahi*, the central *Terai* district of the *Chure-Tarai* Landscape, situated 330 km southeast from Kathmandu, Nepal. The total area of the district is 125,948 ha, of which 15.5% consists of the *Siwalik* mountains and the remainder comprises, the *Bhawar* and *Tarai* regions. The *Siwalik* region lies parallel to the Lesser Himalayas in the southern part of the Indian sub-continent (Sivakumar et al. 2010) and extends 2400 km across four countries, Pakistan, India, Nepal and Bhutan. Our study sites are located in part of the *Siwalik* region in the northern part of the study district.

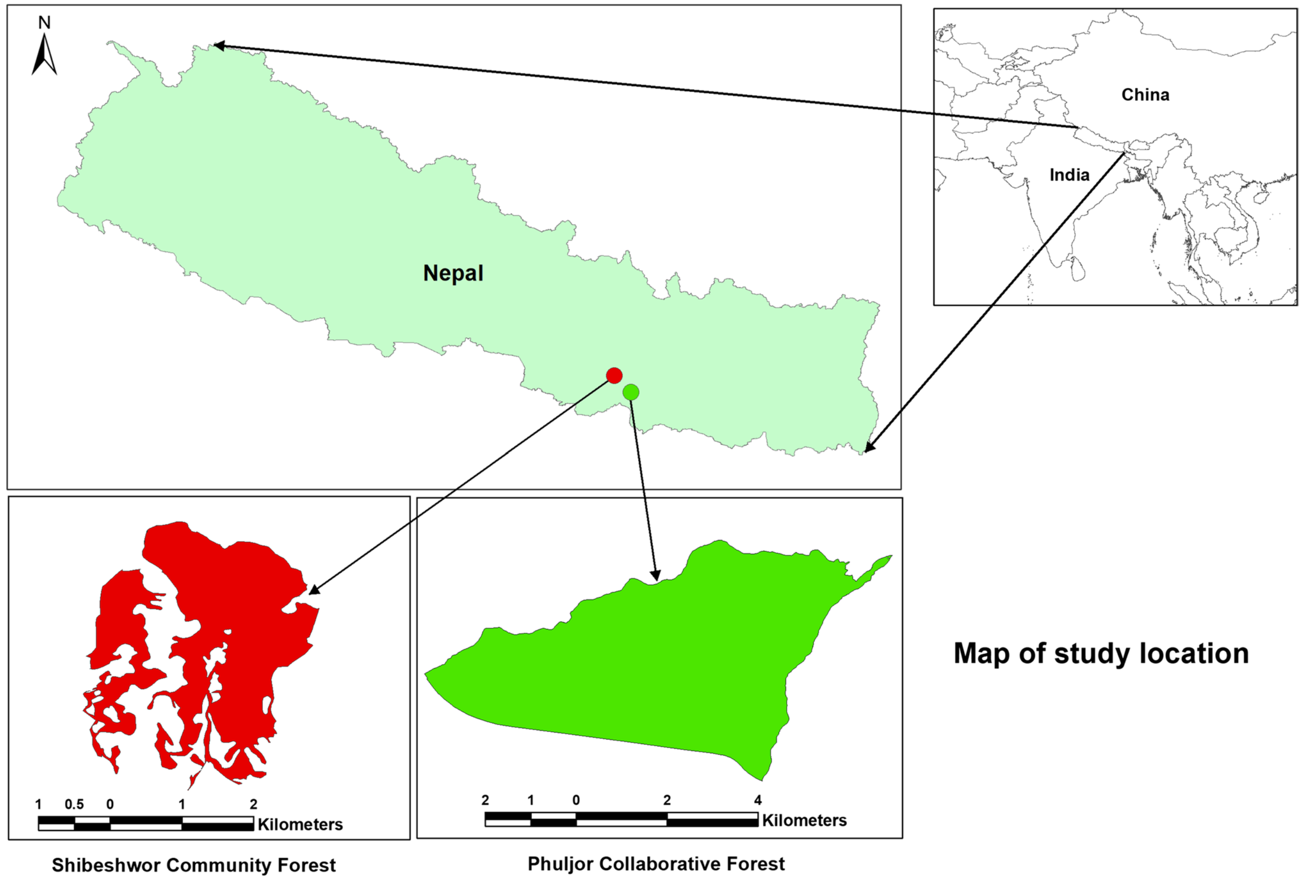


Fig. 1 Location map of study sites (Shibeshwor CF to the left and Phuljor CFM to the right) in Nepal

This area displays multiple land uses. Cultivated land constitutes the highest percentage (66.57%) of land use, followed by forests (23.31%) and sand/gravel extraction (4.31%) (DFO 2017). Forests in the area are managed through both community (45%) and collaborative forest management (18%). Due to the high elevation range, from 60 m above sea level (masl) to 659 masl (DDC 2016), the region is diverse in climate, vegetation and land use patterns (DFO 2017; Singh 2017).

We chose two community-based forest management units (one CF and one CFM) for the case study. *Shibeshwor* community forest is located in the *Hariyon* municipality and *Phuljor* CFM is situated in the *Ishworpur* municipality, covering 3121 hectares of forest area (*Shibeshwor*: 711 hectares, and *Phuljor*: 2419 hectares) (see Fig. 1). Sal (*Shorea robusta*) is the dominant tree species in community-based forest management and comprises almost 55% of crown cover in both units.

Members of the community-based forest management groups, which are made up of people from different socioeconomic backgrounds, are responsible for the protection, management and use of these forests. Those users living nearby both the community forests and collaborative forest management areas live in the *Siwalik* foothills. They rely mainly on agriculture and animal husbandry for their livelihoods. Forest users who are more distant from the community forest live within 5 km of the forests in a semi-urban (small town) area and are engaged in multiple occupations including commercial agriculture, services and small shops. The nearby users in both community-based forest management units take advantage of the many services provided by the forests such as firewood, fodder, grazing, timber, poles, agriculture implements, medicinal and aromatic plants (MAPs), and wild foods for their daily use. Similarly, they benefit from regulating services such as flood control (FC), water quality improvement (WQI) and cultural services, namely the aesthetic and bequest values of the forests. The distant users of the collaborative forest live further away from the forest (> 5–20 km) (Bhattarai et al. 2018; Acharya et al. 2020a) and depend on agriculture and animal husbandry for their livelihoods (GON 2016). These distant users receive services mainly in terms of firewood, timber, sand/boulders/gravel, and poles as provisioning services, and also derive benefits from regulating and cultural services. We selected these two community-based forest management areas for the following reasons: (1) they comprise both nearby and distant users with different degrees of intensity of both direct and indirect use of the forests' ecosystem services; (2) users have a long history of public contribution to forest protection, management and utilization; (3) the areas comprise naturally rich and productive ecosystems; and (4) the landscape faces severe soil erosion and flooding (DPR 2014; PCTMCDB 2017).

2.2 Data and methods

Many methods have been used to estimate monetary values of regulating and cultural forest services, which include revealed price (e.g. revealed price, travel cost and the production approach), stated preference (e.g. contingent valuation method (CVM)) and a cost-based approach (replacement or avoided) (Pagiola et al. 2004; Farber et al. 2006; Christie et al. 2012). Contingent valuation methods can (in principle) estimate both use and passive-use values and can be employed to estimate the non-marketed ecosystem services, those are not traded in the markets (Bateman and Turner 1992; Segerson 2017). In contingent valuation, an investigator generally asks people to indicate how much they would be willing to pay (WTP) for non-marketed ecosystem services if they were in a hypothetical situation. The method is called contingent valuation because the values revealed by respondents are contingent upon the constructed or simulated market presented in the scenario.

Based on the elicitation questionnaire format, the stated preferences can be categorized as discrete choice experiment (DC), bidding game (BG), choice-based conjoint analysis (CBC) and open-ended questionnaire (OE). The theoretical background of the open-ended contingent valuation of regulating and cultural ecosystem services is rooted in welfare economics, in which the neoclassical concept of economic value is outlined under the broader framework of individual utility maximization (Bateman and Turner 1992; Hoyos and Mariel 2010). If anybody perceives a utility from the use of any non-marketed ecosystem services, he/she can offer a maximum monetary amount to utilize these services. Contingent valuation methods are capable of directly obtaining a monetary (Hicksian) value of welfare associated with changes in the provision of a particular ecosystem service such as flood control or water quality improvement (Bateman and Turner 1992). Theoretically, we specified the open-ended willingness to pay model as described in Jala and Nandagiri (2015),

$$WTP = f(\text{ES, DF, EL, HS, TI, C, G, AR}) \quad (1)$$

where WTP means Hicksian compensating measures of welfare, ES refers to economic status of respondent, DF denotes distance from forests, EL refers to educational level of the respondent; HS refers to household family size (No); TI refers to household yearly income (NRs), C refers to caste; G refers to gender; and AR refers to age of the respondent (years).

As discussed earlier, there exists a variety of stated preferences techniques and each of them has merits and demerits. DC format is complex for designing their choices and scenarios, and CBC rarely estimates an individual's WTP; rather, data from groups are aggregated for analysis. The bidding game is lengthy and criticized for its starting bias. The OE method, on the other hand, is flexible, easy to understand and analyse, and produces direct continuous individual WTP. This method has also been criticized by some scholars on the grounds of hypothetical bias, strategic bias (Pagiola et al. 2004; Venkatachalam 2004) and incentive incompatibility (Bateman et al. 2010; Rasul et al. 2011). Some of these criticisms could be addressed if hypothetical scenarios and questionnaire are properly designed and implemented.

2.2.1 Valuation of regulating and cultural ecosystem services

In general, Siwalik forests provide both direct and indirect ecosystem services. The direct services include firewood, timber, grass, fodder, bedding material, medicinal plants, sand/stone/boulders and grazing services, while indirect services comprise soil conservation, water quality improvement, erosion control, run-off mitigation, flood regulation, bequest, aesthetic existence, recreation, cultural heritage, tourism and educational services (Basnyat et al. 2012; Sharma et al. 2019). We categorised forest users into eight homogeneous sub-groups (4 sub-groups from community forests and another four sub-groups from collaborative forest management). The databases used to create the different strata were obtained from the forest constitutions and forest operational plans of the community/collaborative management groups (see Appendix 1 for locally adopted criteria for rich and poor). These databases were further verified with their executive committees and district forest officials. Eight different focus groups were set up representing each sub-group (Community Forest: nearby[1]-rich/poor,[2] distant-rich/poor; Collaborative Forest: nearby-rich/poor, distant[3]-rich/poor). In each focus group, 11–18 sub-group members participated in the discussion and a total of 15 regulating and 11 cultural services were documented (Acharya et al. 2019a). The priorities recorded for the different groups contrasted for the different forest management

[1] Nearby users live adjacent to the forest areas (within 3 km) in CF areas whereas in the collaborative forest system, the nearby users live up to five km from the forest area.

