Tropical Agricultural Research (2026) 37(1):73-89

Contents available at: Sri Lanka Journals Online

Tropical Agricultural Research

Journal Home Page: https://tar.sljol.info

RESEARCH

Potential Land Use Options in Hanthana Mountain Range, Sri Lanka: An Analysis of Economic Potential and Community Preferences

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ARTICLE INFO

Article history:
Received: 10 November 2025
Revised version received: 19 December 2025
Accepted: 20 December 2025
Available online: 01 January 2026

Keywords:
Cost-benefit analysis
Economic
Ecosystem services
Hanthana
Reforestation

Citation:
Idirisinghe, I.M.G.C.K. and Prasada, D. V. P. (2026). Potential Land Use Options in Hanthana Mountain Range, Sri Lanka: An Analysis of Economic Potential and Community Preferences. Tropical Agricultural Research, 37(1): 73-89.
DOI: https://doi.org/10.4038/tar.v37i1.8962

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ABSTRACT

Forests are a significant aspect of nature that deliver ecosystem services for the betterment of living beings. Most ecosystem services of forest are unquantified in monetary terms due to the unavailability of direct market values. The main objective of this study was to evaluate the costs and benefits of various reforestation scenarios. The study is conducted based on the economics of ecosystem and biodiversity framework to recognize, demonstrate and capture the values of forests with reference to *Hanthana* forest range. The study targeted the responses of three main segments of the community related to the forestry site; Villagers of *Uda-peradeniya* and *Mawelawaththa* villages, community of University of Peradeniya and institutional stakeholders of the conservation forest areas of *Hanthana*. The sample consists of 85 respondents randomly selected within each group above. A benefit-cost analysis was performed to assess the economic viability of three selected reforestation scenarios: ecotourism site, primary forest, and participatory forest. The study revealed that the most preferred reforestation scenario was the ecotourism site, with average benefit-cost ratios for ecotourism site, primary forest and participatory forest calculated as 0.865±0.462, 2.233±0.101, and 6.86±2.509, respectively. Despite not being the most popular choice, the participatory forest scenario demonstrated the highest return relative to its costs. This study serves as a feasibility assessment, highlighting the comparative merits of reforestation projects and the importance of community participation.

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INTRODUCTION

Forests, as natural renewable resources, are pivotal to sustaining biodiversity and supporting the existence of life on Earth. They serve as reservoirs of rich biodiversity and play a critical role in stabilizing ecosystems by providing a wide array of ecosystem services (Tilman, Reich & Knops 2006; Hautier et al. 2014; Isbell et al. 2015a). More than 350 million human beings reside in or near forests (Chao, 2010). Forests contribute significantly to global food security by supplying edible food, additives and energy for food preparation. Around one-third of the global population relies on firewood from forests for cooking (FAO and UNEP, 2020). More than 1.6 billion people depend on forests for their livelihoods, with one billion of them are among the world poorest population (Adams and Tanos, 2021). According to World Bank data, approximately 13.2 million people are employed in the formal timber sector. An additional 41 million work in the informal sector. Timber is utilized to produce over 5,000 types of wood-based products, generating more than $600 billion in gross value annually. Informal wood collection predominantly involves gathering firewood, wood for charcoal production, and materials for other small-scale activities.

Forests absorb approximately 16 billion metric tons of CO_2 each year, which assists in mitigating climate change and facilitating carbon cycling (Harris et al., 2021). Forests mark a crucial role in regulating the water cycle by influencing evaporation, precipitation, and natural water flows. Around 31% of the world's watershed areas are covered by forests (Qin et al., 2016), which also contribute to regeneration and purification of water, as well as flood control and water temperature regulation.

Non-consumptive benefits from forests, such as tourism and recreational value significantly contribute to sustaining marginal rural communities by providing both indirect benefits and costs. Around 8 billion travellers explore the world's national parks and other protected areas annually (Balmford et al., 2015). Further forests hold cultural and transcendental values, with many religious sites being located in forests, and they are often associated with beliefs and practices linked to the surrounding communities.

The expansion of large and medium-scale commercial agriculture has caused for about 40% of tropical forest deforestation between 2000 and 2010, while subsistence agriculture has contributed for another 33% deforestation. Consequently, forests are increasingly at risk of encroachment (FAO and UNEP, 2020). Natural disasters such as droughts, wildfires, and floods also contribute to deforestation. Several human-induced causes have exacerbated the issue, including excessive timber harvesting, selective logging, intentional forest fires for hunting, land encroachment for large-scale development projects, and the establishment of residential housing schemes.

VALUATION OF BENEFITS AND COSTS: EVIDENCE FROM LITERATURE

Numerous studies have attempted to quantify the benefits and costs of forest ecosystems using both qualitative and quantitative approaches. Eono and Harrison (2002), for instance, assessed the economic viability of a rainforest reforestation program in Northern Queensland. Their evaluation considered multiple ecosystem services including recreational value, wildlife habitat preservation, water quality improvements, timber benefits, carbon sequestration, and noise attenuation. The analysis also included secondary benefits such as economic spillovers to upstream industries, education and training, and conservation. Project viability was tested using an estimated valuation model and net present value analysis. In Sri Lanka, Rathnayake and Gunawardena (2011) applied the travel cost method to estimate the recreational value of Horton Plains National Park, determining a visitors' willingness to pay an estimated entrance fee of Rs. 472.00. Similarly, Schirpke et al. (2016) explored cultural and ecosystem services in the Central Alps. They used a GIS-based model and perception surveys to assess aesthetic landscape values, applying a spatially explicit modelling approach to link physical landscape patterns with human perceptions using photo-based surveys.Negewo et al. (2016) examined the economic value of forests conserved by local communities in

Ethiopia's Humbo District for their carbon sequestration potential. Using the contingent valuation method and a double-bounded bivariate probit econometric model, the study estimated respondents' willingness to pay for improved forest ecosystem services. Ekanayake et al. (2021) focused on socio-economic determinants influencing rural residents' willingness to participate in community forestry programs in Sri Lanka. Meanwhile, Bandara and Bandara (2021) investigated spatial and temporal changes in ecosystem service values in the Hanthana Mountain Range. Their study analysed land use and ecosystem service value changes from 1956 to 2019 using GIS and remote sensing techniques, employing Landsat-based land use/land cover classifications.

