ISSN: 3102-0402 (print)

PADMAKANYA JOURNAL OF SCIENCE AND TECHNOLOGY (PJST)
Volume 1, Issue 1
September 2025

Research Article

Economic valuation of ecosystem services in Bihani Community Forest, Sarlahi

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Article details

Received: July 30, 2025
Revised: August 24, 2025
Accepted: August 29, 2025

Keywords:
Contingent valuation method,
Economic valuation,
Market price method,
Provisioning services,
Willingness to pay.

Cite this document as:
Nepal, P., Nepal, N. & Shrestha, Z. (2025), Economic valuation of ecosystem services in Bihani Community Forest, Sarlahi, *Padmakanya Journal of Science and Technology*, 1(1), 45-52.

Abstract

Ecosystem services (ES) play a crucial role in supporting livelihood and fostering socioeconomic status of rural community. Economic valuation of ES perceived by community serves as a basis for data driven sustainable resources management and integrated decision making. This study estimates the value of provisioning services provided by the Bihani Community Forest (BCF) by using the market price method. The statistically determined sample size of 79 households was surveyed via systematic sampling method during January, 2024. The value of provisioning services received by household was found to be average equivalent to NRs. 50,720.25 per household per year; which was 9.27% of average income of NRs. 4, 96,528.10 per household per year. It also evaluates the value of ecosystem services provided from BCF by calculating willingness to pay (WTP) by Community Forest User Group (CFUG) member for regulating, supporting and cultural services through their physical and monetary contribution in the conservation and sustainable management of the CF. The average WTP for the conservation and sustainable management of CF was found to be NRs. 3,649.64 per households (HH) per year. The study revealed that 29.11% of HHs was willing to pay only via physical participation, whereas 70.89% of HHs was willing to pay via both physical participation and monetary values. To assess the influence of various independent variables into WTP; multiple linear regression model with natural logarithm transformation was designed, which indicated that the time to reach CF and Family size are statistically significant predictors of WTP. The community forestry practice in BCF, Sarlahi has proven to be beneficial by providing various provisioning, regulating and aesthetic services that contributes to their livelihood and well-being. Additionally, the transfer of forest management responsibility to local community has promoted improved conservation and sustainable management of forest ecosystems.

Introduction

An ecosystem encompasses a wide range of services involving all living organisms (plants, animals, and microorganisms) and their interactions with the non-living components of their environment, such as weather, soil, sunlight, climate, and the atmosphere (Pant et al., 2012). Ecosystem services are "the benefits that people obtain from ecosystems" (Millennium Ecosystem Assessment, 2005). It is defined as "The direct and indirect contributions of ecosystems to human wellbeing" (The economics of ecosystems and biodiversity, 2010).The significance of goods and services provided by natural and managed ecosystems to humans is substantial. These valuable contributions made by ecosystems to mankind are referred to as ecosystem services (Acharya et al., 2019).

Forest ecosystems provide a range of services to human society, such as supplying environmental goods (e.g., food, fiber, and fuel), regulating climate and natural disasters (e.g., floods and erosion), supporting nutrient cycling, and offering cultural benefits related to aesthetics and recreation. Protected areas (PAs) can enhance these services through their dedicated protection and management, offering benefits like climate regulation, air and water purification, soil erosion prevention, and nutrient cycling (Department for Environment, Food & Rural Affairs, 2007). The intricate structures and essential components of ecosystems continuously interact with

one another. These interactions are vital for providing essential materials and services required for the ecosystem's maintenance and functionality, as well as for human well-being (Mengist et al., 2019).

According to Nepal's Forest Act (2019), community forests are specific areas within the national forest designated for development, conservation, and utilization by user groups with the goal of benefiting the community as a whole. This approach aims to reduce deforestation and forest degradation, while also addressing the negative impacts on rural livelihoods through the active participation of local people. The Community Forestry program involves the collaborative governance and management of forest resources by communities, the government, and other stakeholders. Its primary objective is to improve livelihoods and mitigate environmental degradation through sustainable forest management (Joshi, 2019). Community forestry mechanism seem to have greater scope in developing countries like Nepal where the state's fund is inadequate and the poverty and conservation issues are to be addressed together (Karna, 2008). The successful management history since their transfer to local communities, the number of community forests in Nepal has now exceeded 19,000 (Joshi, 2019).