[2] Rich/poor: CBFM classifies users into four categories (well-off, medium, poor and very poor). This study considers the first two as rich and the other two as poor.

[3] Distant users live from three to five km away from the CF area, while distant users live 5–20 km away from the CFM area.

modalities, spatial distance from forests and economic classes. Overall, the four top ranking FES (two regulating and two cultural services) for all sub-groups were flood control, water quality improvement, bequest and aesthetic services: these became the bases for this study. See Acharya et al. (2019a) for details of prioritisation of all the forest ecosystem services in the study area.

Method of data collection. The primary data for the study was collected from July to October 2018 using a household survey following a stratified random sampling technique. Local users were stratified based on management modality (community forest/collaborative forest), economic class (rich/poor) and spatial distance (nearby/distant) from the forests. A total of 253 households ranging from 31 to 33 households from each sub-group was surveyed from both community-based forest management types. Socioeconomic data for households, for the classification of poor and rich, was obtained from the records of forest users' meeting minutes and was verified with key informants and community-based forest management executives. In order to address the issues raised by the 'open-ended questionnaire' discussed above (Sect. 2.2), we followed the guidelines developed by the National Oceanic and Atmospheric Administration (NOAA) (Arrow et al. 1993) and 'incentive compatible conditions' suggested by Vossler and Holladay (2018). In order to meet incentive compatible conditions, we suggested that respondents: (1) take care about the outcomes; (2) that the authority can enforce the payment they themselves indicated; (3) that there are 'yes' and 'no' options for each scenario; and (4) that there is high chance of project execution if the proportion of the 'yes' response is high.

Following suggestions offered in focus group discussions, we designed our questionnaires to comprise the baseline condition of forest crown cover, mechanisms of forest condition improvements, changes to be valued and price information. Accordingly, the household questionnaire consisted of five main sections. The first section comprised basic household variables of gender, age, caste, ethnicity and livestock numbers while the second, third, fourth and fifth sections were intended to elicit detailed information on flood control and water quality, bequest and aesthetic services in three different hypothetical scenarios—increasing crown cover by 15%, 30% and 45% from current crown cover (baseline) of 55% to elicit users' willingness to pay (WTP) in either cash or labour for different management interventions (Table 1). As noted earlier, we conducted eight focus group discussions, in which we discussed forest degradation issues and their implications for high priority ES, the concept of WTP and its implications for the outcomes and uncertainty about the actual cost of improving the forest condition, preferred payment vehicle (cash or in-kind) and potential authority to enforce the payment fees/levies (e.g. by executive committee) and methods of expressing their WTP. We also carried out a small pilot testing of the questionnaire before proceeding to the actual household survey as suggested by many studies (Bateman and Turner 1992; Adamowicz 2004).

We employed the face-to-face open-ended contingent valuation method with two payment options since many forest users face cash constraints, and thus could express their WTP in terms of labour (Rai et al. 2015). This method was the preferred option proposed in the focus group discussions and has many advantages. To control hypothetical bias, we created the scenarios in the questions to allow the respondents feel they were paying the agreed amount of money. The participants are forest users and use many FES in their daily lives, consequently they are concerned about the imposition of any rules and regulations that would lead to the improvement/degradation of forest conditions. They were reminded that while they offered money and labour contribution to forest management, their purchasing power and labour-force would be reduced by the same amount (money/labour). After informing them of the consequences of all situations and highlighting the uncertainty about the actual cost of forest management, to control strategic bias and informing them of the probability of executing the project if they agreed, they were asked whether or not they agreed to participate in the process. If the respondent agreed, then he/she was asked what would be the highest amount in terms of cash as an annual fee to CBFM or the number of annual labour days they would be willing to pay for each of the three scenarios. If he/she did not agree then he/she was asked to state the reason for being unwilling to participate. More than 95% of the participants ($n = 241$) agreed to contribute either cash or in-kind for all four services. Table 1 provides details of the methods used to elicit the willingness to pay for regulating and cultural services.

Method of data analysis. The maximum willingness-to = pay amount for each sub-group was estimated following Boyle (2017) as expressed in Eq. 2.

$$Mean\ WTP = \left(\sum\nolimits_{i=1}^{n} WTP_i\right)/n \quad (2)$$

where WTP is the maximum willingness to pay expressed by individual households, and n is the number of observations.

While contingent valuation undertakes to elicit maximum willingness to pay for a household, it is essential to identify the contribution of different social attributes, e.g. age, income etc. to willingness to pay of the respondents. To observe the relationship between maximum willingness to pay amount and social attributes, we specified the following econometric model for the data analysis as shown in Eq. 2.

$$y_i = \beta' X_i + \varepsilon_i \quad (3)$$

where y_i is the dependent variable, in our case willingness to pay, in monetary terms or labour days, which a respondent offers during the questionnaire survey, β is the vector of unknown parameter, X is the set of independent variables,

Table 1 Contingent valuation method to estimate regulating and cultural services

FES category	Background information	Hypothetical scenario
Flood control	You have witnessed floods and sediments for a long time in your area. You know better than I do about the causes which could be deforestation/degradation, land use changes and unmanaged infrastructure development. You are aware of the impacts of sediment and flood damage to public and private properties like agriculture land (144,724 ha), livestock (US$ 96.50 million), houses (192,510), irrigation (961 schemes), transport—local roads, bridges, culverts (26.60 mil) and human casualties (almost 134 lives) including more than US$ 552 million loss) in Tarai-Madesh area in last August 2017 (NPC 2017). You might still remember or have heard about- worse past incidents in your area	Considering the current situation, GON is going to implement various forests management activities under Chure management to reduce the risk of human casualty, and loss of private property through unsustainable management of forests. GON wants to reduce the impacts of the deposition of sediment and flood, which you are frequently suffer from. Particular forest management activities can increase tree and ground cover that can control the problem of frequent flooding in your area. Currently, you know that the forest crown cover is almost 55%. As a resident of several years, you know better than me about the “flood control benefits” of increased crown cover of the forests on your private property only. Here, we are proposing three hypothetical scenarios (increasing CC by 15%, 30% and 45%). This will not totally mitigate the whole flood problem, however, it can reduce the losses on your private property significantly. Considering the impacts and potential mitigation measures to protect your private property, and remembering that this will reduce your purchasing power or labour force, and implications of the outcomes and uncertainty about the actual cost to improve the forest condition, would you vote in favour of reducing such loss of private property? Yes No Yes No Yes No If yes, what would be the highest amount in cash or labour days of contribution as an annual fee/labour contribution to each of the three scenarios (15%, 30% and 45%) improvements in CC? Increase CC by 15% / Increase CC by 30% / Increase CC by 45% In cash NRs……/Year / In cash NRs……/Year / In cash NRs……/Year Labour days …../Year / Labour days …../Year / Labour days …../Year If no, why do you say no? What would be the least amount of cash/labour contribution in all three scenarios? In cash NRs……/Year Labour days …../Year

Table 1 (continued)

FES category	Background information	Hypothetical scenario
Water quality improvement	You have witnessed situations, problems, and causes of poor water quality in your area. You know better than I do the causes which could be deforestation/degradation, intensive agriculture and unmanaged infrastructure development. You are aware of the impacts of WQ on your family especially increase in maintenance cost of water pipe clogging/plumbing, cost of additional pipes for your pump to access good quality water compared to several years ago, and ultimately problems in human health. This also demands additional maintenance and consequently increased water maintenance and treatment costs like chemicals, filtering and boiling. At the same, you are also interested in receiving good quality water through a long-term solutions. Considering your current situation, GON is going to implement various forest management measures to improve the water quality and help reduce the risks to human health through sustainable management of forests	GON wants to provide quality water, which you also want to receive. These forest management activities can increase tree and ground cover and thus improve water quality in your area. Currently, you know that the forest crown cover is almost 55%. As a resident of several years, you know better than me the "water quality improvement benefits" derived through increased crown cover of the forests: decrease water treatment costs and gaining health benefits for you and your family. Here, we are proposing three hypothetical scenarios (increasing CC by 15%, 30% and 45%). This will not totally mitigate all water related problems; however, it can decrease the cost of achieving quality water and can also significantly moderate risks to human health. Considering your impacts and potential mitigation measures to decrease water treatment cost and gaining health benefits for you and your family, and also remembering that this will reduce your purchasing power or labour force, implications of the outcomes and uncertainty about the actual cost to improve the forest condition, would you vote in favour of water quality improvement through forest management activities? Yes No Yes No Yes No If yes, what would be the highest amount in-terms of cash or labour days contribution as an annual fee or labour contribution of all three 15%, 30% and 45% CC improvement? Increase CC by 15% — In cash NRs……/Year; Labour days …../Year Increase CC by 30% — In cash NRs……/Year; Labour days …../Year Increase CC by 45% — In cash NRs……/Year; Labour days …../Year If no, why do you say no? What would be the least amount of cash/labour contribution in all three scenario? In cash NRs……/Year Labour days …../Year

Table 1 (continued)

FES category	Background information	Hypothetical scenario
Aesthetic	You have witnessed situations, problems, and causes of aesthetic quality decreasing in your forests area. You know better than I do the causes which could be deforestation/degradation, other land use changes and unmanaged infrastructure development. You are also aware of the impacts on aesthetic values in you and your family especially loss of greenery or changing one land use system to other compared to several years back, and ultimately your decrease in satisfaction from the aesthetic values of the forests. At the same time, you are also interested in receiving aesthetic quality through a long-term solution	Considering your current situation, GON is going to implement various forests management activities to maintain or improve the aesthetic value of forests through sustainable management of forests. GON would like to assure you of providing aesthetic quality, which you are also interested in receiving. These forest management activities would increase tree and ground cover and thus improve the situation of aesthetic value in your forest area. Currently, you know that the forest crown cover is almost 55%. As a resident of several years, you know better than I do the "aesthetic improvement benefits" through increased crown cover of the forests to you and your family. Here, we are proposing three hypothetical scenarios (increasing CC by 15%, 30% and 45%). This will not totally improve the whole aesthetic issue; however, it can significantly increase satisfaction. Considering your satisfaction from increased forest cover and gaining personal benefits for you and your family, and also remembering that this will reduce your purchasing power or labour force, implications of the outcomes and uncertainty about the actual cost to improve the forest condition how would you vote in favour of aesthetic quality improvement through forest management activities? Yes No Yes No Yes No If yes, what would be the highest amount of cash or labour days contribution as an annual fee or labour contribution to all three 15%, 30% and 45% CC improvements? Increase CC by 15% Increase CC by 30% Increase CC by 30% In cash NRs……/Year In cash NRs……/Year In cash NRs……/Year Labour days …../Year Labour days …../Year Labour days …../Year If no, why do you say no? What would be the least amount of cash/labour contribution to all three scenarios? In cash NRs……/Year Labour days …../Year