Proper valuation encourages the community to take ownership of the conservation process rather than perceiving it as an initiative imposed by outsiders. Globally, more than half a billion people in developing countries rely on forests managed through community forestry (Agarwal, B. 2009), encompassing approximately 732 million hectares across 62 countries; about 28% of the world's total forest cover (Gilmour, D. 2016; World Bank Group. 2002). The foundation of community forestry lies in voluntary participation to protect nearby forest areas. Communities become actively involved when they recognize the direct impact on their lives and understand their critical role in safeguarding these resources.

Reforestation and Community Engagement in the *Hanthana* Mountain Forest Range

The *Hanthana* mountain forest range, lies in the central highlands of Sri Lanka, southwest of *Kandy*, is a biologically rich and sensitive ecosystem that provides numerous direct and indirect economic and social benefits to the local community. Historically, during the 18th and 19th centuries, the area was entirely covered with lush broadleaved wet evergreen forests, with only minor disturbances caused by natural events. The establishment of commercial plantations led to the disturbance of these natural forests. With the shift in land use patterns exposed the soil and altered the vegetation in different stages, resulting in large patches of land now dominated by perennial grasslands, mainly covered by *Cymbopogon nadus* and *Panicum maximum*. In the wake of unsuccessful reforestation initiatives, some patches have been turned into unproductive Pinus plantations. Researchers suggest that the patches should be restored, either to its previous state or to an improved version of the forest ecosystem. Reforesting these patches is crucial to achieving a uniform forest cover. The reforestation process, however, entails both economic and social costs and benefits, which must be carefully considered in planning effective interventions.

Potential Land-use Options

Restoration of a deforested forest patch with the target of establishing an eco-tourism–oriented forest can attract community participation while providing economic benefits to host communities and recreational opportunities for tourists, all while achieving conservation and environmental goals. Ecotourism is defined as responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and creates knowledge and understanding through interpretation and education of all involved: visitors, staff and the visited (Global Ecotourism Network, 2016)

Another approach for restoring a deforested forest patch is the establishment of a primary forest through Assisted Natural Regeneration (ANR). According to FAO (2012), ANR is a reforestation method that enhances the establishment of secondary forests from degraded grassland or shrub vegetation by protecting and nurturing the mother trees and wildlings inherently present in the area. ANR accelerates natural successional processes by removing or reducing barriers to natural forest regeneration such as soil degradation, competition with weedy species, and recurring disturbances, rather than replacing the vegetation.

Restoring a deforested area as a participatory forest (community-managed forest) aims to rehabilitate degraded lands, conserve forests and woodlands, and support community livelihoods (Gumbo et al., 2018). FAO defines community forestry as any situation that intimately involves local people in a forestry activity. This encompasses a wide range of arrangements, from woodlots in areas with scarce forest resources for local needs, to tree cultivation at the farm level for cash crops, to the processing of forest products at household, artisan, or small-industry levels, and the activities of forest-dwelling communities. Community-managed forests provide the surrounding communities with direct benefits from the forest, and the sense of ownership is a key driver of forest protection and sustainable management.

The primary objective of this study is to assess the feasibility of different land use options by examining their economic costs and benefits, based on the preferences of the local community surrounding the *Hanthana* forest mountain range. The study will explore how their involvement and choices in the reforestation process can yield benefits. By incorporating these insights, the conservation initiative can be optimized to ensure active community participation, empowering local communities to become the true custodians of conservation efforts.

Theoretical Foundation of application of Cost–benefit analysis (CBA)

Cost–benefit analysis is a formal and systematic tool for identifying, measuring, and comparing the benefits and costs associated with a policy intervention, investment project, or management activity (Bonner, 2022). In the context of forest land use, CBA provides a structured approach to evaluate alternative management or land use scenarios by quantifying relevant consequences in monetary terms.

CBA is closely linked to welfare economics, as it aims to ensure that resources are allocated efficiently among competing uses (Boardman et al., 2018). The concept of net social benefit is central: when social benefits exceed social costs, a project or policy improves total social welfare, providing a measure of allocative efficiency (Bonner, 2022). This framework is particularly relevant to the present study, which compares alternative forest land-use scenarios, Primary forest, Eco-tourism-oriented forest, and Participatory forest (community-managed forest) based on the perceived benefits and costs as reported by participants.

A key element of CBA is discounting, which converts future costs and benefits into present value, allowing a common metric for comparison. In this study, many benefits, such as carbon sequestration, firewood and timber, accrue over time, making discounting essential to evaluate trade-offs across scenarios (Bonner, 2022).

By combining primary survey data with both market and non-market valuation techniques, the application of CBA allows a comprehensive assessment of the total economic welfare generated under different potential forest land-use options. This methodological approach ensures that both direct and indirect benefits and costs are systematically accounted for, providing a robust framework to guide forest management and policy decisions.

METHODOLOGY

The study applied a cost–benefit analysis (CBA) to assess the economic feasibility of the three land use scenarios. A community perception survey first identified the preferred scenario and the expected cost and benefit components, without requiring respondents to provide monetary values. Quantitative estimates were derived using realistic market values, with discounting applied where relevant. Averaged costs and benefits were used to calculate benefit–cost ratios (BCRs), and kernel density plots were employed to illustrate their variation. Probit regressions estimated the association between land use preferences and related factors.