Study and valuation of ecosystem services explores the vital role of ecosystem contribution in socio-economy and livelihood of agriculture and farming based livelihood (especially in rural area) via monetary valuation of various services they are receiving, which in turn guides sustainable resources management and promote integrated decision-making. However, there are very few studies regarding economic valuation of ecosystem services, leading to unsubstantiated development of benefit sharing mechanisms.

Before this study; KC et al., (2013) conducted economic valuation of ecosystem services in protected areas in inner Terai region of Baghmara Buffer Zone Community Forest of Chitwan National Park in September 2010; whereas Pant et al., (2012) estimated and studied forest ecosystem services quantitatively in the Kangchenjunga landscape in eastern Nepal during 2012. This study depicts its novelty in terms of study area (i.e. this is a case study from core Terai region) and time frame (as this research is based on latest data collected during 2024).

The study aims to evaluate the ecosystem services provided by BCF. Simultaneously the study estimates the economic value of provisioning services that are provided by BCF which are traded in market, calculates the Willingness to pay (WTP) by BCFUG members for conservation and sustainable management of BCF and explores effect of various independent variables (e.g. Time to reach CF, HH size, gender of respondent and land owned by HH) with WTP (dependent variable).

Materials and Methods

Study Area

Bihani Community Forest (Figure 1, BCF in pink shade), situated at Haripur Rural Municipality ward no. 1, Sarlahi, encompasses an area of 37.56 hectares. It is located at about 9 km south from New Road on Mahendra Highway, east of the Bagmati Canal expanding from 27.01312 °N to 27.0208 °N and 85.49535 °E to 85.50331 °E. It is located on a flat terrain in a tropical regional environment at an altitude of 85m to 100m above sea level. This forest is combination of natural and planted forest. Black, loamy soil is found in this forest.

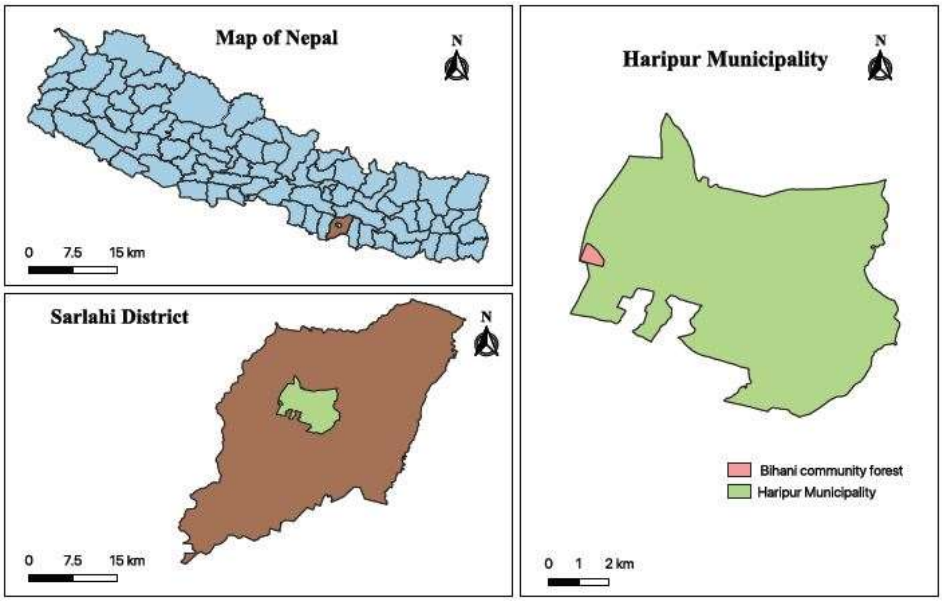

Figure 1: Study Area (Bihani Community Forest, Sarlahi) in pink shadow

The forest was handed over from District Forest Office Sarlahi as Bihani Community Forest to local user committee on 2060/03/26, the importance of forest is increasingly perceived by public hence conservation and sustainable management of BCF is satisfactory till date. The area has tropical climate with dry and cold winter and hot and humid summer lying in southern foothills of the Himalayas, temperature reaches up to 40-45°C during summer whereas the lowers around 7-12°C during winter (BCFUG Committee Chairperson, personal interview, 19th January, 2024).