Table 1 (continued)

FES category	Background information	Hypothetical scenario
Bequest	You have witnessed current bequest value in your forest area. You know better than I do the causes which could be deforestation/degradation, land use changes and unmanaged infrastructure development that impact the BV of your forests. BV is a non-use value that denotes a special case of option value representing the value (to current users) of being able to bequeath the value of FES to coming generations. It is not like existence values which are fuzzy values and which accrue mainly to people who do not use the forest, and may never see it except in books. In countries like Nepal, where people are more religious, are immersed in traditional culture and believe in incarnation, and earn and save everything for the future generation; forest users may agree to amount of WTP to bequeath the forest to your children and grandchildren. You are also aware that our society believes in incarnation and is conscious of future benefits to your off-spring in your future generation	Considering your current situation, GON is going to implement various forests management activities to improve the bequest value through a variety of management activities in forests. GON would like to improve forest quality, which you are also interested in improving. Such forest management activities can increase tree and ground cover that can improve the value of your forest area. Currently, you know that the forest cover is almost 55%. As a resident of several years, you know better than I do about the bequest value of forests derived through forests management. Here, we are proposing three hypothetical scenarios (increasing CC 15%, 30% and 45%). This will not only determine the total bequest value, but will also significantly increase bequest value. Considering your ability to protect the forests for future generations, and also remembering that this will decrease your purchasing power or labour force, implications of the outcomes and uncertainty about the actual cost to improve the forest condition would you vote in favour of BV? Yes No Yes No Yes No If yes, what would be the highest amount in-terms of cash or labour days contribution of all three 15%, 30% and 45% CC improvements? Increase CC by 15% / Increase CC by 30% / Increase CC by 30% In cash NRs……/Year / In cash NRs……/Year / In cash NRs……/Year Labour days …../Year / Labour days …../Year / Labour days …../Year If no, why do you say no? What will be the least amount of cash/labour contribution as an annual fee or labour contribution to all three scenarios? In cash NRs……/Year Labour days …../Year

CBFM community-based forest management, *GON* Government of Nepal, *NRs* Nepalese rupees, *CC* crown cover, *FES* forest ecosystem services, *WTP* willingness to pay and ε is the random error term which is normally distributed with a zero mean and constant variance. To identify the relationship between maximum willingness to pay and social attributes, we used a mixed effect model, which deals with both fixed and random effects.

To explore the relationship between key independent variables and forecast WTP based on selected variables, we analysed the data in Rstudio as suggested by Bolker et al. (2009). A generalised linear mixed model (GLMM) was used to assess the correlation and estimate the effects of the explanatory variables (economic status, distance from forests, level of education, household size and caste, a fixed variable; age of respondent, gender, a random variable) on response variables. GLMM with PQL (penalized quasi-likelihood) function in R package (Pinheiro et al. 2018) was used for fitting the model. This GLMM was selected because it deals with non-normal data with unbalanced design and cross-random effects.

We checked multicollinearity among the independent variables through one-on-one correlation among independent variables and through variance inflation factors (VIF). Correlation between income and economic status and income and caste are 0.59 and 0.26, respectively. Among the independent variables the VIF value is less than 2.06, which indicates no multicollinearity was found (please see test results in Appendix 2). Further, we employed the forward method, that is, we started with economic status, age, and gender and added other variables (distance from forest, caste, income, family size and livestock) in different combinations (see Appendix 3 for six different combinations).

To select the best models among six different combinations, we calculated adjusted R^2 values of these models and checked their p values. The first two models yielded adjusted R^2 values less than 0.3, which means the model does not provide a reliable prediction. The third model yielded R^2 0.36, which also predicts moderately. Models four and five produced R^2 values 0.74 and 0.75, respectively, showing good predictive capacity. We chose the sixth model (adjusted R^2 equal to 0.8, the highest among the models), in which three variables (Eco_Status, Edu_lev, Distant_For) were the main variables, three (Total.income, Tot_Fam_memb and Caste) were associated variables and Gender and Age_response were random variables (please see adjusted R^2 value for all models in Appendix 4). In addition, we also checked the Pearson's residuals for all models and found that neither does any model indicate a lack of fit nor provide evidence of over-dispersion of the fitted value (p values greater than 0.05). From these two different tests, it is clear that the sixth model exhibits the best fit since it produces significance for most of the variables.

In addition, we further tested the selected model using other criteria. For example, we plotted fitted values with standard residuals for our observation of total incomes, age of the respondents, and household size and found that the residual values were mostly distributed near to zero, which means the sum of residuals is almost zero and predicted value is fitted well with our observed values. Moreover, we performed an ANOVA test between observed mean and predicted mean and found no significant difference among them. Therefore, we concluded that the model can predict with selected observed variables. We repeated the same process for all four regulating and cultural services and six different scenarios for both the cash and labour payment options.

3 Results

3.1 Sociodemographic information and fitted generalised linear mixed model

Table 2 provides relevant socio-demographic information on gender, age, household size, education level, ethnic, religion, household income, expenditure, status of private forest and dependency on forests for the sampled households. Overall, the median age of the respondents is 45 years. A majority of the respondents were of mixed ethnic composition and follow either Hinduism or Buddhism. The average household income was US$ 2884, while expenditure is US$ 2142, which reflects almost similar national income figure of US$ 2987 and expenditure of US$ 2152 in rural settings (CBS 2015).

From the GLMM analysis, we found the following model showed the best fit; most of the socio-economic and demographic attributes were significant for both cash and labour. We also plotted fitted values with standard residuals for total incomes, age of the respondents, and household size and found that the values were mostly distributed near to zero (see Appendix 5 for fitted model for all four services in different scenarios). In addition, no significant difference among observed and predicted mean in the ANOVA test, which suggesting that the model is fitted our observed values. We present here a sample of a predicted model for flood control services (15%) for the cash option as in Eq. 3 (please see Appendix 6 for the 24 fitted models in total, for four forest ecosystem services and six different scenarios).

$$\begin{aligned} \textit{Average of flood control value } (15\%) = & 6.657 - 0.623 \\ & * AF(Eco\_Status2) \\ & + 0.888 * AF(Edu\_Lev2) \\ & - 0.573 * AF(Dis\_For2) \\ & - 0.0638 * HHsize + 0.000001 \\ & * Tot\_Inc - 0.492 \text{ Caste2} \end{aligned} \tag{4}$$

Table 2 Sociodemographic information of the respondent

Demographic information	CF nearby		CF distant		CFM nearby		CFM distant	
	Rich ($n=32$)	Poor ($n=31$)	Rich ($n=31$)	Poor ($n=31$)	Rich ($n=32$)	Poor ($n=31$)	Rich ($n=33$)	Poor ($n=32$)
Gender (%)	F = 63 M = 37	F = 65 M = 35	F = 19 M = 81	F = 32 M = 68	F = 31 M = 69	F = 35 M = 65	F = 15 M = 85	F = 19 M = 81
Median age with range (years)	41 (19–75)	40 (18–80)	48 (24–79)	48.50 (21–74)	39 (22–68)	45 (20–75)	51 (20–84)	45 (25–77)
Family size (std. error of mean)	6.10 (0.461)	5.33 (0.37)	6.3 (0.5)	5.67 (0.413)	6.27 (0.401)	5.83 (0.525)	6.10 (0.461)	7.43 (0.545)
Educational status (%)	L = 38 U = 62	L = 68 U = 32	L = 16 U = 84	L = 58 U = 42	L = 47 U = 53	L = 61 U = 39	L = 45 U = 55	L = 78 U = 22
Ethnic composition (%)	HC = 13 LC = 87	HC = 6 LC = 94	HC = 77 LC = 23	HC = 26 LC = 74	UC = 44 LC = 56	UC = 23 LC = 77	UC = 85 LC = 15	UC = 53 LC = 47
Religion (%)	H = 75 B = 25	H = 77 B = 23	H = 100	H = 90 M = 10	H = 72 B = 22 M = 6	H = 68 B = 29 M = 3	H = 100	H = 100
Average annual income[a]/HHs (US$[b]) (std. dev.)	3532 (±2172)	1395 (±794)	6515 (±3767)	1421 (±935)	4933 (±2520)	1463 (±708)	3684 (±1785)	1671 (±985)
Average annual expenditure[c]/HHs (US$)	2026	1091	6161	1302	2672	1319	2321	1470
Private forests owners	66%	50%	40%	37%	28%	16%	64%	41%
Dependency on CBFMs	56%	46.3%	6%	14%	65%	68%	6%	11%

Data in parenthesis is standard deviation; gender: M: male, F: female; lower education level (L) (I = illiterate, P = primary/lower secondary), upper (U) = (high school and college above); ethnic composition: higher caste (HC): Bahun/Kshetri/Dashanami/Madeshi, lower caste (LC): Janajati, Janajati/Madhesi, and Dalit; religion: H = Hindu, B = Buddhists, M = Muslim

[a]Incomes are derived from agriculture, horticulture, livestock, daily wages, foreign employment, different types of salaries, small businesses, fisheries, NTFP/medicinal plants and firewood collection

[b]One US$ = NPR 110.52

[c]Expenditure includes foodstuff, clothing, education, health, agriculture, purchasing land, livestock, paying interest, etc.

where ES refers to economic status of respondent (1 rich, 2 poor), DF refers to distance from forests (1 nearby, 2 far from forests), EL refers to educational level of the respondents (1 high school and below, 2 college and above); HS refers to household family size (number); TI refers to household yearly income (NRs), C refers to caste (1 upper, 2 lower); G refers to gender (male 1, female 2); and AR is age of the respondents (years)..

3.2 Valuation of regulating services

We calculated average willingness to pay of all eight sub-groups: the sum of willingness to pay divided by the total number of respondents in each sub-group. We also included the standard deviations of willingness to pay values in the results.

3.2.1 FC values

The average willingness to pay for flood control services differs according to management modality, economic status, and proximity to forest area (Table 3).

In the community forest, rich-distant users expressed the highest willingness to pay for flood control services (US$4.95 to US$13.5/HH/year) followed by rich-nearby users (US$3.2 to US$7.2/HH/year) for all three scenarios. Irrespective of spatial distance to forests, poor households expressed low willingness to pay (US$1.5 to US$3.3/HH/year). In terms of labour contribution, rich-nearby users offered the highest number of labour days (2.2 to 7.2 man-day/HH/year) followed by rich-distant users for all scenarios. Poor households (both nearby and distant) offered a lower labour contribution for the same scenario (1.5 to 3.5 man-day/HH/year).