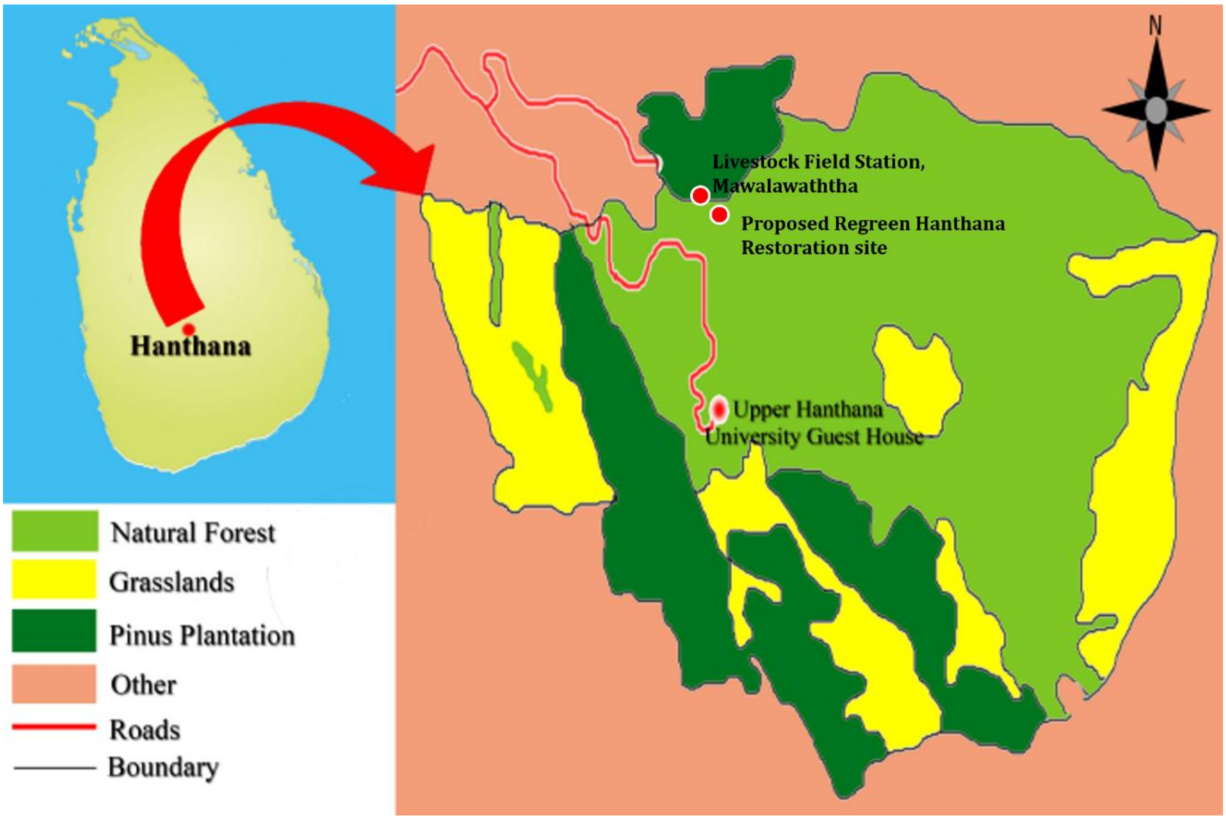

Figure 1. The Upper *Hanthana* Mountain Range and major habitat types (Source: Chathuranga and Ranawana, 2018) and the location of proposed site

Study area

The study site is located in the *Kandy* district of Sri Lanka. The *Hanthana* Mountain range is situated in the *Kandy* district (7° 15' N and 80° 37' E). It was announced as a protected area by the Gazette Notification No. 1641/28 under the act of Environmental Protection areas, 2013. Depending on altitude, the forest range is divided into two regions; Lower *Hanthana* mountain area (< 600 m), Upper *Hanthana* Mountain area (> 600 m). Even though the Upper *Hanthana* area is comparatively less disturbed than the Lower *Hanthana* area by the human settlements, it is found highly fragmented. Three habitat types are identified in the area; Pine plantations (*Pinus carribaea*), secondary natural forest, and grasslands (dominated by *Pennisetum polystachyon, Megathyrsus maximus* and *Cymbopogon nardus*). These are distributed as patches irregularly in the upper mountain range (Figure 1). The mean annual temperature and mean annual rainfall in the area are recorded as 26°C and 1840 mm respectively. The rainfall is received from North-East monsoons, South-West monsoons. The dominant tree species are *Swietenia mahagoni, Michelia champaca, Clusia rosea, Alstonia macrophylla, Artocarpus* nobilis (Chathuranga and Ranawana, 2018; Ekanayake et al., 2021).

The proposed site (Figure 1) is situated at 7°15'04.7"N 80°36'34.4"E and span approximately over 4200 m^2 (0.42 ha) and characterized by a sloping terrain. The vegetation is predominantly composed of *Pennisetum polystachyon*, *Megathyrsus maximus*, and *Cymbopogon nar*dus, indicative of its current ecological state.

Study design

The primary data for this study was collected through a comprehensive questionnaire designed to capture the perspectives of various community stakeholders, including Villagers of *Uda-peradeniya* and *Mawelawaththa* villages, the community of the University of Peradeniya and institutional stakeholders of the conservation forest areas of *Hanthana*. The questionnaire was structured into two key sections. The first part focused on gathering demographic and socio-economic data, such as gender, ethnicity, education level, marital status, occupation, and land ownership. The second part assessed participants' preferences for different land use scenarios. Respondents were presented with three distinct options: an ecotourism site, a primary forest, and a participatory forest. This scenario development approach allowed participants to model their preferences based on hypothetical land-use transformations. While all three scenarios aimed to convert grassland into forested land, the tree species diversity, wildlife composition, and other ecological components varied according to the specific vision proposed in each scenario. Through these land use alternatives, the study sought to understand how surrounding community and stakeholders prioritize and conceptualize ecological restoration, offering valuable insight into their preferred strategies for land use transformation. Upon selecting a preferred land use scenario, respondents were asked to specify the features and quantities they conceived within the chosen scenario (Table 1). The detailed input allowed the study to capture the community's desired characteristics for each land use option. To estimate the associated costs and benefits, market values were applied to the requested aspects, and reasonable assumptions were made where direct market values were unavailable.