BCF is habitat for species like *Shorea robusta* (Sal), *Syzygium cumini* (Jamun), *Dalbergia sissoo* (sisau), *Amaranthus viridis* (bajhi), *Bixa orellana* (Vermilion), *Bambusa vulgaris* (Bamboo) and *Eucalyptus globulus* (Spices/Masala) etc.; wild animals like *Order Artiodactyla* (Deer), *Cervus axis* (Chittal), *Susscrofa* (Wild pig), *Simiiformes catarrhine* (Monkey) as well as birds like *Columba livia* (Dove), *Corvus splendens* (Crow), *Gallus gallus* (Forest chicken or Ban kukhura), *Psittacula eupatria* (Parrot), *Pavo cristatus* (Peacock);which are commonly found in the forest.

Field Methods

Prior to the field survey, questionnaire for the HH survey was prepared and finalized. The questionnaire consisted of 18 questions. Questions regarding personal details to time to reach CF, livestock farming, land owned, sources of energy use, income, provisioning service being used from CF, ranking of services, advantages and disadvantages of CF, mode and amount of WTP were included in the questionnaire.

The total HHs registered in BCF user group was 98 (Population size). Systematic sampling was done by selecting the sample for household survey. The sample was designed for 95% confidence level and 5% margin of error. The sample was calculated based on standard formula given by (Arkin & Colton, 1963). The formula resulted the justified sample should be 79 (sample size). Using the designed questionnaires, household survey was conducted from 15th to 21st January, 2024. The BCFUG member HH's were distributed in Haripur rural Municipality-1 and Barahathawa Municipality-9.

Market Price Method

Pant et al., (2012) evaluated the economic value of provisioning services which were traded in market was calculated using Market Price Method. In this study, key informant interview, HH survey data for annual consumption of CF goods; market rate (median of rates) collected from 4 different shops/ haatbajaar were considered for the valuation of market tradable provisioning services that were being collected by HHs from BCF..

Contingent Valuation Method

This study adopted Contingent Valuation Method (CVM), which is a form of "Stated Preference Method" to identify willingness to pay. The Contingent Valuation (CV) is a standardized and widely used survey method for estimating WTP or Willingness to Accept (WTA) compensation for use, existence and bequest values for resources (Loomis, 1996). During HH survey, respondents' knowledge and awareness on various indirect services that have being provided by BCF were enquired and deliberated upon. Most of the respondents were found to be aware of provisioning service offered by BCF only whereas not sufficiently aware of other indirect services BCF provides such as carbon sequestration, local temperature control, air purification, soil erosion control, water flow regulation, hosting habitat for biodiversity, pollination, recreational and cultural significances etc.) Hence the indirect service BCF offers were discussed with respondents; following that questionnaires; they were asked to record their WTP for indirect (regulating, supporting and cultural services) that don't have market value and for conservation and sustainable management of BCF.

The understanding of respondents regarding intangible benefits of BCF such as climate regulation (carbon sequestration, local temperature control etc.), air purification, soil erosion control and water flow regulation, habitat for biodiversity, pollination, recreational and cultural significances were enquired and deliberated upon; using the questionnaires.

BCFUG members are voluntarily involved in different activities for conservation and sustainable management of CF for 5 days per year, 4 hours per day (BCFUG Committee Chairperson, personal interview, 19th January, 2024). Considering the 7 working hours per working day and district rate for forest workers as 800/day/person (District rate fixation committee, Sarlahi, 2023); monetary value of WTP for such involvement was calculated and added with collected WTP to calculate final WTP.

Multiple Linear Regression Analysis

After the compilation and entry of independent variable data (Table 1) collected from survey and calculation of WTP; scatter plots were drawn between them. The plot showed non-linear relationship between them. Wooldridge (2020) and Fox (2016) advocated for the use of log transformations to linearize non-linear relationships, which is an approach adopted in models to meet the assumptions of ordinary least squares regression. Hence following natural log-log multiple linear regression model was developed to find out the effect of considered independent variables on WTP.

$$\text{Ln(WTP)} = \alpha_0 + \alpha_1 * \text{Ln}(X_1) + \alpha_2 * \text{Ln}(X_2) + \alpha_3 * \text{Ln}(X_3) + \alpha_4 * \text{Ln}(X_4) + \varepsilon$$

Model assumed natural logarithm of WTP to be function of natural logarithm of independent variables (time to reach CF (X_1), gender of respondent (X_2), HH size (X_3) and land owned by HH (X_4)). The analysis was performed using Microsoft Excel 2010, data analysis add-in tool.