In the case of collaborative forest management, wealthier-nearby users showed the highest willingness to pay for flood control services (US$3.5 to US$10.10/HH/year) followed by poor users from the same area. Poor users in both nearby and distant forest areas expressed the minimum (US$0.4 to US$1.1/HH/year) willingness to pay for all scenarios. Regarding labour contribution, the poor for all groups showed similar willingness to pay compared to a cash contribution for all scenarios (Table 3).

Table 3 Average willingness to pay (WTP) for flood control by different sub-groups per households per year (in US$ and labour days)

Services types	Category	CF nearby		CF distant		CFM nearby		CFM distant	
		Rich, $n=30$	Poor, $n=31$	Rich, $n=30$	Poor, $n=30$	Rich, $n=30$	Poor, $n=30$	Rich, $n=30$	Poor, $n=30$
Flood control	FCC_15%	3.2 (1.9)	1.8 (1.4)	4.9 (4.1)	1.5 (1.1)	3.5 (2.5)	1.7 (1.3)	1.1 (0.7)	0.4 (0.2)
	FCL_15%	2.2 (1.7)	2.0 (1.6)	2..0 (1.6)	1.5(1.2)	2.0 (1.5)	1.8 (1.2)	0.5(0.2)	0.4 (0.3)
	FCC_30%	4.9 (3.1)	2.5 (1.7)	9.4 (8.2)	2.8 (1.5)	6.5 (5.2)	2.8 (2.1)	2.0 (1.3)	0.7 (0.4)
	FCL_30%	3.0 (2.1)	2.9 (2.3)	3.0 (2.2)	2.9 (2.3)	3.8 (2.1)	3.5 (1.5)	1.0 (0.6)	0.8 (0.5)
	FCC_45%	7.2 (4.7)	3.3 (2.1)	13.5 (11.0)	5.3 (3.5)	10.1 (5.2)	3.9 (2.7)	3.0 (2.2)	1.1 (0.6)
	FCL_45%	3.6 (2.1)	3.5 (2.2)	4.5 (3.1)	4.5 (3.1)	5.9 (4.3)	4.0 (1.9)	1.6 (1.1)	1.0 (0.7)

FCC flood control value in cash, *FCL* flood control value in labour days (standard deviation in parenthesis)

The generalised linear mixed model (GLMM) employed confirmed that economic status, educational level, distance from forests, household size and caste have a significant correlation with willingness to pay for flood control services (see Table 4 for test results for all variables with Pearson's chi-square residual p value of the model).

3.2.2 Water quality improvement values

The average willingness to pay values for water quality improvement (WQI) services for the different sub-groups varied by spatial distance and socio-economic status (Table 5).

In community forest, rich-nearby households expressed the highest willingness to pay for water quality improvement services (US$6 to US$18/HH/year) for increased forest cover (15% to 45%), while poor households stated low willingness to pay (US$2.5 to US$4.5/HH/year) for different water quality improvement scenarios. Rich-distant users expressed a similar desire for WQI as rich-nearby users; however, poor-distant users offered somewhat higher (US$3 to US$4.5/HH/year) for the different scenarios. Referring to labour days, rich users in the community forest offered the highest man-days (2.0 to 7.5 man-day/year) irrespective of their proximity to a forest area. Poor-distant users showed similar man-day contributions, while the nearby-poor households offered the least labour contribution (1.2 to 3.6 man-day/year).

In the case of collaborative forest management, rich-nearby households were willing to pay the highest amount (US$6.5 to US$17/HH/year) followed by poor households living in the same area (US$3 to US$7.40/HH/year). Both types of users (rich and poor) living a long distance from forests expressed a low willingness to pay ranging from US$ 1.0 to US$4.0/HH/year. For labour contribution, rich-nearby users offered the highest number of days (2.7 to 7.6

Table 4 Effect of different socio-demographic characteristics on willingness to pay for flood control service under different conditions (15%-45%)

Fixed effects	Coefficient	Std. err	p value	Coefficient	Std. err	p value	Coefficient	Std. err	p value
FRC	FRC_15%			FRC_30%			FRC_45%		
Intercept	6.75775	0.3596270	0.0000	7.012494	0.3436474	0.0000	7.364783	0.3379891	0.0000
AF (Eco_Status)2	− 0.62381	0.1696527	0.0003	− 0.533945	0.1644978	0.0015	− 0.547819	0.1610087	0.0009
AF (Edu_lev)2	0.88823	0.1601841	0.0000	0.821379	0.1532963	0.0000	0.718067	0.1516314	0.0000
AF (Distant_For)2	− 0.57345	0.1641240	0.0006	− 0.477084	0.1579875	0.0030	− 0.498803	0.1539332	0.0015
Household size	− 0.06386	0.0281076	0.0246	− 0.051607	0.0265135	0.0536	− 0.040750	0.0256047	0.1137
Total Income	0.00000	0.0000002	0.0004	0.000001	0.0000002	0.0000	0.000001	0.0000002	0.0000
Caste2	− 0.49243	0.1528783	0.0016	− 0.502633	0.1465624	0.0008	− 0.539571	0.1425283	0.0002
Pearson's χ^2 residuals	0.001			0.0009			0.0001		
FRL	FRL_15%			FRL_30%			FRL_30%		
Intercept	0.89085	0.2952606	0.0030	1.3863187	0.282	0.0000	1.7982	0.2968	0.0000
AF (Eco_Status)2	− 0.10243	0.131801	0.4383	− 0.194487	0.124456	0.1203	− 0.2540676	0.12947892	0.0500[1]
AF (Edu_lev)2	0.5524099	0.1246256	0.0000	0.5225054	0.1184	0.0000	0.5753	0.1224	0.0000
AF (Distant_For)2	− 0.4673833	0.1216811	0.0002	− 0.48405	0.1159	0.0001	− 0.4533	0.1220	0.0003
Pearson's χ^2 residuals	0.0003			0.0001			0.001		

Eco_Status economic status, *Edu-lev* education level, *Distant_For* distant for, *Age_respon* age of the respondents, *Tot_Inc* total income, *AF* as a factor, *FRL* flood control in labour days

Table 5 Average—willingness to pay for water quality improvement by different sub-groups per HHs per year (in US$ and labour days)

Services types	Category		CF nearby	CF distant		CFM nearby		CFM distant	
		Rich, $n=30$	Poor, $n=31$	Rich, $n=30$	Poor, $n=30$	Rich, $n=30$	Poor, $n=30$	Rich, $n=30$	Poor, $n=30$
Water quality improvement services (WQI)	WQIC_15%	6.0 (3.9)	2.5 (1.1)	6.0 (4.0)	3.0 (1.2)	6.5 (4.2)	3.0 (2.0)	2.0 (1.0)	1.0 (1.0)
	WQIL_15%	2.4 (1.5)	2.0 (1.3)	2.0 (1.3)	2.0 (1.0)	2.7 (2.0)	1.5 (1.1)	1.0 (0.7)	0.5 (0.2)
	WQIC_30%	11.9 (8.0)	5.0 (2.9)	9.0 (6.0)	4.0 (2.7)	13.0 (9.4)	5.7 (3.2)	3.0 (1.8)	1.8 (1.0)
	WQIL_30%	4.7(3.2)	4.0 (2.0)	3.5 (2.4)	3.8 (2.0)	4.8 (2.0)	3.0 (1.6)	1.9 (1.1)	1.0 (0.6)
	WQIC_45%	18.0 (7.9)	7.4 (5.0)	11.9 (7.8)	5.0 (3.9)	17.0 (12.0)	8.4 (5.0)	4.0 (2.0)	2.9 (1.0)
	WQIL_45%	7.5 (5.0)	6.5 (5.0)	6.5 (4.5)	6.5 (3.0)	7.6 (4.0)	4.5 (2.0)	2.7 (1.0)	1.5 (0.5)

WQIC water quality improvement value in cash, *WQIL* water quality improvement value in labour day (standard deviation in parenthesis)

man-day/HH/year) followed by poor users in the same area. Poor-distant users offered the lowest labour contribution (0.5 to 1.5 man-day/year).

Of all attributes tested, total income and education level are positive, and household size, economic status and caste are negatively associated with willingness to pay for water quality improvement as a cash option, while education is positive, and economic status and distance from the forests are negatively correlated with labour contribution (Table 6).

3.3 Valuation of cultural services

3.3.1 Bequest values

The average willingness to pay for bequest value (BV) also differed according to socioeconomic condition and distance to the forest (Table 7).

Referring to the community forest, the rich-nearby users offered the highest willingness to pay (US$7 to US$14/HH/year) followed by rich-distant users for three different scenarios of bequest value. In contrast, poor-distant users offered the lowest willingness to pay (US$1 to US$3/HH/year). A similar trend to that indicated for willingness to pay cash is shown for labour contribution. Well-off users were ready to invest the highest number of man-days (2 to 5.5 man-day/HH/year), while poor users offered slightly lower numbers (1.5 to 4.2 man-day/HH/year) for the different scenarios.

In the collaborative forest management FM area, the rich-nearby users offered the highest amount (US$8 to US$ 15/HH/year) for bequest value, while distant users from the same category offered almost one-fourth that. The labour contribution offered, on the other hand, was highest (2.5 to 6 man-day/HH/year) for rich users living near the forests followed by poor users from the same area.