Table 1. Questions included in the questionnaires related to the developed scenarios

Scenario	Features
Ecotourism site	Preference of having features Preference of having job opportunities Number of trees per acre Number of visitors per week
Primary forest	Tree species for reforestation Number of trees per acre Number of visitors per week
Participatory forest	Expected benefits Tree species for reforestation Number of trees per acre Number of visitors per week

Sample Population

The *Hanthana* Protected Area comprises 29 villages distributed across four divisional sectors (Bandara and Bandara, 2021). For this study, the three villages nearest to the reforestation site (*Mawalawaththa*, *Uda-Peradeniya*, and *Peradeniya*) were selected as the primary focus for data collection, comprising the first segment of the study population. Out of the population of these villages, the perceptions of 32 villagers were captured using a convenience sampling approach, which aimed not to represent the entire population but to capture a variety of preferences within the surrounding community.

The second segment consisted of the community of University of Peradeniya, given their proximity and potential interest in the project. Respondents in this segment were primarily drawn using convenience sampling from the Faculty of Agriculture and the Faculty of Science, the University of Peradeniya. Undergraduates and academics from the Faculty of Agriculture regularly attend practical sessions at the Livestock Field Station (*Mawalawaththa* Farm), which is located in close proximity to the proposed reforestation site. Similarly, several buildings of the Faculty of Science are situated near the *Hanthana* Forest, and the Faculty is actively involved in the *Regreen Hanthana* reforestation initiative. These groups were therefore considered to have greater exposure to and awareness of the study area, and this segment comprised 38 individuals.

The third segment comprised individual institutional stakeholders associated with the conservation forest areas of *Hanthana*. The segment included religious leaders, labourers working at the *Mawalawaththa* Agricultural Farm, technical officers at the same facility, temporary lecturers at the Veterinary Farm in *Uda-Peradeniya*, security personnel, hotel managers, the postmaster of the *Uda-Peradeniya* sub-post office, the land use planning officer from the Divisional Secretariat Office in *Dekthota*, the sub-warden of *Ramanathan* Hall at the University of Peradeniya, the accounting assistant at the Uda-Peradeniya Rural Bank, and a work aide from the Swine Unit of the *Mawalawaththa* Agricultural Farm.

Data collection and analysis

Face-to-face interviews, guided by a structured questionnaire, were conducted to gather cross-sectional primary data from all three segments of the population. The pilot survey, conducted on October 7, 2022, involved five respondents to test and refine the questionnaire. Subsequently, data collection took place between October 13 and October 29, 2022, during which a total of 80 respondents were interviewed.

Descriptive analysis (cross-tabulation) illustrated the variability in demographic characteristics, while cost-benefit analysis was based on spreadsheet analysis in Microsoft Excel. Subsequent calculations of CBA were carried out using Stata. Combined approach allowed for the estimation of net benefits for each scenario, as perceived by individual respondents, based on their inputs and preferences (Figure 2).

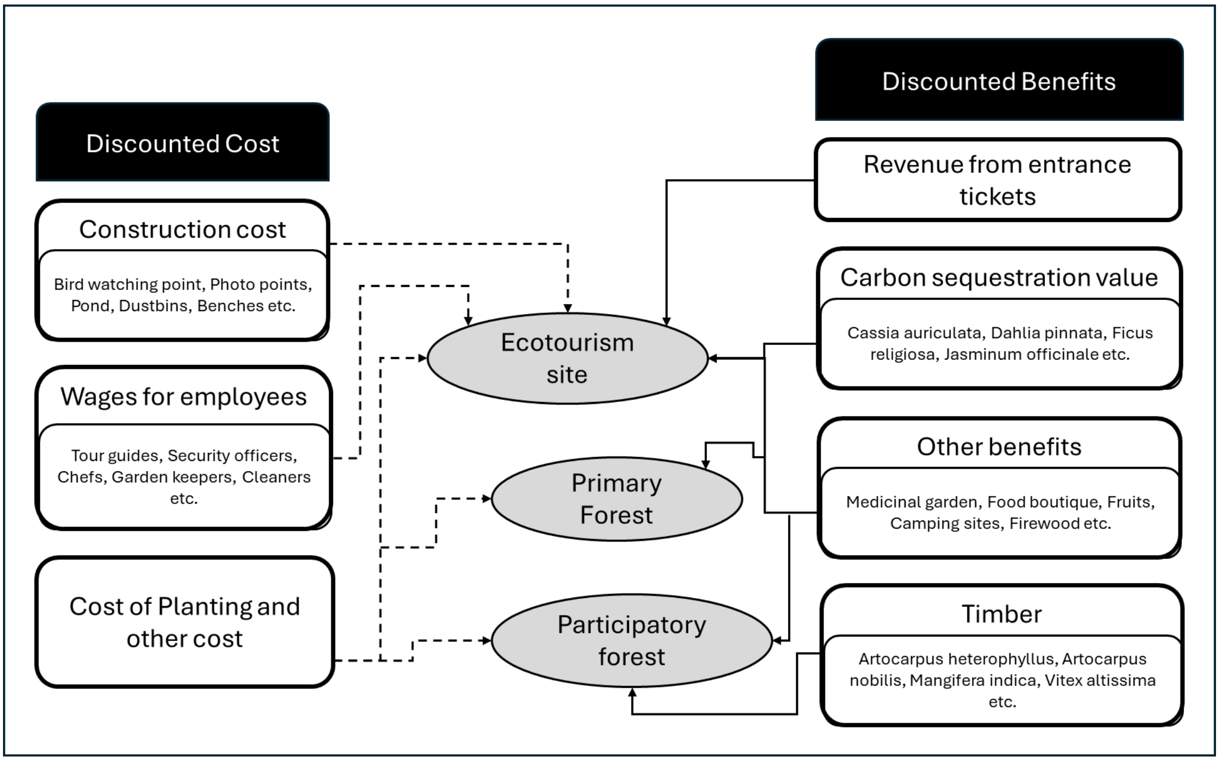

Figure 2. Conceptual Diagram of Cost and Benefits of each Scenario

Cost estimation

The ecotourism site is characterised with a range of optional features, including bird watching points, walking trails/footpaths, photo points, accommodation facilities, a pond, a medicinal garden, food boutique, statues, dustbins, name boards, benches, waterfalls, taps, bird park, butterfly garden, swimming pool, arches, ecolodge, toilets, fruit garden, beekeeping unit, scenario drawings, ropes, camping sites, and a summer hut. Respondents were requested to indicate their preferences for incorporating these features into the ecotourism site. The estimation of sizes and conditions for each feature was based on the assumptions. Pricing for the features was determined by referencing local market rates and Building Schedule of Rates (2021) for construction works of government buildings.

