ICIMOD Working Paper 2012/5

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Value of Forest Ecosystem Services

A quantitative estimation from the Kangchenjunga landscape in eastern Nepal

2011-2020 United Nations Decade on Biodiversity

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Value of Forest Ecosystem Services

A quantitative estimation from the Kangchenjunga landscape in eastern Nepal

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Acronyms and Abbreviations

NTFP	non-timber forest product
PSU	primary sampling unit
TEV	total economic value
VDC	village development committee

Note

Monetary values in this document are given in Nepali Rupees (NPR). At the time the survey was held in 2010, the exchange rate was USD 1 = NPR 71.

Executive Summary

The ecosystem services derived from conservation areas have a high value for human wellbeing, but they do not receive due consideration in public policy in the Hindu Kush Himalayan region. As a result, conservation areas do not receive adequate public support for participatory management and other approaches. The lack of recognition is in part due to the lack of explicit calculations of the actual economic value of these areas for the local, regional, and global populations.

As in other conservation areas in the Hindu Kush Himalayan region, the protected areas around Mount Kangchenjunga, the third highest peak in the world, are facing diverse threats to the capacity of the ecosystem to generate goods and services. These threats result from insufficient investment and weak management stemming from inadequate understanding and recognition of the services that the areas provide. Valuation of ecosystem services is expected to help raise awareness of their importance and stimulate support for appropriate conservation measures. This paper presents the results of an attempt to estimate the monetary value of the goods and services provided by the forest ecosystems of three districts of eastern Nepal. A market method was used for valuation of the provisioning services, a benefit transfer method for the regulating services, and a productivity method for the supporting services, using primary data from nine village development committees and secondary data from the three districts.

The economic benefits generated by the flow of selective forest ecosystem services in the three districts was around NPR 8.9 billion per year (approximately USD 125 million) equivalent to NPR 30,000 per hectare per year. Almost 80% of the total benefits (NPR 7.01 billion per year or approximately USD 98 million) was from provisioning services, i.e., goods from the forests used directly or indirectly. The average benefit per household from ecosystem services was estimated to be NPR 60,144 per year. The value of carbon sequestration services was also considerable at NPR 1.65 billion annually, close to 18% of the total value of the ecosystem services. The value of regulating and supporting services was estimated to be about NRP 1.89 billion per year (approximately USD 26.6 million), providing a benefit per household of about NPR 16,238 per year if they are sold in the global market. These values are conservative estimates and may vary with changes in the market prices used to make the assessments.

The study showed that the forested areas provide immense economic benefits to the local people and that people living in the three districts are highly dependent on forest ecosystem services for their subsistence and wellbeing. However, these benefits are not recognized in national and local planning and development. Estimation of the economic value of the ecosystem services will help facilitate understanding of the importance of services that are otherwise ignored and can be used to create awareness of the importance of conservation for rural households residing in or near conservation areas. This will help in advocating for incentive mechanisms for local communities to maintain the ecosystem and meet their livelihood needs by sustaining the flow of services. Planners and policy makers can also use the estimates in cost benefit analyses and in support of appropriate conservation related decisions. The estimated economic value of ecosystem services provides a strong rationale for the need to conserve protected areas and the ecosystems they contain. The estimated values are indicative and do not include a number of services that could not be assessed. Further research is necessary into the biophysical relationships between the stock and flow of services, and to estimate the value of other services not yet included. The methodology used in this study can be scaled up to the entire Kangchenjunga landscape to support regional collaboration in conservation, and can be applied in other areas of the region after modification to take into account the local conditions.