Similar to FC and WQI, income is positively associated with level of willingness to pay for bequest value (BV), suggesting that increases in unit level in income increases WTP

Table 6 Effect of different socio-demographic characteristics on willingness to pay for water quality improvement under different conditions (15–45%)

Fixed effects	Coefficient	Std. err	*p* value	Coefficient	Std. err	*p* value	Coefficient	Std. err	*p* value
WQIC	WQIC_15%			WQIC_30%			WQIC_45%		
(Intercept)	7.234446	0.275954	0.0000	7.054326	0.3692724	0.0000	7.325048	0.3367777	0.0000
AF (Eco_Status)2	− 0.742254	0.140987	0.0000	− 0.619699	0.1866758	0.0011	− 0.642210	0.1644233	0.0001
AF (Edu_lev)2	0.494297	0.12479	0.0001	0.467985	0.1602609	0.0041	0.293649	0.1529548	0.0569
AF (Distant_For)2	− 1.20822	0.140534	0.0000	− 0.920797	0.1771162	0.0000	− 0.772341	0.1565443	0.0000
HH size	− 0.05549	0.02285	0.0164	− 0.035823	0.0283771	0.2089	− 0.042591	0.0264820	0.1100
Total Income	0.000001	0.000000	0.0033	0.000001	0.0000002	0.0062	0.000001	0.0000002	0.0001
Caste	− 0.25622	0.12563	0.0433	− 0.02722	0.1697772	0.8728	0.007228	0.1481291	0.9611
Pearson's χ^2 residuals	0.0001			0.00001			0.0002		
WQIL	WQIC_15%			WQIC_30%			WQIC_45%		
(Intercept)	1.4674236	0.24166894	0.0000	1.9493200	0.24927453	0.0000	2.3076056	0.25315178	0.0000
AF (Eco_Status)2	− 0.2356257	0.11145401	0.0362	− 0.2572740	0.11644421	0.0287	− 0.2948412	0.11909439	0.0145
AF (Edu_lev)2	0.4014262	0.10432512	0.0002	0.4421669	0.10840738	0.0001	0.4228179	0.11096201	0.0002
AF (Distant_For)2	− 0.6641104	0.10509946	0.0000	− 0.7061746	0.10958154	0.0000	− 0.6286190	0.11132355	0.0000
Pearson's χ^2 residuals	0.000006			0.00001			0.00003		

Eco_Status economic status, *Edu-lev* education level, *Distant_For* distant for, *Age_respon* age of the respondents, *Tot_Inc* total income, *AF* as a factor

Table 7 Average willingness to pay for bequest value by different sub-groups per HHs per year (in US$ and labour days)

Service types	Category	CF nearby		CF distant		CFM nearby		CFM distant	
		Rich, $n = 30$	Poor, $n = 31$	Rich, $n = 30$	Poor, $n = 30$	Rich, $n = 30$	Poor, $n = 30$	Rich, $n = 30$	Poor, $n = 30$
Bequest value	BVC_15%	7.0 (5.2)	2 (0.5)	5 (2.3)	1 (0.4)	8 (6.0)	2 (1.5)	2 (1.0)	1 (0.4)
	BVL_15%	2.3 (1.2)	1.9 (1.3)	2.3 (1.3)	1.9 (1.1)	2.3 (1.7)	1.9 (1.2)	2.0 (0.3)	1.6 (0.6)
	BVC_30%	11 (7.8)	4 (1.9)	9 (5.8)	2 (1.2)	12 (7.8)	3 (1.8)	3 (1.4)	1(0.5)
	BVL_30%	4 (2.7)	3.5 (2.1)	4.1 (2.5)	3.4 (2.1)	4.4 (2.2)	3.4(1.6)	3.5 (0.6)	3 (0.9)
	BVC_45%	14 (9.5)	5 (3.5)	13 (8.0)	3 (1.3)	15 (10.8)	5 (2.4)	4 (1.9)	2 (0.9)
	BVL_45%	5.9 (2.9)	4.9 (2.2)	6.0 (3.3)	4.8 (2.1)	6.0 (3.5)	4.9 (1.7)	4.3 (0.8)	4.0 (1.2)

CF community forest, *CFM* collaborative forest, *BVC* bequest value in cash, *BVL* bequest value in labour day (standard deviation in parenthesis)

of all three scenarios, while economic status, distance from forests, and household size of the respondents are negatively associated with willingness to pay for bequest value (Table 8).

3.3.2 Aesthetic values

Table 9 shows the average willingness to pay values for aesthetic value (AV) for the different sub-groups in both community-based forest management types.

Rich-distant users of community forests offered the highest willingness to pay (US$4 to US$10/year) followed by nearby-users in the same economic category. Poor users from both nearby and at a distance expressed a lower willingness to pay (US$1 to US$5/HH/year). Considering the labour contribution, rich-distant users offered a high number of man-days followed by nearby users from same the category living adjacent to a forest area. Poor users living nearby and at a distance from a forest offered a low labour input (1–3 man-days/HH/year) for the scenario of aesthetic services.

Total income and education of the respondents are positively associated with willingness to pay for AVs while distance from forests, household size and caste of the respondents are negatively associated with willingness to pay for aesthetic value in cash (Table 10).

4 Discussion

The open-ended contingent valuation method is flexible, easily understood by the users and useful for estimating many non-use ecosystem services. This method is easy to analyse and does not rely on distributional assumptions and is statistically more efficient than the dichotomous contingent approach because it identifies continuous individual WTP and does not suffer from “yea-saying” (Gordillo et al. 2019). Despite many researchers’ concerns about the CVM method in relation to invalidity and replicability (Pagiola et al. 2004; Venkatachalam 2004) and differences between hypothetical scenarios and actual behaviour (Bateman et al. 2010; Rasul et al. 2011), many studies have applied this method to elicit

Table 8 Effect of different socio-demographic characteristics on willingness to pay for bequest value under different conditions (15–45%)

Fixed effects	Coefficient	Std. err	p value	Coefficient	Std. err	p value	Coefficient	Std. err	p value
BVC	BVC_15%			BVC_30%			BVC_45%		
(Intercept)	6.854291	0.3239501	0.0000	7.080303	0.3268791	0.0000	7.320905	0.31004869	0.0000
AF (Eco_Status)2	− 0.861778	0.1698299	0.0000	− 0.91685	0.1642297	0.0000	− 0.804582	0.15461807	0.0000
AF (Edu_lev)2	0.165754	0.1543238	0.2846	0.04950	0.1519552	0.7449	0.106384	0.14372103	0.4604
AF(Distant_For)2	− 0.970307	0.1628313	0.0000	− 0.74175	0.1582851	0.0000	− 0.696427	0.14852181	0.0000
HH size	− 0.053368	0.0265950	0.0467	− 0.05271	0.0260378	0.0448	− 0.051601	0.02447466	0.0367
Total Income	0.000001	0.0000002	0.0003	0.000001	0.0000002	0.0002	0.000001	0.00000019	0.0000
Caste	− 0.169950	0.1467619	0.2488	− 0.07057	0.1453976	0.6282	− 0.099055	0.13743103	0.4722
Pearson’s χ^2 residuals	0.0001			0.0004			0.0005		
BVL	BVL_15%			BVL_30%			BVL_45%		
(Intercept)	1.086001	0.26701764	0.0001	1.349592	0.26088434	0.0000	1.6574205	0.25414627	0.0000
AF(Eco_Status)2	0.273467	0.1182	0.0222	0.293619	0.11483012	0.0116	0.3533008	0.11204596	0.0020
AF(Distant_For)2	− 0.461914	0.1116179	0.0001	− 0.446919	0.10969181	0.0001	− 0.4060569	0.10694301	0.0002
Pearson’s χ^2 residuals	0.0001			0.00002			0.0002		

Eco_Status economic status, *Edu-lev* education level, *Distant_For* distant for, *Age_respon* age of the respondents, *Tot_Inc* total income, *AF* as a factor

Table 9 Average willingness to pay of aesthetic value by different sub-groups per HHs per year in US$ & labour days

Service types	Category	CF nearby		CF distant		CFM nearby		CFM distant	
		Rich, $n=30$	Poor, $n=31$	Rich, $n=30$	Poor, $n=30$	Rich, $n=30$	Poor, $n=30$	Rich, $n=30$	Poor, $n=30$
Aesthetic value	AVC_15%	3 (1.6)	1 (0.3)	4 (2.1)	1 (0.3)	4(1.7)	1(0.5)	1 (0.2)	0.3(0.1)
	AVL_15%	2(1.1)	2 (1.2)	2 (1.3)	1 (0.7)	2(0.8)	2(1.0)	1(0.5)	0.2(0.07)
	AVC_30%	4 (2.3)	2 (1.1)	7 (4.5)	2 (1.4)	5(3.3)	2(1.1)	1(0.6)	0.4(0.2)
	AVL_30%	3 (1.5)	3(1.7)	3.2 (2.1)	1 (0.6)	3 (1.4)	3(1.1)	1(0.4)	0.2 (0.1)
	AVC_45%	6 (2.5)	3 (1.1)	10 (6.8)	3 (1.6)	7 (4.4)	3(1.8)	2 (1.1)	1(0.4)
	AVL_45%	4(2.1)	3 (2.2)	4.2 (3.2)	2 (1.1)	4(3.1)	3(1.3)	1(0.7)	0(0.0)

CF Community Forest, *CFM* Collaborative forest, *AVC* Aesthetic Value in Cash, *AVL* Aesthetic Value in Labour Days (standard deviation in parenthesis)

information for flood control, water quality improvement, bequest and aesthetic value of forest. As noted, they have overcome the limitations by utilising the guidelines developed by the National Oceanic and Atmospheric Administration (NOAA) (Arrow et al. 1993) and fulfilling the conditions OE contingent valuation required to be incentive compatible as suggested by (Vossler and Holladay 2016).

The results of FES research have to date played a limited role in discussions of the management of ecosystems to achieve combined social and ecological objectives. The lack of consideration and poor integration of social sciences in ecological or economic studies have resulted in limited progress in understanding the socio-ecological complexities inherent in these areas (Reyers et al. 2010; Lele et al. 2013; Lele and Srinivasan 2013). This could be improved by incorporating socially disaggregated economic values of many high-priority FES to enrich our understanding of how people place values on FES (Polishchuk and Rauschmayer 2012; Forsyth 2015). Although we have analysed our data in a disaggregated manner, we could not compare our results with other studies due to the lack of such studies, and therefore, we compared our overall results with other global literature.

Above 95% of the respondents are willing to pay either in cash or in kind for all four services. These results are consistent with many studies conducted in developing countries (Maraseni et al. 2008; Rai et al. 2015; Atinkut et al. 2020) and also indicate a clear a demand for those non-marketed forest ecosystem services. The reasons behind the high response rate in our case are as follows: (1) the use of face-to-face interviews; (2) flexibility of our interview times (we usually conducted interviews in respondents′ leisure time, either early in the morning or late evening); (3) the research issues are of interest to forest users and they care about the outcomes of the research; and (4) offering the opportunity to express willingness to pay as two different options (labour days and cash).