Respondents were requested to select the types of job opportunities they believed suitable for the ecotourism site. The roles included tour guides, security officers, chefs, hospitality officers, receptionists, garden keepers, hotel managers, cleaners, tree pruners, and zoo keepers. The number of employees required for each position was also specified by the respondents. The minimum wage values for each job were chosen based on local salary ranges (Salaryexplorer, 2021).

The cost of planting and maintaining a single tree for a five-year period was estimated at 100 LKR. Some labour for primary preparations could be provided on a voluntary basis, and water for the trees could be sourced from natural resources. 50,000 LKR was included in the cost section to account for fencing and miscellaneous expenses associated with the reforestation project.

Benefit estimation

Direct benefits:

Timber harvesting was permitted solely in the participatory forest scenario. The calculations related to timber harvesting were based on the guidelines provided by the State Timber Corporation, Ministry of Wildlife and Forest Resources Conservation. The timber classification system includes six primary timber classes (STC, 2017). The information regarding the number of trees and species of plants in the forest was gathered from the respondents.

Community members were permitted to collect firewood only in the primary forest and participatory forest scenarios. The firewood production for the primary forest was assumed to be 1.9 tons per hectare per year, while for the participatory forest, it was assumed to be 1.5 tons per hectare per year (Ngulani & Shackleton, 2022). The price of one kilogram of firewood was estimated at 200 LKR based on local market prices.

Medicinal plants, fruits, leafy vegetables, and under cropping benefits were identified under the participatory forest scenario. The number of trees related to each case was assumed to be 200, with each plant valued at 100 LKR. These values were incorporated into the benefits section based on respondents' preferences for including them as a benefit.

Animal herding was permitted exclusively in the participatory forest scenario, with respondents given the option to decide whether it should be allowed. The total value derived from animal herding was estimated at 20,000 LKR.

Visitors were allowed to experience the recreational, aesthetic, and educational value of the ecotourism site. The revenue generated was estimated based on ticket sales, with the ticket price assumed to be 100 LKR, referencing similar sites (table 2) The expected number of visitors was gathered from the data collected through the questionnaire.

Indirect benefits:

Carbon stocks of the trees were calculated using following equations (Bas Fransen, 2019).

$$\text{Dry weight (kg)} = 0.725 * \text{Green mass (kg)}$$

$$\text{The carbon stock of the plant (kg)} = 0.5 * \text{Dry mass}$$

The green mass of all the plant species mentioned was assumed to be similar. The value of the carbon stock was derived by referring to voluntary carbon markets, which facilitate the trading of carbon offsets and carbon credits between investors and corporations.

When tree species were specified by respondents, the number of trees per species was determined by dividing the proposed total number of trees by the number of species mentioned. If no specific species were mentioned by the respondent, it was assumed that there would be a single species. The number of trees planted per unit land area varied depending on the conditions assumed for each scenario. This variation in the number of trees directly influenced the carbon sequestration value for each scenario.

The benefit cost structure was discounted based on the assumption included in the Table 3.

Table 2. Ticket prices of similar sites (Ecotourism site)

Location	Ticket price
Botanical garden (Peradeniya)	120 LKR (local/ 3000(foreigner)
Ritigala	20 LKR (local) 500 (foreigner)
Sigiriya	50 LKR (local) 5000 (foreigner)
Hakgala botanical garden	60 LKR (local) 1500 (foreigner)

Table 3. Considered discount rates for the benefit-cost analysis

	Discount rate	Time duration (years)
Firewood	5%	14
Carbon value (Jantawong et al., 2022)	5%	14
Timber (Farm Forest Line, 2009)	8%	14

RESULTS AND DISCUSSION

Socio-demographic characteristics

The data reveal that 62.35% of the total sample were male, with the largest percentage (47.17%) in the 18-35 age group. Among the female respondents (37.65%), the highest percentage also belonged to the 18-35 age category. Ethnically, the majority of respondents (85.89%) were Sinhalese, followed by Sri Lankan Tamils (10.59%). Among the villagers, only one respondent was identified as not having formal education. Of the remaining villagers, 43.75% had primary education (ranging from preschool to Grade 11), and 37.50% had completed secondary education (Grades 12-13). A smaller proportion, 15.63% held qualifications at the diploma, degree, or post-graduate level. Regarding the institutional stakeholders, most were found within the secondary education category. In terms of income, the highest proportion (26.19%) fell within the 45,000 – 65,000 LKR range, with the community of University of Peradeniya accounting for the majority (45.45%) of this group. The highest income range (over 105,000 LKR) was predominantly represented by the community of University of Peradeniya (57.14%). Most villagers (34.88%) earned between 25,001 LKR and 45,000 LKR (Table 3). Land ownership data revealed that 72.29% of respondents owned more than 12 perches of land. However, villagers exhibited more variability, with most living in *Mawelawaththa* owning between 5-8 perches of land (34.38%). In contrast, the majority of villagers from *Uda-Peradeniya* and *Peradeniya* (46.88%) had more than 12 perches (Table 4).

Community Preferences for Land use options

Across all respondent categories, the majority expressed a preference for the eco-tourism site, with community of University of Peradeniya at 50%, villagers at 62.5%, and institutional stakeholders of the conservation forest areas of *Hanthana* at 46.67%. In aggregate, 54.11% of the sample favoured the ecotourism site option. The primary forest scenario was predominantly favoured by the community of University of Peradeniya, following their preference for the ecotourism site, while villagers showed a stronger preference for the participatory forest scenario after the ecotourism site. Collectively, the primary forest garnered the support of 30.59% of respondents, surpassing the 15.29% who favoured the participatory forest (Table 5). The preferences were taken into account during the data collection process to quantify the values associated with the CBA of the proposed scenarios.