Introduction

The global community depends on natural ecosystems not only for goods such as food, timber, and medicine, but also for the provision of a broad array of services such as fresh air and water, climate regulation, carbon storage, and the maintenance of aesthetic, cultural, and spiritual values (Diaz et al. 2006; Haines-Young and Potschin 2010). However, most ecosystems are facing challenges from factors such as a rapid change in the global climate, loss of biological diversity, habitat degradation and loss, desertification, and environmental pollution. The Millennium Ecosystem Assessment, one of the most comprehensive analyses of ecosystem services to date, reported that of the 24 major services, 15 are in a state of decline (MA 2005). Despite their inbuilt resilience, these ecosystems are now approaching the point where they may not be able to meet the human demand for adequate food, clean water, energy, medicines, and a healthy environment. These changes are intensifying and starting to have a serious impact on the development goals and needs of a growing human population (Zedan 2005), which is especially significant in regions of high poverty (Turner et al. 2012). The declining natural capital has serious implications for our own species as the degradation of ecosystem services poses a significant barrier to the achievement of the Millennium Development Goals (MDG) and the targets for 2015 (MA 2005; Sachs et al. 2009; Secretariat of the CBD 2010; Diaz et al. 2011). Ecosystem health plays an important role in human life; for example, 40% of the world economy is derived directly from biodiversity (Balmford et al. 2002; Zedan 2005). Mountain ecosystems are particularly significant as they provide critical goods and services both to local communities and to communities downstream (Schild 2011). Therefore, it is essential to continue to work towards conservation of the natural capital in the mountains and to augment the flow of ecosystem services.

Maintenance of the flow of ecosystem services and avoidance of irreversible damage to the base for these services are a precondition for sustainable growth. Economic development needs to be socially inclusive and instrumental in poverty reduction while avoiding environmental damage (World Bank 2012). Thus economic development and the sustainability of resources are directly linked to people's wellbeing (Dasgupta and Heal 1979; Daily and Ellison 2002; Duraiappah 2011). Resource degradation results when there is open access to a resource and harvesting rates are based on immediate individual needs and benefits without consideration of the status and regeneration capacity of the resource. One reason for this is that ecosystem services are freely available and not captured by the market, thus there is no direct cost involved in using them or reducing the amount available. Ecosystem services are not quantified in a way sufficient to make them comparable with economic services or manufactured capital, and thus have a low weight in policy decisions (Costanza et al. 1997; Secretariat of the CBD 2007; Balmford et al. 2011). Exploitation of ecosystem services is not socially equitable, not least because we tend to ignore the fact that the generation of such services depends on the conditions and processes within the given ecosystem and the species that make them up (Daily 1997; Chee 2004). Biodiversity is a major component in many of the aspects of ecosystem functioning that are necessary to generate the required services and provide a stable flow (Mooney et al. 1995; Tilmann et al. 1996; Balvanera et al. 2006). Diverse ecosystems and species are needed to ensure a sustainable supply of varied ecosystem services (Costanza et al. 2007; Turner et al. 2007; Butler and Oluoch-Kosura 2006; Cardinale 2011). Environmental degradation leads to a reduction in the flow of services, which compels people to engage in unsustainable extraction of resources, thus degrading the ecosystem further (Diaz et al. 2011).

In recent years, there has been an increasing realization that protected areas and the biodiversity they contain are critical sources of ecosystem goods and services, and that the value of protected areas is an important building block in economic development (Dasgupta 2010; DEFRA 2010; TEEB 2010). Economic valuation, as defined by the Convention on Biological Diversity (Secretariat of CBD 2007), helps to demonstrate that conservation can provide tangible and intangible economic, environmental, and social benefits (Rasul et al. 2011), and provides information that can facilitate conservation policies (Costanza et al. 1997; Maharana et al. 2000; Badola et al. 2010). Valuation also helps to integrate ecological problems with economic forces and thus rectify the long-standing disregard of ecosystem services in national accounting and policy decisions (TEEB 2010). Economic valuation of an ecosystem has a wide range of uses including in formulation of national and international policies, for informing management decisions, and in garnering the support of local people for conservation (Chan et al. 2006). Ecosystem valuation is necessary to enable estimates to be made of the value of goods and services provided by an ecosystem and thus create incentive mechanisms (DEFRA 2007). Such estimates are useful when investments are appraised, development and conservation activities are planned, policies are formulated, or resource use decisions are made, so that the available resources can be allocated in the best way for society (Emerton and Bos 2004). Thus quantifying the economic value of ecosystem services is useful for strengthening the case for conservation (Dale and Polasky 2007; Swinton et al. 2007). Recognizing the importance of valuation of ecosystems, the Conference of the Parties to the Convention on Biological Diversity (CBD) stated that "economic valuation of biodiversity and biological resources is an important tool for well-targeted and calibrated economic incentive measures" (Secretariat of CBD 2002: Decision IV/10). Similarly, the CBD Programme of Work on Protected Areas urges integrating the use of economic valuation and natural resource accounting tools into national planning processes (Secretariat of CBD undated, Activity 3.1.2).