Table 1: Details of independent variables and coefficients considered for MLRM

S.N.	Independent Variable	Description	Variable type
1.	Time (X_1)	Time required to reach CF from HH	Continuous
2.	Gender (X_2)	Gender of respondent	Binary (0=male, 1=Female)
3.	HH Size (X_3)	HH size in terms of no. of members	Continuous
4.	Land (X_4)	Area of agricultural land in current possession	Continuous
5.	$\alpha_1, \alpha_2, \alpha_3, \alpha_4$	Regression coefficients for respective natural logarithm of independent variables	
6.	α_0	Regression constant or y-intercept, which is not logged in equation because parameter that is logged wasn't being estimated. rather (α) sitting in front of logged independent variable in linearized equation was being estimated.	

Results

General Description of Respondents

General demographic and socioeconomic attributes of respondents incorporated during HH survey is summarized in Table 2.

Table 2: General characteristics of respondents

Municipality/Ward no.	Haripur-1	Barahathawa-9		
	41	38		
Gender	Male	Female		
	39	40		
Age	Less than 25	25 to 45	45 to 60	Above 60
	0	31	34	14
Education	Illiterate	School level	Bachelor	Masters or higher
	49	27	3	0
Occupation	Farmer	Wage labor	Other	
	64	4	11	

Provisioning services utilized by BCF members

Key informant interview followed by HH survey reported that Food, medicines, raw materials, fuel woods and water have been provisioned by the forest user group members Table 3. Most of the food resources provisioned by the forest were the fruits and some vegetables.

Table 3: Provisional services being collected by community from BCF

Services	Name of the species
Food	*Myrica esculenta* (Kafal), *Diplazium esculentum* (fern), *Syzygium cumini* (Jamun), *Mangifera indica* (Mango), *Citrus limon* (lemon), *Artocarpus lacucha* (Barahar), *Artocarpus heterophyllus* (Jackfruit)
Medicines	*Terminalia bellirica* (barro), *Eucalyptus globules* (Masala)
Raw Materials	Timber: *Terminalia bellirica* (barro), *Shorea robusta* (Sal), *Dalbergia sissoo* (Sisau), *Eucalyptus globules* (Masala) *Bambusa vulgaris* (Bamboo) Construction material: Mud
Energy sources	*Melia azedarach* (Bakaino), *Dalbergia sissoo* (Sisau), *Eucalyptus globules* (Masala)
Water	Irrigation Purpose

Valuation of provisioning services and total income of BCFUG member HHs

The average annual income from provisioning services HHs receive from CF calculated based on market rate was found to be NRs. 50,720.25. Comprising of such income, the share of economic values for the provisioning services was via timber 48.22%, fuel wood 36.01%, Fodder 10.37%, Bamboo 2.31%, Grass 1.57% and traces via Saal leaf, Fern fiddlehead; Amriso kucho (Table 4).The average annual income of BCFUG member HHs was NRs. 4, 96,528.10. These result showed that the contribution of BCF based services (mostly via timber, fuel wood and fodder) into total income of BCFUG member HH is 9.27% (Table 5).

Table 4: Share of value for various products collected by BCFUG member HHs

S. N.	CF products	Annual consumption by Users	Market rate (NRs./Unit)			Total value (NRs.)	Average HH consumption (NRs./HH/Year)	Share of value
			Max.	Min.	Median			
1	Fodder (Bhari)	2770	175	140	150	415,500	5,259.49	10.37
2	Fuelwood (Bhari)	2886	600	450	500	1,443,000	18,265.82	36.01
3	Grass (Bhari)	630	100	75	100	63,000	797.47	1.57
4	Timber (Amount)	Saal (Cu. Ft.)	2500	2300	2450	1,932,000	24,455.70	48.22
		Sisau (Cu. Ft.)	1350	1350	1400			
5	Bamboo (Nos.)	770	150	140	140	92,400	1,169.62	2.31
6	Saal leaf (Mutha)	694	40	30	30	20,820	263.54	0.52
7	Fern fiddlehead (Mutha)	1793	25	20	20	35,860	453.92	0.89
8	KuchoAmriso (Nos.)	54	85	75	80	4,320	54.68	0.11
						Total (NRs.)	50,720.25	100

Notes:

1. Total value of timber purchased by CFUG members was found to be NRs. 3, 22,000.
2. Amount for item no. 4 and 5 was calculated considering market rate is 7 times higher than rate fixed for BCFUG members.
3. Bhari = 25kg, Saal leaf mutha = 250 gram, Fern fiddlehead mutha = 250 gram and Kucho amriso = 800 gram