Table 4. Distribution of demographic data

Variable and Category		Type of the Respondent		
		University community members (%)	Villager (%)	Other institutional representatives (%)
Gender	Male	37.7%	41.5%	20.8%
	Female	56.3%	31.3%	12.5%
Age	18-35	82.6%	13.0%	4.3%
	36-55	0.0%	50.0%	50.0%
	55<	0.0%	88.2%	11.8%
Education level	No formal	0.0%	100.0%	0.0%
	Primary education	0.0%	82.4%	17.6%
	Secondary education	0.0%	63.2%	36.8%
	Undergraduates	100.0%	0.0%	0.0%
	Diploma/ Degree	9.1%	45.5%	45.5%
Status of employment	Government employment	13.3%	13.3%	73.3%
	Private sector employment	10.0%	60.0%	30.0%
	Self-employment	35.7%	64.3%	0.0%
	Unemployed	52.9%	47.1%	0.0%
	Other	72.4%	24.1%	3.4%
Monthly family income	<25,000	40.0%	53.3%	6.7%
	25,001-45,000	36.8%	57.9%	5.3%
	45,001-65,000	45.5%	31.8%	22.7%
	65,001-85,000	37.5%	25.0%	37.5%
	85,001-105,000	66.7%	33.3%	0.0%
	105,000<	57.1%	14.3%	28.6%
Land extent	Own land	0.0%	100.0%	0.0%
	Government permits	0.0%	91.7%	8.3%
	Leased land	25.0%	37.5%	37.5%
	Rental land	58.3%	25.0%	16.7%

Table 5. Preferences (highest rank) for land use choices

Type	**Eco-tourism site** (Frequency)	**Primary forest** (Frequency)	**Participatory forest** (Frequency)
Community of the University of Peradeniya	19	16	3
Villagers of *Uda-peradeniya* and *Mawelawaththa* villages	20	4	8
Institutional stakeholders	7	6	2

Table 6. Model Estimation related to the Land Use Choice and the Demographics of the Respondents[2]

	Model 1 - Ecotourism	Model 2 – Primary forest	Model 3 – Participatory forest
Gender	0.860**	-0.665	-0.695
Marital status	0.019	-0.028	-0.187
Age	0.065	-0.968**	1.365
Villager	0.897	-0.818	-5.43
Monthly income	0.136	-0.0353	-0.266
Land extent	0.329	-0.158	-0.774*
Government employed	0.664	0.0358	-5.672
Self employment	0.403	0.254	-1.610**
Unemployed	-0.088	0.286	-0.287
Log Likelihood	-50.338	-40.728	-20.052
Cons	-4.182	4.715	5.651
Prob > chi2	0.463	0.125	0.009***
Pseudo R2	0.104	0.178	0.381

[2] Significance - ***P<0.001 **P<0.05 *P<0.1

Relationship between Land Use Choice and the Socio-economic Characteristics of the Respondents

The influence of socio-economic characteristics on individual choices among the three land-use options is captured using three multinomial probit models (Table 6).

With a log-likelihood value of −20.052 and a p-value of 0.009, Model 3 (choice of participatory forest) was statistically significant. Comparison of the three models based on log-likelihood values indicates that Model 3 provides the best fit, capturing the relationship between the choice of participatory forest and the socio-demographic characteristics of the community. The second-best fit was observed for Model 2, which represents the relationship between the choice of primary forest and demographic characteristics.

Model 1 indicated that gender was significantly associated with ecotourism site choice ($\beta = 0.860$, $p < 0.05$). Model 2 showed a significant negative relationship between age and the choice of a primary forest site ($\beta = -0.968$, $p < 0.05$). Model 3 demonstrated a significant negative relationship between land ownership and the choice of participatory forest ($\beta = -1.610$, $p < 0.05$) (Figure 4.11).

Estimation of Benefits and Costs

Option 1 – Ecotourism scenario

With regard to costs, the highest incurred cost was wages for employees, which could be reduced by either decreasing the number of employees or lowering wage rates. The second largest cost was the construction cost (a one-time capital investment). Revenue from ticket sales and extra features was found to be substantial, especially when compared to the benefits derived from carbon sequestration. Despite these revenue streams, the net benefit remained negative due to the significant initial investment costs associated with the ecotourism scenario (table 7).

The benefit-cost ratio of 0.865±0.462 suggests that the expected benefits are relatively low compared to the high costs associated with the project. To improve the project's sustainability, it would be beneficial to explore strategies such as increasing the entrance fee, enhancing the efficiency of workers, and introducing more income-generating activities. If wages are a significant portion of the costs, a reassessment of wage structures could help reduce overall expenditures.

Table 7. Results of Benefit cost analysis - Ecotourism site

Item (LKR/Acre)	Average
Costs	
Construction cost of features	1,207,360.00
Wage for employees	4,199,270.00
Planting cost	66,700.00
Benefits	
Revenue from tickets	2,215,652.00
Discounted carbon value	187,905.80
Other benefits from features	2,227,602.00
Total cost	5,473,330.00
Total benefit	4,631,160.00
Net benefit	(842,170.30)
Benefit cost ratio	0.865
Standard deviation of BCR	0.462

Option 2 - Primary forest scenario

The benefit-cost calculation for the primary forest scenario (table 8) reveals that the highest cost is attributed to planting, followed by fencing and other associated costs. The most significant benefit in terms of value is the discounted carbon sequestration value, which plays a major role in carbon cycle. However, when considering direct benefits, firewood collection is a key benefit for the community.

The primary forest scenario shows a positive net benefit, as the benefits outweigh the costs. However, unlike the other two scenarios, the direct benefits of the primary forest are limited to firewood collection. When considering the discounted carbon sequestration value, the primary forest demonstrates significant indirect contributions to environmental well-being. The scenario was predominantly favoured by the community of the University of Peradeniya, following their preference for the ecotourism site. This preference may stem from the community of the University of

Peradeniya higher valuation of environmental and regulatory benefits, such as the long-term ecological advantages provided by carbon sequestration, which contribute to overall environmental sustainability.