Kangchenjunga is the third highest mountain in the world, and the surrounding area, which covers parts of Bhutan, China, India, and Nepal, is one of the richest landscapes in the Hindu Kush Himalayas. This region forms a part of the 'Himalaya Hotspot', one of the world's critical centres of biodiversity (Mittermeier et al. 2004; WWF 2001), and is an important transboundary area for biodiversity conservation (Rastogi et al. 1997; Chettri et al. 2008). There are 15 protected areas in the southern part of the landscape and it is home to many flagship species such as the snow leopard (*Uncia uncia*), tiger (*Panthera tigris*), elephant (*Elephus maxima*), red panda (*Ailurus fulgen*), takin (*Budorcas taxicolor*), and musk deer (*Moschus chrysogaster*). However, the landscape is facing numerous conservation and development challenges. The most pervasive threat hindering conservation efforts is habitat loss and fragmentation, which reduces the habitat range of already small populations and isolates them further, making them vulnerable to extinction (Chettri et al. 2002; 2005). Thus recent conservation efforts have focused on using a landscape approach to guide conservation measures, and especially on proposals to increase habitat contiguity by connecting isolated protected areas with environmentally managed corridors (Sharma and Chettri 2005; Chettri et al. 2007). Developing a network of corridors linking protected areas is not only an important strategy for conservation at the landscape level; it can also contribute to enhancing the livelihoods of the local people by promoting maintenance and sustainable utilization of resources in the corridors.

The Kangchenjunga landscape is exceptionally rich in biodiversity and provides numerous ecosystem services to local communities, downstream populations, and the global community (Chettri et al 2008). However, various drivers of change are contributing to the deterioration of the landscape's valuable ecosystems and reducing their capacity to generate ecosystem services (Chettri et al. 2008). At the same time, the importance of the ecosystem services generated in the protected areas, the linking biological corridors, and the landscape as a whole is not sufficiently well recognized or valued to attract the attention of conservation agencies and policy makers at national and international levels. This is largely due to the lack of a standard methodology that can be used to compare the costs of conservation with the cumulative benefits that accrue from natural ecosystems and the returns per unit cost from conservation with those from other sectors of the economy.

Valuation of ecosystem services can be used as a basis for highlighting the importance of protected areas, corridors, and the landscapes in the conservation discourse. The study described here was designed to estimate the monetary value of ecosystem services from the forested areas in eastern Nepal, with the aim of raising awareness and facilitating action for improved management of the Kangchenjunga landscape. The study was designed to estimate the utilitarian or instrumental values of the services provided by the forest ecosystem of the proposed corridors within the landscape. The utilitarian value is the value of services that contribute to people's welfare in terms of both direct use, for consumption or production, and indirect use, which promotes human wellbeing generally. It is differentiated from the intrinsic value, which is the worth inherent in the existence of the ecosystem as such (Lockwood 1999). Specifically, the study estimates the economic value of the provisioning, regulating, and supporting services from the forest ecosystems.

The Study Area: Forested Corridors of the Kangchenjunga Landscape

The southern part of the proposed Kangchenjunga landscape covers an area of 14,500 km^2 across parts of Bhutan, India, and Nepal (Chettri et al. 2008). The Kangchenjunga complex is part of the Eastern Himalayan ecoregion, which includes Himalayan Alpine Meadows, the Eastern Himalayan Broadleaf and Conifer Forests, and the Terai-Duar Savannas and Grasslands, which are among WWF's Global 200 Ecoregions. The landscape includes part of the Himalaya Global Biodiversity Hotspot and contains diverse ecosystems, species, and genetic resources of global importance with a high level of endemism (Myers et al. 2000; Mittermeier et al. 2004). There are 15 protected areas within the southern part of the landscape, with areas ranging from 0.04 km^2 (Jore Pokhari Salamander Reserve, India) to 2,620 km^2 (Khangchendzonga Biosphere Reserve, India). Together they cover 6,038 km^2, or 42% of the landscape area. Six conservation corridors are proposed which cover an additional 11% of the landscape area and connect 9 of the 15 protected areas (Sharma 2008). Most of the corridor areas are in government reserve forest, except in Nepal where the proposed corridor areas comprise government owned forest and private agroforestry systems.