Table 5: Distribution of total annual income and annual income from BCF among BCFUG member HHs

Income of BCFUG member HHs distribution parameters	Total annual income (NRs. Per Year)	Total annual income from BCF (NRs. Per Year)
Minimum	55,000.00	0.00
First quartile(Q1)	244,700.00	21,615.00
Median (Q2)	400,000.00	31,040.00
Third quartile (Q3)	713,300.00	74,175.00
Maximum	1,361,000.00	218,550.00
Average	496,528.10	50,720.25
Contribution of income from BCF into total income	9.27%	

Willingness to pay for conservation and sustainable management of CF

Out of the total surveyed BCFUG member HHs, 29.11% were willing to pay for conservation and sustainable management of BCF only via physical participation and not willing to pay in the monetary terms. Remaining 70.89% were willing to pay via both monetary terms and physical participation for the same purpose. The analysis revealed that 32.91% of HHs were willing to pay up to NRs. 2,500 per year; 53.16% willing to pay NRs. 2,501-4,000, 7.59% of HHs were willing to pay NRs. 4,001-6,000 and 6.33% of HHs were willing to pay more than NRs. 6,000 for the conservation and sustainability of BCF (Figure2). Hence the average WTP for the conservation and sustainable management of BCF was found to be NRs. 3,649.64per HH per year.

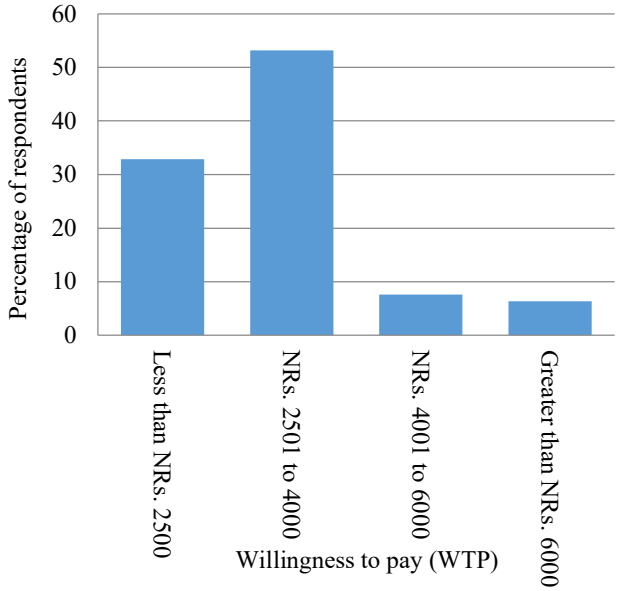

Figure 2: WTP by BCFUG member HHs (In NRs. per year)

Factors affecting WTP

The results of Natural log-log multiple linear regression model showed that the model has R^2 value of 0.218 and F Significance of 0.001. F value of 0.001 indicated the model as highly statistically significant meaning the relationship it captured was real and not due to any random chance. However low R^2(0.218) indicated that while independent variables were significant predictors, they explain only 21.8% of variation in the outcome leaving most of it to other unmeasured factors. Table6summarized the model result which showed that time to reach the forest and family sizes have significant relationship with WTP as both have p-value less that margin of error considered.

The model concluded the non-significant and random relation between WTP and gender of the respondents, land owned by HH as they have p-value higher than margin of error considered.

Table 6: Results of Multiple linear regression model

Variables	Coefficients	Standard error	P-Value
Time to reach BCF (X_1)	-0.1459	0.0650	0.0278
Gender of respondent (X_2)	0.1059	0.0893	0.2393
Family Size (X_3)	0.4157	0.1411	0.0043
Land owned (X_4)	0.0781	0.0522	0.1391
Intercept	7.4682	0.3447	0

Discussions

BCFUG member HH was utilizing various forest ecosystem products in terms of food, medicine, raw materials (eg. Timber), energy resources (eg. Fuelwood), grass and fodder for livestock etc. as mentioned in Table 3.Economic value of provisioning services from BCF was found to be NRs. 50,720.25 per HH per year; which was 9.27% of average gross income of NRs. 4, 96,528.10 per HH per Year. Lamsal et al.(2015) evaluated wetland (Ghodaghodi Lake,

western Nepal) resources contribution to the household economy of the local people. Study revealed each household extracted lake resources at an annual worth of NPR 4,379 ($63 USD), equivalent to 12.4% of the HH annual gross income. Such significant contribution from ecosystem services is remarkable for understanding crucial role of forest ecosystem in supporting socio-economy of local community.