Table 10 Effect of different socio-demographic characteristics on willingness to pay for aesthetic value under different conditions (15%-45%)

Fixed effects	Coefficient	Std. err	p value	Coefficient	Std. err	p value	Coefficient	Std. err	p value
AVC	AVC_15%			AVC_30%			AVC_45%		
(Intercept)	6.182200	0.3536673	0.0000	6.429598	0.3281168	0.0000	6.445659	0.3254425	0.0000
AF (Eco_Status)2	− 0.502158	0.1801870	0.0060	− 0.482245	0.1671861	0.0045	− 0.553733	0.1655559	0.0011
AF (Edu_lev)2	0.105608	0.1676143	0.5297	0.151627	0.1551772	0.3302	0.121634	0.1534932	0.4294
AF (Distant_For)2	− 0.639470	0.1652191	0.0002	− 0.619360	0.1516574	0.0001	− 0.483271	0.1485676	0.0014
Household size	− 0.046442	0.0274386	0.0927	− 0.028393	0.0248149	0.2545	− 0.010959	0.0240763	0.6497
Total Income	0.000001	0.0000002	0.0001	0.000001	0.0000002	0.0000	0.000001	0.0000002	0.0000
Caste	− 0.287061	0.1607573	0.0763	− 0.302449	0.1480634	0.0429	− 0.178681	0.1457123	0.2221
Pearson's χ^2 residuals	0.0002			0.00008			0.0002		
AVL	AVL_15%			AVL_30%			AVL_45%		
(Intercept)	1.0270129	0.4015267	0.0116	1.409633	0.3876668	0.0004	1.7582509	0.4006866	0.0000
AF (Eco_Status)2	− 0.3862142	0.1850431	0.0386	− 0.391073	0.1757758	0.0277	− 0.3935216	0.1879756	0.0381
AF (Edu_lev)2	0.6070391	0.1708090	0.0005	0.686339	0.1634834	0.0000	0.6779231	0.1689266	0.0001
AF (Distant_For)2	− 0.6752174	0.1768470	0.0002	− 0.719352	0.1700438	0.0000	− 0.6658728	0.1775134	
Pearson's χ^2 residuals	0.0004			0.00006			0.00004		

Eco_Status economic status, *Edu-lev* education level, *Distant_For* distant for, *Age_respon* age of the respondents, *Tot_Inc* total income, *AF* as a factor

Our results suggest that users' wealth level, proximity to a forest area, income and size of the household generally govern the WTP values of all four services, which is consistent many global studies. For example, as income increases, the WTP value for the water quality improvement scenario and flood control also increases in USA (Nelson et al. 2015; Aguilar et al. 2018). Furthermore, our study revealed that the WTP value of three services, namely flood control, water quality improvement and aesthetic values, is consistent for both cash and labour payment options. In contrast, poor households offered a higher WTP in the case of bequest value in both labour and cash options, suggesting that they are more concerned to preserve the forests for future generations. This is very logical as they do not have many things to leave for their future generations, except their forests.

Many researchers suggest that the payment option is critical for exploring the WTP value and suggest that labour input is a better option in the case of low-income countries (Vondolia et al. 2014; Rai et al. 2015; Owuor et al. 2019), as their opportunity cost of time is low. However, our finding reveals that such a wholesale approach needs to be critically weighed. Our case study country, Nepal, is a low-income country, however, most of the well-off households offered fewer labour-days compared to their offer of cash, whereas the opposite was true for poor households. This is because the opportunity cost of time for rich people is higher than that for poor people. This provides evidence that the willingness to pay in the form of labour could be a better option mainly for poor households, regardless of their country of origin or location.

We have also predicted the WTPs for all four services and six different scenarios using 24 fitted models along with other socio-economic attributes. Details of the discussion are in Sect. 4.1.

4.1 Economic contribution of regulating services by different sub-groups

4.1.1 Willingness to pay for flood control service

Forest users offered an overall WTP of US$3.2 to US$7.2/HH/year for different scenarios of flood control service. This WTP value is both similar to (US$ 6.2/HH/year) (Birol et al. 2009) and higher than (US$23 to US$620/HH/year) the results of other global studies (Ryffel et al. 2014; Soy-Massoni et al. 2016; Aguilar et al. 2018). A possible reason for the low value placed on flood control in our study could be due to the level of average annual income of the respondents. For example, Ryffel et al. (2014) assessed the flood control value in the Kleine Emme catchment in Switzerland, a high-income country with an average annual income of US$57,119 in contrast with the average annual income of our respondents of US$2884.

The WTP for the FC service differs according to users' economic status. As presented in the results, distant-rich users in CF offered almost one and a half to two times more willingness to pay compared to nearby-rich users. Another potential reason for the high WTP of the rich-distant users in our study could be the price of private property (e.g. house and land) and the type of farming system. For instance, the rich distant users in the CF live in a semi-urban area, where the price of land is almost five to six times higher than the price of land in the nearby community forest area. Similarly, the distant users in the community forest mostly engage in commercial sugarcane cultivation (Neupane et al. 2017; Acharya et al. 2019a), which yields high profits from agriculture in comparison to the subsistence farming of the nearby users. In terms of labour contribution, rich users offered a low number of labour-days compared to a cash contribution for all scenarios. Rich users in our study area engage in multiple livelihood options such as commercial agriculture, small shops and professional occupations and unsurprisingly could not offer high numbers of labour days.

Statistical analysis for income and education are positively associated, and economic status, distance from forests, HH size and caste are negatively associated with the cash option, while education is positive and distance from forests is negatively correlated with the labour payment option. The higher the annual income and education of the respondents, the higher the WTP in all scenarios, which is consistent with the findings of global studies (Lehtonen et al. 2003; Devkota et al. 2014; Nyongesa et al. 2016). In contrast, as household size increases, the WTP for FC value decreases, which is also consistent with some other studies (Rai et al. 2015; Nyongesa et al. 2016).

4.1.2 Willingness to pay for water quality improvement

Our overall results for water quality improvement as presented in Table 9 (US$ 3.8 to US$ 9.0/HH/year) for different scenarios both concur with and contradict other global studies. The results are similar (US$2.0 to US$12.64/HH/year) to the findings of some studies (Johnson and Baltodano 2004; Roesch-McNally and Rabotyagov 2016; Chaikaew et al. 2017), while they are higher than those (US$19.5 to US$107/HH/year) reported in other studies (Milon et al. 1999; Shrestha and Alavalapati 2004; Tao et al. 2012; Dauda et al. 2014; Aguilar et al. 2018) (Table 9). Since WTP is influenced by attitude towards the type of service and the level of awareness of forest conservation, the results revealed relatively low WTP for WQI. Scholars accept that all non-marketed FES, including WQI benefits from forests, are supposed to be free services (Bhatta et al. 2014; Aguilar et al. 2018), which could influence the low WTP in our study site. Some researchers have claimed that low WTP for forest conservation is associated with a lower level of conservation

Table 11 Overall results and global literature on water quality improvement services (US$/Year). WQIC = water quality improvement value in cash

Category	Our study	Other global references									
		(Shrestha and Alavalapati 2004)	(Chaikaew, Hodges et al. 2017)	(Aguilar, Obeng et al. 2018)	(Tao, Yan et al. 2012)	(Johnson and Baltodano 2004)	(Dauda, Yacob et al. 2014)	(Roesch-McNally and Rabotyagov 2016)	(Milon, Hodges et al. 1999)	(Mueller 2014)	(Mueller et al. 2019)
	Country										
	Nepal	USA	USA	USA	China	Nicaragua	Nigeria	USA	USA	USA	USA
WQIC	US$ 3.8–US$ 9.0	30.24–71.17/HH/year	US$ 2/HH/year	US$ 42–73/HH/year	US$ 34.44/HH/year	US$ 4.5/HH/year	19.5–107/HH/year	4.71–12.64/HH/year	US$ 60–70/HH/year	US$ 59/HH/year	US$ 59/HH/year

awareness about the resources (Baral et al. 2016) and this could lead to an acute problem of deforestation in Siwalik landscape (DFRS 2015; Singh 2017; GON 2019) (please see Table 11).

Our results revealed that the economic background of the respondent plays a key role in WTP for WQI service. For instance, rich users in both CBFM types are willing to pay a large amount of money for WQI service, compared to poor users. The difference in WTP in both sub-groups could be attributed to education and awareness among the respondents. Rich users in the study site have a higher education level (> 63% attended college and above). Moreover, rich users may have greater exposure to information about WQI service of forests through participating in a variety of training and interactions (Bhandari et al. 2016; Torkar and Krašovec 2019). This could be one reason for showing a higher WTP to pay for WQI service.

While carrying out modelling with different socio-economic variables, forest users with higher income and higher education offer higher WTP in cash for WQI in both CBFM arrangements, which is similar to the findings of other studies (Shrestha and Alavalapati 2004; Genius et al. 2008; Bhandari et al. 2016). In contrast, as the HH size increases, WTP for water quality decreases, contradicting the results of other studies (Tao et al. 2012). This could be attributed to the many competing interests for cash in a large family-household to fulfil the demand of food, clothing, and education reducing he disposable income for various purposes including forest conservation for WQI service.

4.2 Willingness to pay for cultural services in different sub-groups

4.2.1 Willingness to pay for bequest values

The overall mean WTP for bequest value (BV) ranged from US$ 3.5 to US$ 8.0/HH/year for all scenarios; these results are congruent with those of Kriström et al. (2001) who estimated US$10 to US$20/HH/year in Sweden. Other studies revealed rather higher (US$25.2 to US$ 107/HH/year) bequest values of the forests (Sattout et al. 2007; O'Garra 2009; Diafas et al. 2017).

The results revealed that irrespective of the spatial distance and economic category, forest users generally offered a high WTP in labour compared to cash for BV. The WTP results clearly indicate that they want to save forest resources for coming generations despite their economic status.

Our statistical analysis reveals that income is positively associated whereas distance from forest and household size is negatively associated with WTP of BV in the case of cash. Our findings are consistent with the findings of many other studies of income and household size (Togridou et al. 2006).

4.2.2 Willingness to pay for aesthetic values

AV refers to the appealing and inspirational aspects of the landscape (Beza 2010) and the pleasure (positive value) derived by human beings from forests. These benefits are highly appreciated. Studies on valuing the AV of forest landscapes are scarce especially in Nepal. Prior studies in Nepal are mostly related to tourism (Baral et al. 2016), ecotourism (Baral et al. 2008; Sharma et al. 2015) and recreational services (Birch et al. 2014; Sharma et al. 2019).

Overall, respondents on average were willing to pay US$ 2.2 to US$4.6/HH/year for AV service under different scenarios, which are similar to those reported by studies conducted in the USA, China and Spain (US$2.4 to US$7.0/HH/year) (Grala et al. 2012; Dou et al. 2017; Torres-Miralles et al. 2017). Other study results were high compared with our results (US$8.5 to US$24.5/HH/year) (Soy-Massoni et al. 2016; Aguilar et al. 2018).

Irrespective of the management modality and distance from forests, poor households in general offered almost eight times lower WTP compared to households in the rich category. One possible explanation for this relatively low WTP may be the respondents' other pressing needs such as housing, education of children and food requirements.

We have discussed some limitations of using the open-ended contingent valuation format and reviewed the ways suggested to overcome them, which we followed in this study. After in-depth assessment, we observed that (1) WTP increased with increasing quality of the forests and therefore there is consistency with rational choice; (2) variation in their responses in terms of cash and labor-based payment options showed that they are serious about the limitations of their disposable income; and (3) being long-term FES users, they are familiar with all the governing policies, rules and regulations of CBFM system, and therefore, they have a strong ability to assimilate and evaluate information provided to them. The logical WTP values for different forest conservation scenarios show that they valued the given environmental services wisely and meaningfully.