The study was conducted in the proposed Eastern Nepal Conservation Corridor, which covers 22 village development committee areas (VDCs) in the three eastern districts of Taplejung, Panchthar, and Ilam. This corridor provides connectivity between the Kangchenjunga Conservation Area in Nepal and the protected areas in India (Figure 1).

The people in the Kangchenjunga landscape depend on agriculture and forests, including non-timber forest products (NTFPs), for their livelihoods. Poorer households are the most dependent. Table 1 and Figure 2 show the area under different land use categories at the district level. On average, 21% of the land in the three districts is under agriculture. A large part of Taplejung is alpine and the district has the lowest proportion of agricultural land, the highest proportion of pasture, and a large amount of rocky and snow-covered land. Ilam has the highest proportion of agricultural land and the lowest proportion of pasture. Forest occupies close to half the area in all three districts and 45% of the land overall.

Figure 1: **Location of the three districts in eastern Nepal where the corridor is proposed**

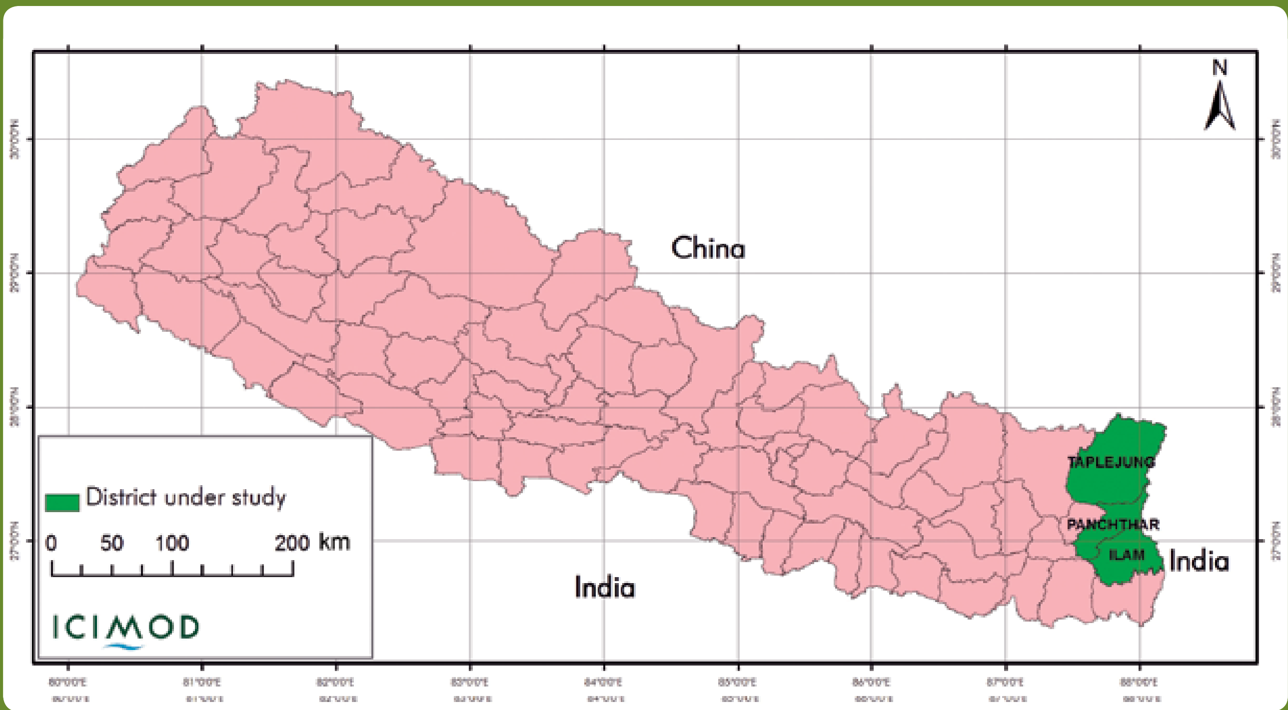


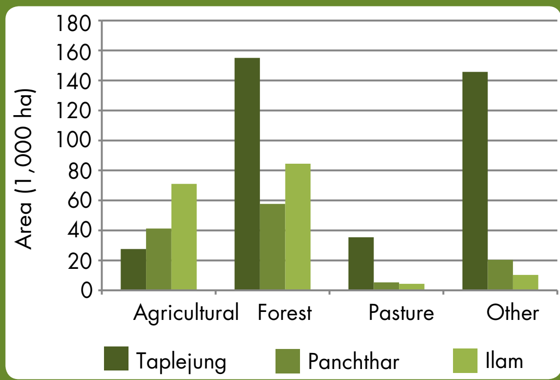
Table 1: **Land use and land cover in the three districts of the proposed Eastern Nepal Conservation Corridor**

Land use/land cover	Taplejung		Panchthar		Ilam		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Agricultural land	27.55	7.6	41.21	33.1	71.08	41.7	139.84	21.2
Forest	155.02	42.6	57.71	46.3	84.51	49.6	297.24	45.1
Pasture	35.38	9.7	5.29	4.3	4.41	2.6	45.08	6.8
Other (settlements, water, rock, slope)	145.75[a]	40.1	20.38	16.4	10.3	6.1	176.43	26.8
Total	**363.70**		**124.59**		**170.30**		**658.59**	

[a]76.41 ha under rocks, 53.96 ha under snow
Source: CBS 2007, 2008a, 2008b

The major cereal crop in all three districts is maize, followed by paddy, millet, wheat, and barley. Other crops include pulses, oilseeds, potato, cardamom, ginger, garlic, turmeric, chilli, and vegetables. Tea and coffee are grown abundantly in Ilam and Panchthar districts, but to only a limited extent in Taplejung. Livestock – cattle, buffalo, sheep, goats, and pigs – are an important component of the farming system. They support crop farming by providing draft power and manure, and provide food and cash income. The forest areas provide extensive support for animal husbandry through the supply of leaf fodder, grass, and leaf litter. The forest biodiversity also supports crop production but the relationship is less distinct.