Table 8. Results of Benefit cost analysis - Primary forest

Item (LKR/Acre)	Average
Costs	
Planting	57,500.00
Fencing and other	50,000.00
Benefits	
Discounted carbon value	164,244.20
Discounted firewood value	77,669.74
Total cost	107,500.00
Total benefit	241,914.00
Net benefit	134,414.00
Benefit-cost ratio	2.233
Standard deviation of BCR	0.101

Option 3 - Participatory forest Scenario

In this scenario, a significant portion of the direct revenue is derived from timber resources, although this benefit takes a longer time to materialize. In contrast, benefits such as medicinal plants, fruits, leafy vegetables, and revenue from animal breeding can be realized in a shorter time frame. Additionally, firewood, another direct benefit, can also be harvested quickly. Overall, the participatory forestry scenario offers more direct benefits to the community, while also fostering a sense of ownership and involvement in the management and sustainability of the forest resources.

With a high benefit-cost ratio of 6.86±2.509, the participatory forest scenario demonstrates a significant benefit relative to the incurred costs (Table 9). While the costs are similar to those of the primary forest scenario, the key differentiating factor is the active involvement of the community in forest management. This direct participation not only enhances the sustainability of the reforestation efforts but also instils a sense of ownership, as the community both maintains and utilizes the resources. Following the ecotourism site, most villagers preferred the participatory forestry scenario, likely due to the immediate livelihood benefits it offers, such as access to timber, firewood, and other resources, which align closely with their economic priorities.

Table 9. Results of Benefit cost analysis - Participatory Forest

Item (LKR/Acre)	Average
Costs	
Planting	38,461.54
Fencing and other	50,000.00
Benefits	
Discounted carbon value	280,459.10
Discounted timber	209,205.30
Medicinal plants	18,461.54
Fruits	1,538.46
Leafy vegetables	1,538.46
Under cropping	3,076.92
Animal herding	1,538.46
Discounted firewood value	61,318.22
Total cost	84,615.38
Total benefit	577,136.40
Net benefit	492,521.10
Benefit cost ratio	6.860
Standard deviation of BCR	2.509

Density Plots for the BCRs across Land Use Scenarios

The kernel density plots illustrate the distribution of Benefit-Cost Ratios (BCRs) across three land use scenarios (participatory forest, primary forest, and ecotourism site) based on the perceptions of the participants (Figure 3).

The participatory forest scenario shows the widest distribution of BCRs, indicating the broad range of perceived economic returns. In contrast, the primary forest scenario exhibits a sharp peak with the highest density concentrated around a specific BCR value, reflecting limited variation and greater consistency in responses. The ecotourism site scenario presents a left-skewed distribution, showing generally low BCR values. However, the distribution is more compact than the other two scenarios, indicating limited profitability but less variation in perceptions.

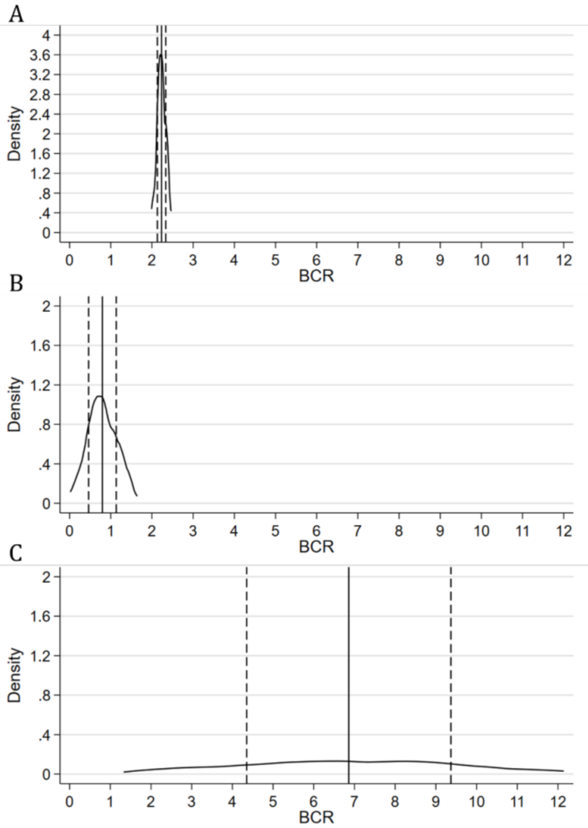

Figure 3. Kernel Density Plots of variation of BCR values (Panel A: Primary Forest) (Panel B: Ecotourism Site) and (Panel C:Participatory Forest)

DISCUSSION

The study captures the perceptions of different respondent categories and reflects their preferences and suggestions in the selection of land-use options. Among the three scenarios analysed, the ecotourism land use option attracted the highest level of preference across all respondent categories, despite exhibiting negative net benefits.

The benefit–cost ratio (BCR) for the ecotourism scenario was estimated at 0.865 ± 0.462, indicating relatively low economic viability. Although the present study reports a low BCR, evidence from a comparable protected area, the Xe Pian National Protected Area in southern Lao People's Democratic Republic, shows substantially higher economic returns from ecotourism-based reforestation, with a BCR of 2.84 (Baylatry et al., 2015). Due to the novelty and perceived attractiveness of the ecotourism concept, respondents were more likely to select the ecotourism scenario over the other land-use options. However, the negative average net benefit observed for this option reflects relatively low expected economic returns. This outcome may reflect limited awareness and understanding of ecotourism sites among respondents. Supporting this explanation, a study from southern Ethiopia reported that the majority of respondents exhibited negative attitudes toward forest-based ecotourism development due to a lack of awareness about conservation and its benefits, as well as perceived conservation-related costs such as crop damage and livestock depredation (Gezahegn et al., 2024).