The percentage of HHs willing to pay for conservation and sustainable management of BCF via both monetary terms and physical participation was 70.89% whereas remaining 29.11% of HHs was willing to pay only via physical participation. The HHs willing to pay only via physical participation might be due to perception of HHs that physical contribution is basic and crucial method for conservation and sustainable management of CF than monetary willingness to pay. The average WTP for the conservation and sustainable management of BCF was found to be NRs. 3,649.64 per HH per year.

Similar study of KC et al., (2013) calculated total WTP by users for the sustainable management and conservation of Baghmara Buffer Zone Community Forest (BBZCF), Chitwan as NRs. 33,310.29/HH/year which is significantly higher than WTP for BCF. This might be due to inadequate awareness and knowledge about various regulating, supporting, cultural and recreational services of community forests in BCFUG member HHs and due to the fact that the users of the BBZCF were getting better benefits owing to high activities of tourists and diversified livelihoods options. Thapa et al. (2021) calculated the average annual average WTP of a local household as US$33.95 (equivalent to NRs. 4,074) for Begnas watershed (Kaski) conservation. The calculated WTP is slightly higher than that for BCF which might be due to community perceiving higher benefits through tourism related economic activities.

Analyzing the related literatures including result of this study, the WTP by local community for conservation and sustainable management of ecosystem is found to be dependent on location of study area, nature of ecosystem services (forest, wetland or lake etc.), and respondents' awareness and knowledge regarding various indirect services offered by ecosystem.

During HH survey in BCFUG member HHs; critical recommendations were identified to enhance community forest governance including the need for greater transparency, education and awareness, improved technical capacity, inclusive participation, equitable benefit-sharing, and diversification of forest products.

The results of Natural log-log multiple linear regressions Model on WTP by the users of BCF for their efforts towards sustainable management and conservation of the forest resources; showed non-significant and random relation of gender of the respondents and land owned by HH with WTP. Whereas time to reach the CF and Family size (for both independent variable $p \leq 0.05$) had significant relation with WTP with variable having negative and positive regression coefficients respectively. It meant more access (i.e. less time to reach CF), more benefits so the HH is willing to pay higher and vice versa. On the contrary; the MLRM result showed HHs having larger family size were willing to pay higher and smaller one willing to pay lesser which might be due to more resource dependency and higher ability to access resources by larger families than smaller families. KC et al., (2013) revealed the relation of distance with WTP were significant ($p \leq 0.01$) with negative regression coefficient. The negative regression coefficient of distance indicated that WTP decreases as the distance from the forest increases. The positive coefficient in gender indicated that the females are more willing to pay as compared to the males. Acharya et al. (2021) 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). Huge variation was found in WTP among these sub-groups. The wealthier households (HH) preferred 'cash' whereas poor HHs preferred 'labor' as a payment option; nearby HH willing to pay more than the farther ones.

The effect on WTP of factors such as gender of respondent (male vs female), HH (family) size, HH income, land owned by HH were found to be depending upon location and nature of ES. But the proximity of HH to specific ES location was found to be significant factor influencing WTP.

Conclusions

The result showed 9.27%contribution of CF based product and services into total income of BCFUG member HH which implies the CF approach of forestry management seem to aid in improving socio-economy, livelihood and wellbeing of locals as well as sustainability of forest ecosystem.

As the study revealed that the CFUG members have WTP for conservation and sustainable management, their sensitization towards sustainable forest management approach was convincing. Nevertheless, several critical recommendations were identified to enhance community forest governance, including the need for greater transparency, education and awareness, improved technical capacity, inclusive participation, equitable benefit-sharing, and diversification of forest products.

There are very few studies regarding economic valuation of ecosystem services, yielding insufficient basis for the development of benefit sharing mechanisms and sustainable management of community forest. Studies regarding evaluation of ecosystem services provides data driven sustainable resources management and promote integrated

decision-making. Hence, such studies must be encouraged, promoted and ought to be brought into mainstream research.

CRediT author statement

PN: Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Data Curation, Writing- Original Draft, Writing- Review & Editing, Visualization, Supervision, Project administration; **NN:** Software, Formal analysis, Writing- Original Draft, Writing- Review & Editing, Visualization; **ZS:** Conceptualization, Writing- Review & Editing, Supervision

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