Figure 2: **Land use in the districts of the proposed Eastern Nepal Conservation Corridor**



Source: CBS 2007, 2008a, 2008b

Methodology

The Millennium Ecosystem Assessment (MA 2005) framework was used to categorize forest ecosystem services and estimate their economic value. The framework classifies ecosystem services into four main types: provisioning services that provide direct inputs to livelihoods and the economy; regulating services such as those that provide flood and disease control; supporting services that sustain and fulfil human life; and cultural services that support recreation and spiritual or historical sites.

The study was limited to ecosystem services related to forest ecosystems and included provisioning services such as the production of timber, fuelwood, and NTFPs including medicinal plants, leaf fodder and grass for livestock, and bamboo; regulating services of carbon sequestration; and supporting services such as soil formation, soil and water conservation, and nutrient recycling. Other ecosystem services were not covered, for example provisioning services of water and genetic resources; regulating services such as ecosystem resilience for climate change adaptation; and cultural services such as religious values and aesthetic values for tourists and other visitors. Although some of these do relate to forests, they could not be evaluated either because the flows were too small (for example tourism) or methods or data were inadequate. The valuation of the supporting services was limited to their effects on annual crop production; effects on perennial crops like tea and on livestock were not evaluated. The effects of livestock grazing and browsing in the forest and the effects of wildlife on crops and livestock were also excluded.

The provisioning services were evaluated using the market price method; the regulating service of carbon sequestration was evaluated using the benefit transfer method; and intangible supporting services such as nutrient recycling and soil formation were evaluated through the productivity method. The revealed preference approach was used in all three methods (King and Mazzotta 2000).