Conversely, the primary forest and participatory forest scenarios generated positive net benefits. Reforestation aimed at establishing a primary forest yielded a benefit–cost ratio of 2.233 ± 0.101, which is consistent with the ranges reported by Mirzabaev (2024) in a study conducted in Vietnam. That study found benefit–cost ratios ranging from 1.5 under pessimistic conditions with disturbances to 7.6 under optimistic scenarios, with an average value of 4.1.

The participatory forest scenario achieved the highest benefit–cost ratio, despite being the least preferred option among respondents, with an estimated value of 6.86 ± 2.509, indicating relatively high economic returns. When compared with evidence from other country contexts, this value appears broadly consistent. For instance, a study conducted in the Tororo Central Forest Reserve in eastern Uganda reported benefit–cost ratios ranging from 0.9 to 5.3 for collaborative forest management (Anguti et al., 2022). Similarly, a review of 12 community forestry restoration models across Brazil, Cambodia, Indonesia, and Peru reported benefit–cost ratios ranging between 0.77 and 3.71 (Gasparinetti et al., 2022). These studies highlight the substantial variation in economic outcomes associated with participatory forest management, consistent with the relatively wide dispersion observed in the present study.

The probit regression results offer insights into socio-economic factors shaping perceptions of land-use options. Model 1 reveals that gender is significantly associated with the choice of ecotourism sites ($\beta = 0.860$, $p < 0.05$), indicating distinct preferences in ecotourism activities between male and female respondents. The positive coefficient suggests that women are more likely than men to select ecotourism sites. This finding aligns with Koskela and Karppinen (2024), where women are more responsive to specific programme designs, accessibility, and socio-economic incentives that reduce barriers to participation. Conversely, the lower likelihood of men choosing ecotourism suggests their forest-based decisions may be more driven by subjective norms or traditional management expectations, consistent with the gender-based variations in social pressure noted by Koskela and Karppinen (2024).

The significant negative relationship between age and the preference for primary forest sites ($\beta = -0.968$, $p < 0.05$) reflects a shift from idealistic preservation toward functional conservation. Younger respondents tend to prioritize the intrinsic value of undisturbed ecosystems, whereas older respondents appear to favour forest models with utilitarian functions. This inclination toward ecotourism and participatory frameworks indicates that, with age, individuals increasingly value forest sites that provide immediate socio-economic benefits and opportunities for community engagement over the long-term, non-extractive benefits associated with primary forests. Consistent with Faham et al. (2008), younger individuals are generally more willing to support reforestation and forest development, whereas older individuals' preferences shift toward forests that offer functional utility. Moreover, Levy-Weinrib and Bentwich (2024) highlight that inclusive infrastructure in forest recreation areas is critical for promoting participation and emotional well-being among older adults. Consistent with this, the present study finds that such facilities are more commonly associated with ecotourism and participatory forest options than with the primary forest option.

Model 3 revealed a significant negative association between land ownership and participation in participatory forest activities ($\beta = -1.610$, $p < 0.05$). Individuals with larger land holdings were less likely to engage in collective forest management, which could reflect differing incentives: landowners may prioritize private land management over community-based initiatives or perceive less need to participate in shared forest resources. This finding contrasts with Adhikari, Di Falco, and Lovett (2004), who reported that households with more land and private property tend to engage more with community forests to gather forest products such as grass and firewood compared to households with little or no land. Larger households may require greater quantities of forest products to support agricultural activities and livestock, whereas the poorest households, constrained by limited complementary resources, use smaller quantities of these products.

With reference to the variability of BCR values, the participatory forest land use scenario is associated with higher perceived risk due to its wide variation in perceived BCRs. However, it also offers the highest average benefits among the three scenarios. The primary forest scenario, despite its lower returns, shows the highest consensus among participants, indicating greater perceived stability and modest but dependable economic outcomes. CBAs derived from the Participatory forest scenario are not perceived as uniform interventions, but rather as context-specific arrangements whose expected benefits depend on species selection, management rules, and benefit-sharing mechanisms.

CONCLUSION AND POLICY IMPLICATIONS

This study examined community preferences and economic valuations for three reforestation land-use options: ecotourism, primary forest, and participatory forest scenarios. Among respondents, the ecotourism site was the most preferred option (54.11%), followed by primary forest (30.59%) and participatory forest (15.29%). While preferences indicate social attractiveness, benefit–cost analysis reveals notable differences in the potential economic returns of each scenario.

The benefit cost analysis reveals that each of the proposed land use scenarios have different valuations based on the evidence considered. The BCR value and their standard deviation are as follows: ecotourism scenario: 0.865 (±0.462); primary forest scenario: 2.233 (±0.101) and participatory forest scenario: 6.86 (±2.509). The participatory forest scenario exhibited the widest distribution of BCRs. In contrast, the primary forest scenario showed a sharply concentrated distribution, while the ecotourism scenario presented a left-skewed distribution, highlighting lower expected economic returns despite its popularity.

The community interest does not always align with economic efficiency. Although the ecotourism site scenario was the most favoured option among respondents, benefit-cost analysis revealed that the participatory forestry approach could deliver significantly greater benefits to the community at a comparatively lower cost. Effective communication of these findings, supported by robust assessments, is crucial for aligning community perceptions with evidence-based recommendations. Poorly planned or misaligned reforestation projects risk resource wastage and may lead to abandonment after completion, undermining long-term sustainability.

The probit regression analysis demonstrates that reforestation success is contingent upon demographic and socio-economic alignment. Gendered preferences reveal that women are more responsive to the structured incentives of ecotourism ($\beta = 0.860$), while age-related trends indicate a transition from the idealistic preservation favoured by youth to a utilitarian, benefit orientation in older cohorts ($\beta = -0.968$). Furthermore, the negative correlation between land ownership and participatory engagement ($\beta = -1.610$) suggests that those with private assets may prefer less collective management, contrasting with traditional models of resource dependency. Collectively, these results underscore that a "one-size-fits-all" approach to forest management is likely to fail. To ensure long-term sustainability and prevent project abandonment, practitioners must design inclusive, functional forest models that accommodate the diverse incentives of gender, age, and land tenure with the economic efficiencies of participatory forestry.

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