There are some more limitations to our study. As noted, we have estimated the value of high priority ES, i.e. flood control, water quality improvement, bequest and aesthetic values, through open-ended contingent valuation. Application of other methods such as the damage cost method for flood reduction and the replacement cost method for water quality improvement to estimate these values present alternative options to verify the WTP values of the respondents. These methods might have provided more accurate estimates. Moreover, due to the limitations of time and financial resources, this study has depended on a small sample size and focussed on one particular region of the Siwalik landscape. A large sample size covering a broad geographical area could provide more credible suggestions.

5 Conclusion

This study estimated the willingness to pay of four non-marketed ecosystem services (with six different scenarios) by members of households in community forestry and collaborative forest management systems in the *Siwalik* region of Nepal. The key conclusions of the study are:

- A large number of forest users (about 95%) from both community and collaborative forest management systems were willing to pay cash and labour for improvements in forest conditions.
- Willingness to pay for all four services is mostly shaped by economic status, distance from forests, household income and household size. For example, rich users living near a community forest showed a willingness to pay almost double for flood control compared to poor users living in the same area. These factors should be taken into account when estimating the willingness to pay for values arising from non-marketed ecosystem services.
- Researchers advocate that elicitation of willingness to pay for labour contribution is a better option in developing countries as people's opportunity cost of time is low. However, our research suggests such a blanket approach needs to be considered carefully. Nepal is a least developed country (LDC) and in our case study area, most of the rich households offered fewer labour-days compared to their cash offer, whereas the opposite was true for poor households. This is because the opportunity cost of time for rich people is higher than that of poor people. This suggests that the willingness to pay in the form of labour could be a better option only for poor households, regardless of their location.
- Although forest sub-groups from both community-based forest management arrangements offered willingness to pay for flood control and water quality services, these services are either not documented or not internalised in the existing forest operational plans. For instance, forest operational plans in Nepal nominate soil and water conservation services of forests as important ecosystem services, however, both forest management systems have implemented an irregular shelter wood system that massively opens up the canopy, leaving only a few trees, and undermining these services. Therefore, there is an urgent need to incorporate these services in the forest users' constitutions and operational plans during the revision of these documents.
- We have developed 24 different models for eliciting average WTPs from different regulating and cultural ecosystem services. The predicted WTP values using these models closely approximate those of observed WTP values. Therefore, researchers can use these models with confidence in similar socio-economic, biophysical, demographic and climatic settings.

Appendix 1. Locally adopted criteria to classify the four categories of users

Criteria	Rich	Medium	Poor	Very poor
Land holding (ha)	> 2	1–2	0.5–1	< 0.5
Occupation	> 2	2	1–2	Only 1
Food sufficiency from their own production	More than 12 months	9 to 12 months	6 to nine months	Less than six months
Livestock no	More than 5	3–5	2–3	Less than 2
Education level	College or above	SLC and above	Primary or above	Literate or illiterate
House types	Two or more storeyed/ with concreted roof	Single or more storeyed/with stone or galvanised sheet roof		Single or more storeyed/with stone or galvanised sheet roof
Membership in social groups (e.g. cooperative members)	More than four	More than three	2–3	No or single

Appendix 2. Multicollinearity test using correlation among independent variables and through variance inflation factors

Example 1: Correlation among independent variables

Mag_Model Eco_Status Distant_For Gender Age_respon

Mag_Model 1.000000000 -0.004132231 0.004132231 0.23422051 0.12027882

Eco_Status -0.004132231 1.000000000 -0.004132231 -0.07610526 0.06922862

Distant_For 0.004132231 -0.004132231 1.000000000 0.30449395 0.23592988

Gender 0.234220507 -0.076105263 0.304493949 1.00000000 0.11965283

Age_respon 0.120278816 0.069228619 0.235929878 0.11965283 1.00000000

Tot_Fam_memb 0.106424115 -0.150165736 0.093926509 0.07964491 0.20294099

Edu_lev -0.236169147 -0.355520892 0.145566362 0.13136066 -0.16336161

Caste -0.198015272 0.299550763 -0.418008835 -0.27945908 -0.17506185

Inc_Ag_AH -0.066142236 -0.393592271 0.283632062 0.16897604 0.01903213

Tot_Inc -0.049706841 -0.599599531 0.095077437 0.10355071 0.03315137

Tot_Fam_memb Edu_lev Caste Inc_Ag_AH Tot_Inc

Mag_Model 0.10642411 -0.23616915 -0.19801527 -0.06614224 -0.04970684

Eco_Status -0.15016574 -0.35552089 0.29955076 -0.39359227 -0.59959953

Distant_For 0.09392651 0.14556636 -0.41800884 0.28363206 0.09507744

Gender 0.07964491 0.13136066 -0.27945908 0.16897604 0.10355071

Age_respon 0.20294099 -0.16336161 -0.17506185 0.01903213 0.03315137

Tot_Fam_memb 1.00000000 0.01223982 -0.09214273 0.07831156 0.26737239

Edu_lev 0.01223982 1.00000000 -0.26170423 0.37192634 0.41137370

Caste -0.09214273 -0.26170423 1.00000000 -0.41580778 -0.26424912

Inc_Ag_AH 0.07831156 0.37192634 -0.41580778 1.00000000 0.52744159

Example 2: Variance inflation factor (VIF) among independent variables

Mag_Model Eco_Status Distant_For Gender Age_respon Tot_Fam_memb

1.247215 1.710172 1.406110 1.216962 1.183831 1.147717

Edu_lev Caste Inc_Ag_AH Tot_Inc

1.479690 1.610020 1.673635 2.063163

Appendix 3. Six different model specifications to select fitted model

1) M1: Depedent variable (e.g.FR). ~ as.factor(Eco_Status) + # main variable (1|Caste) + (1|Distant_For) + (1|Gender) , # random variabledata=a.df,family="poisson")……………(1)
2) M2: Depedent variable ~ as.factor(Eco_Status) * as.factor(Caste) + as.factor(Gender) + # main variable (1|Distant_For), # random variable data=a.df,family="poisson")……………………(2)
3) M3: Depedent variable ~ as.factor (Eco_Status) + Tot_Fam_memb + Caste + Tot_Inc + as.

factor(Edu_lev),random = ~ 1|Distant_For/Gender,data = dt,family = "poisson")..................(3)

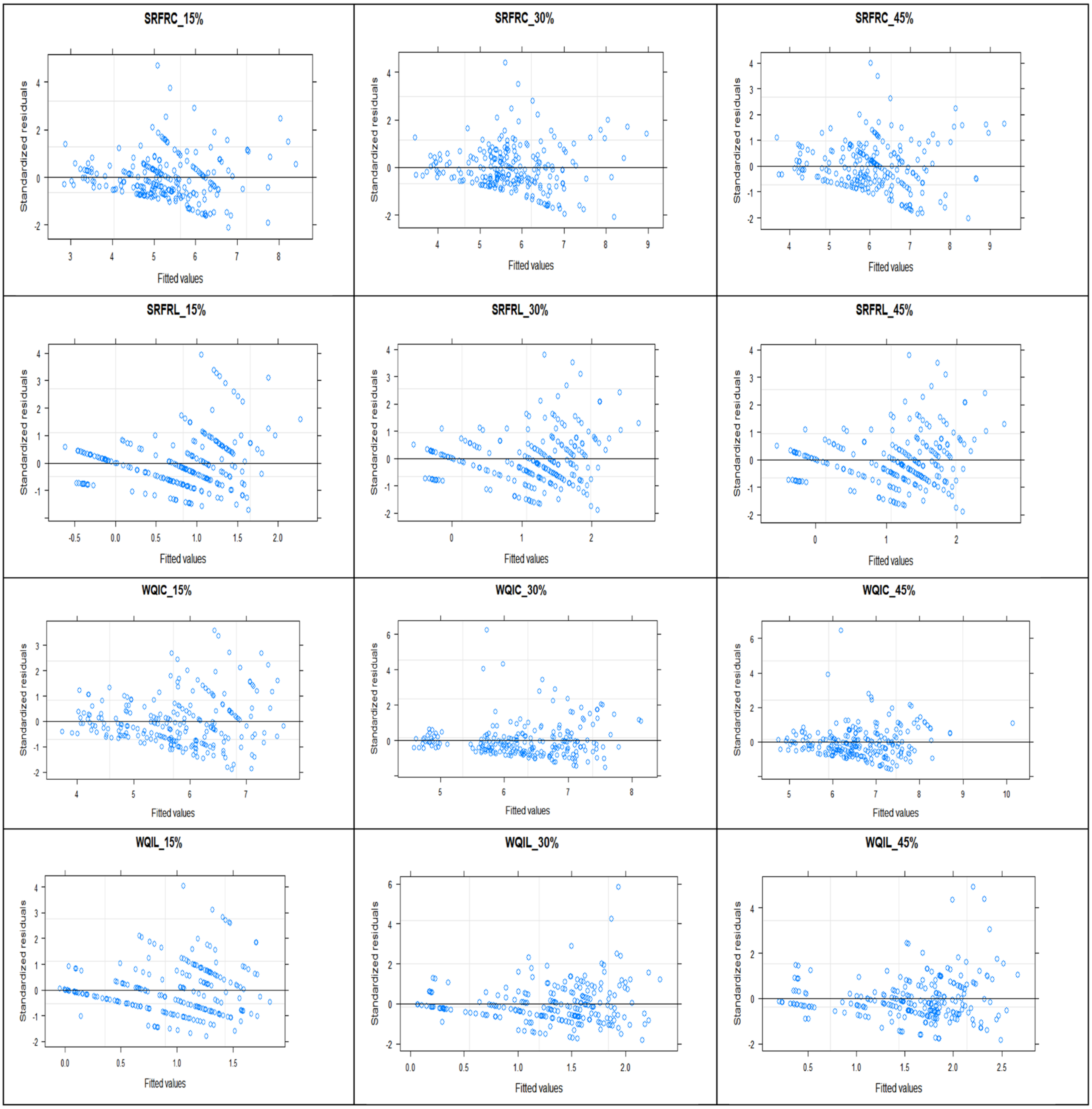
4) M4: Depedent variable ~ as.factor (Eco_Status) + as.factor(Edu_lev) + + As.factor(Distant_For)+as.factor(Tot_Fam_memb)+Tot_Inc+Caste+Gender, + random = ~ 1|Age_respon,data = dt,family = "poisson")........................ (4).
5) M5: Depedent variable. ~ as.factor(Eco_Status) + Edu_lev + * as.factor(Distant_For) + Tot_Fam_memb + as.factor(Age_respon) # main variable (1|Caste/Gender), # random variable data = a.df,family = "poisson")..................(5)
6) M6: Dependent variable ~ as.factor(Eco_Status) + as.factor(Edu_lev) + as.factor(Distant_For) + Tot_Fam_memb + Tot_Inc + Caste, random = ~ 1|Gender/Age_respon, data = dt,family = "poisson")...................(6)