The major ecosystem services flowing out of the study area of the landscape are summarized in Table 2. The provisioning and supporting ecosystem services were evaluated in the context of local people whose day-to-day decisions are directly related to the services that form the basis of their livelihoods; the regulating services were evaluated in terms of their global impact. The values for individual components were added together to give an estimate of the total annual flow. The value of the annual flow of ecosystem services was capitalized to derive the value for the landscape.

The total economic value (TEV) approach was followed for the final valuation. TEV is the framework most widely used to identify and quantify the contribution of ecosystem services to human wellbeing (MA 2005; Pearce and Moran 1994; Young 1995). It is the aggregate of the use and non-use values of the ecosystem services. The use value includes the direct-use value of the provisioning services and the indirect-use value of the regulating and cultural services; the non-use value (not evaluated in the study) includes the existence value and bequest value of the biodiversity (indicating that people place a value on the existence and good condition of the biodiversity and on passing this to future generations). The TEV approach of valuation evaluates the total flow of the ecosystem services that are relevant to the people in the economic system of the country, region, or globe for their own needs, wishes, and aspirations.

Data collection and sampling

A household survey was conducted by questionnaire in 9 of the 22 VDCs in the proposed corridor area in Taplejung, Panchthar, and Ilam districts between March and May 2010. Three VDCs (strata) were selected in each

Table 2: **Ecosystem services from the study area, the main users, and the valuation methods used**

Type of ecosystem service	Major services	Main users	Valuation methods
Provisioning	Timber and wood (poles, fuelwood) Medicinal plants (chiraita, Himalayan yew, valerian, prickly ash, asparagus) Biomass for animal husbandry (fodder, grass, leaf litter) Farming (vegetables) Subsidiary food (mushrooms, bamboo shoots, other vegetables, edible fruit, honey)	Local people, contribute to livelihoods	Market price method used to estimate the village level price or its equivalent
	Fresh water	Downstream populations	Not included in the study
	Genetic resources of flora and fauna	Researchers and future generations	Not included in the study
Regulating	Carbon sequestration	Global community	Benefit transfer method
	Air quality regulation, climatic regulation, natural hazard regulation, water regulation and purification, soil erosion control, pollination, pest control	Local, regional, and global	Not included in the study
Supporting	Soil formation and nutrient recycling for farmland	Local farmers, contributes to livelihoods	Change in crop productivity
Cultural	Aesthetic and recreational for ecotourism Spiritual and religious	Visitors and local tribal populations	Not included in the study

Source: Adapted from MA 2005

Table 3: **Samples and sample weights**

District	Total VDCs[b]	VDCs selected (strata)	VDC weight	Total households in VDC[b]	No. of sampled households	Inverse of stratum sampling rate (SSR)	Sample weight
Taplejung	50	Aangkhop	16.67	457	50	9.14	0.452
		Kalikhola	16.67	115	50	2.30	0.114
		Sadewa	16.67	209	50	4.18	0.207
Panchthar	41	Chyangthapu	13.67	492	50	9.84	0.399
		Memeng	13.67	962	50	19.24	0.781
		Sidin	13.67	778	50	15.56	0.631
Ilam	49[a]	Gorkhe	16.33	1,031	50	20.62	1.000
		Jamuna	16.33	684	50	13.68	0.663
		Maipokhari	16.33	802	50	16.04	0.778

[a] Includes a municipality
[b] CBS 2007, 2008a, 2008b

district based on dependence on natural resources and resource use patterns. Fifty households were selected at random in each sample VDC to give a total sample of 450 households (Table 3). The sample was adjusted using the design effect through sampling weights. The sampling weights denote the inverse of the probability that a household in the stratum is included in the sample; undersampled strata such as Gorkhe and Memeng VDCs had higher weights than oversampled strata such as Kalikhola and Sadewa.

The households sampled in each VDC were taken as the primary sampling unit (PSU), as the finite population correction (FPC) for the variance estimates of survey data does not allow sampling within a PSU. The ratio of the sample size (50 PSU for each VDC) to the total PSU (total number of households) in each stratum is the stratum sampling rate (SSR).