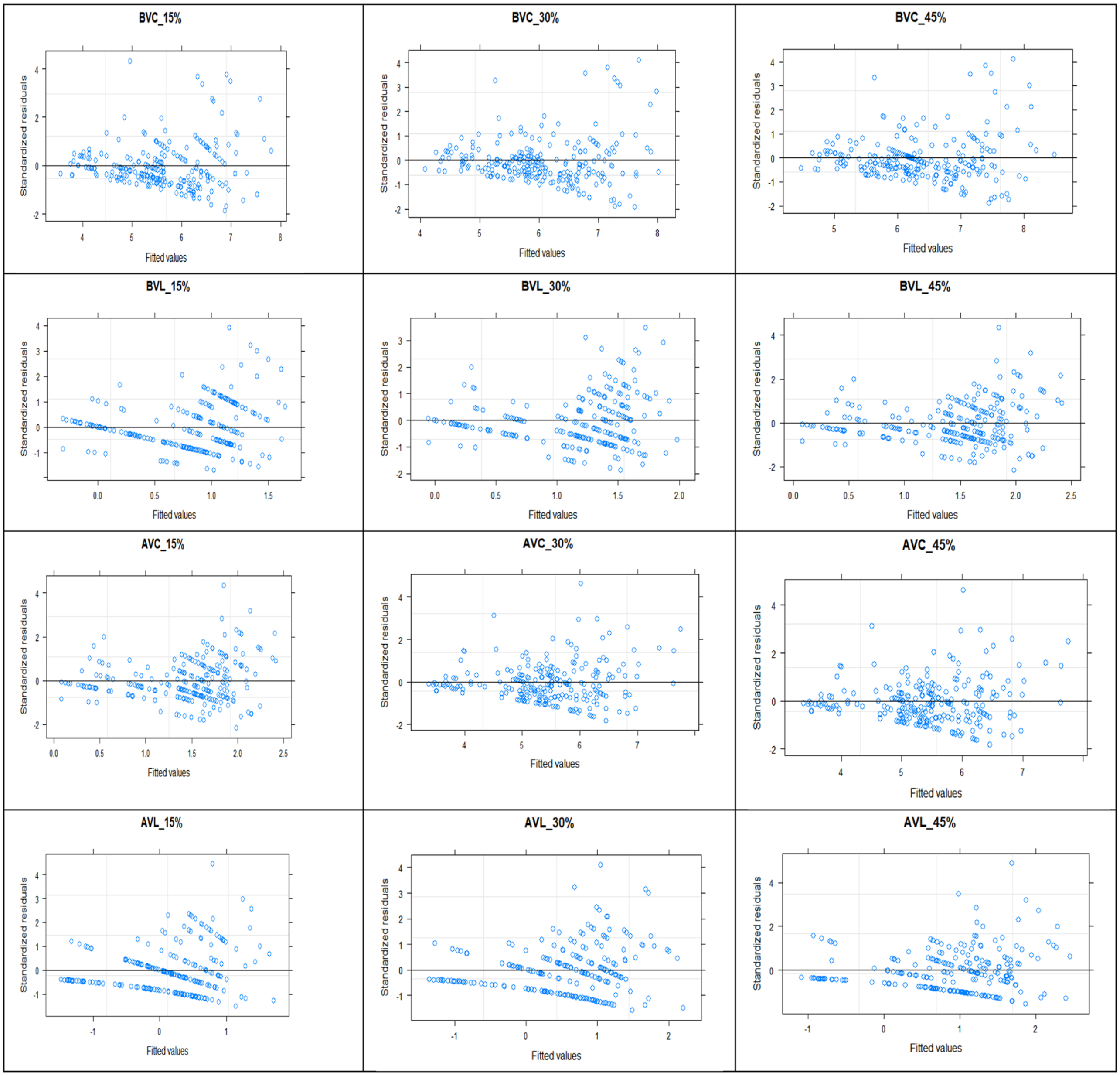
Appendix 4. X^2 Pearson's residual and adjusted R^2 values for all models

Model No	X^2 Pearson's residual	Adjusted R square	p value	Remarks
M1	1.02	0.097	4.94e−07	In M7, total income is drop from model
M2	1.025	0.11	6.44e−08	
M3	1.09	0.36	< 2.2e−16	
M4	1.093	0.74	< 2.2e−16	
M5	1.35	0.76	< 2.2e−16	
M6	1.85	0.80	2.2e−16	
M7	1.86	0.75	2.2e−16	

- The Pearson's residuals from neither model indicate a lack of fit or evidence of over dispersion of the fitted value (p values greater than 0.05).
- p Value is always less than 0.05 shows the significance of the fitted model.
- Adjusted R^2 value increases with progressive forward modelling.

Appendix 5. Standardised residuals and fitted values of all 24 selected fitted models





Appendix 6. Models for four high priority forest ecosystem services and six different scenarios

Model for flood control service prediction

1) Average of WTP of flood control value in cash (15%) = 6.757–0.623*AF(Eco_Status$_2$) + 0.888*AF(Edu_Lev$_2$)—0.573*AF(Dis_For$_2$)-0.0638*HH size + 0.000001* Tot_Inc—0.492 Caste2 ....(1)
2) Average of WTP of flood control value in cash (30%) = 7.01–0.533* AF(Eco_Status$_2$) + 0.821*AF(Edu_Lev$_2$)- 0.477*AF(Dis_For$_2$) + 0.000001*Tot_Inc – 0.526*Caste2 .... (6)
3) Average of flood control value in cash (45%) = 7.36–0.547* AF(Eco_Status$_2$) + 0.718*AF(Edu_Lev$_2$)—0.498*AF(Dis_For$_2$) + 0.000001*Tot_Inc – 0.539*Caste2 ....(3)
4) Average of flood control value in labour day (15%) = 0.89 + 0. 0.552*AF(Edu_Lev$_2$) – 0.467*AF(Dis_For$_2$) .... (4)
5) Average of flood control value in labour day (30%) = 1.38 + 0. 0.52*AF(Edu_Lev$_2$) – 0.484*AF(Dis_For$_2$) ....(5)
6) Average of flood control value in labour day (45%) = 1.80 + 0. 0.57*AF(Edu_Lev$_2$) – 0.122*AF(Dis_For$_2$) ....(6)

Model for water quality improvement services prediction

7) Average of WTP of Water Quality Improvement value in cash (15%) = 7.234 − 0.742*AF(Eco_Status$_2$) + 0.494*AF(Edu_Lev$_2$) − 1.208*AF(Dis_For$_2$)- 0.055*HH size + 0.000001* Tot_Inc − 0.256 Caste ……………*(7)*
8) Average of WTP of Water Quality Improvement value in cash (30%) = 7.054 − 0.619*AF(Eco_Status$_2$) + 0.160*AF(Edu_Lev$_2$) − 0.920*AF(Dis_For$_2$)- 0.035*HH size + 0.000001* Tot_Inc − 0.027 Caste………(8)
9) Average of WTP of Water Quality Improvement value in cash (45%) = 7.325 − 0.642*AF(Eco_Status$_2$) + 0.293*AF(Edu_Lev$_2$) − 0.77*AF(Dis_For$_2$) + 0.000001* Tot_Inc…….(9)
10) Average of WTP of Water Quality Improvement value in labour day (15%) = 1.467 − 0.235*AF(Eco_Status$_2$) + *0.40**AF(Edu_Lev$_2$) − 0.66*AF(Dis_For$_2$)…………(10)
11) Average of WTP of Water Quality Improvement value in labour day (30%) = 1.949 -0.257*AF(Eco_Status$_2$) + 0.442*AF(Edu_Lev$_2$) − 0.706*AF(Dis_For$_2$)…………….(11)
12) Average of WTP of Water Quality Improvement value in labour day (45%) = 2.307- 0. 0.294* AF (Eco_Status)2 + 0.422*AF(Edu_Lev2)—0.628*AF(Dis_For2)…….(12)

Model for bequest value prediction

13) Average of WTP of Bequest value in cash (15%) = 6.854 − 0.861*AF(Eco_Status$_2$) − 0.970*AF(Dis_For$_2$)—0.053*HH size + 0.000001* Tot_Inc …………….*(13)*
14) Average of WTP of Bequest value in cash (30%) = 7.080 − 0.916*AF(Eco_Status2) − 0.741*AF(Dis_For2)—0.052*HH size + 0.000001* Tot_Inc……………(14)
15) Average of WTP of Bequest value in cash (45%) = 7.325 − 0.80*AF(Eco_Status2) − 0.69*AF(Dis_For2)—0.051*HH size 0.000001* Tot_Inc ……….(15)
16) Average of WTP of bequest value in labour day (15%) = 1.08 + 0.273*AF(Eco_Status2) − 0.461*AF(Dis_For2)……..(16)
17) Average of WTP of bequest value in labour day (30%) = 1.34 + 0.353*AF(Eco_Status2) − 0.446*AF(Dis_For2)……..(17)
18) Average of WTP of bequest value in labour day (45%) = 1.65 + 0.293*AF(Eco_Status2) − 0.406*AF(Dis_For2)……..(18)

Model for aesthetic value prediction

19) Average of WTP of Aesthetic value in cash (15%) = 6.182 − 0.502*AF(Eco_Status2) − 0.639*AF(Dis_For2) + 0.000001* Tot_Inc ……………. (19)
20) Average of WTP of Aesthetic value in cash (30%) = 6.429 − 0.482*AF(Eco_Status2) − 0.619*AF(Dis_For2) + 0.000001* Tot_Inc …………… (20)
21) Average of WTP of Aesthetic value in cash (45%) = 6.445 − 0.553*AF(Eco_Status2) − 0.483*AF(Dis_For2) − 0.010*HH size 0.000001* Tot_Inc ……….(21)
22) Average of WTP of Aesthetic value in labour day (15%) = 1.02 − 0.386*AF(Eco_Status2) + 0.607*AFEdu_lev2 − 0.675*AF(Dis_For2)……..(22)
23) Average of WTP of Aesthetic value in labour day (30%) = 1.40 − 0.391*AF(Eco_Status2) + 0.686*AFEdu_lev2 − 0.719*AF(Dis_For2)……..(23)
24) Average of WTP of Aesthetic value in labour day (45%) = 1.75 − 0.393*AF(Eco_Status2) + 0.677*AFEdu_lev2 − 0.665*AF(Dis_For2)……..(24)

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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical statement The authors declare that they obtained the approval of the USQ Human Research Ethics Committee (Approval No. H18REA127) for conducting the present study based on Interviews/survey.

Conflict of interest The authors declare that they have no conflict of interest.

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