Indicators were used to link the ecosystem to the economy. The income generated by households from provisioning services and supporting services provided by the corridor were taken as indicators of wellbeing. This wellbeing was attributed to forest biodiversity and agrobiodiversity (farm-level crop species diversity) separately. The ecosystem extent (defined as the original area of a biome minus the area occupied by agricultural and urban land use, see GLOBIO 2012) was taken as an indicator of forest biodiversity. Considering the land use pattern in the area, forest ecosystems, excluding agricultural land and human settlements were used as a reliable proxy for ecosystem extent. As most of the forest in the area is natural, with some level of timber, leaf litter, and NTFP collection, the intact forests were taken as a good surrogate for forest biodiversity. Crop species reported by households were used as the observed proxy for species richness (more specifically the species density) in the agroecosystem. Thus, the ecosystem extent was used as the index for the forest ecosystem and species density as the index for the agroecosystem. The ecosystem extent was obtained from the district profiles, and the species density from the household survey.

Data analysis

The analysis used three methods: the market price method, benefit transfer method, and productivity method.

First, the value of the provisioning services of the forest ecosystem was estimated by converting the timber and NTFPs harvested by local households into monetary terms using the reported market prices. The population and subpopulation means, standard error, and 95% confidence interval were estimated. The subpopulation mean for each district was multiplied by the number of households in the district to derive the aggregate amount, which is the minimum level of benefit obtained by society from the biodiversity provisioning services.

Second, the land cover types for the area were obtained from the literature and the annual value of carbon sequestration estimated for each type of land use. The carbon sequestration index was estimated for primary forest and natural pasture with low tree density (<30/ha) as described by Pagiola et al. (2004, 2007) and Rasul (2009). The carbon sequestration index was converted to monetary terms using the rate given by Pagiola et al. (2007) of US$75 per point per year (NPR 5,325 per point per year at a rate of USD 1 = NPR 71 at the time of the survey). Specifically, value of the carbon sequestration services = point of carbon sequestration in specific land use (point/ha) x price of carbon (NPR/point).

Third, the value of the supporting services of the forest ecosystem was captured by estimating the effects of nutrient recycling and soil formation on crop production and thus on people's wellbeing. The effects of the forest and agroecosystem services were estimated using an econometric model and sample statistics. The supporting services from forest biodiversity were estimated econometrically from the contribution of the forest ecosystem to the crop income of the households (as measured by the ecosystem extent index) after controlling the effects of other measurable confounding factors. The major confounding factors were variations in village characteristics, household characteristics, and the characteristics of the respondents.

A linear regression was used to estimate the contribution of the agroecosystem and forest ecosystem to household wellbeing using indices for crop income as follows.

$$\textbf{incrop} = \alpha + \beta 1\textbf{sppdensity} + \beta 2\textbf{ecoextent} + \beta 3\textbf{vroad} + \beta 4\textbf{age} + \beta 5\textbf{female} + \beta 6\textbf{higher} + \beta 7\textbf{innonagk} + \beta 8\textbf{landoper} + \beta 9\textbf{irrigat} + \beta 10\textbf{vliter} + \beta 11\textbf{tibeto} + \varepsilon$$

The variables are described in Table 4. The coefficients α and β_i are estimated econometrically, and ε is an error term that is expected to have a zero mean (unbiased) and constant standard deviation (homoscedastic). The coefficient β_1 is the contribution of the agroecosystem to crop income whereas the coefficient β_2 is the contribution of the forest ecosystem to the crop income.

The value per household generated by the forested ecosystems was applied to all households in the study area to estimate the aggregate values. Due to the paucity of data at the VDC level, we extrapolated the data for the whole of the three districts based on the unit cost derived from samples from the nine VDCs.

The total value of ecosystem services from the forest ecosystems was estimated by summing the values for provisioning services, regulating services, and supporting services.

Table 4: **Variables used in the estimation of supporting services**

Variable	Unit	Description
sppdensity	number	species richness of agrobiodiversity as measured by the number of major crops grown
ecoextent	ha	ecosystem extent as measured by the area of the forest in each VDC
vroad	dummy	access of household to road: access yes = 1, no = 0
age	years	age of respondent
female	dummy	female respondent = 1, male = 0
higher	dummy	respondent above secondary education = 1, otherwise = 0
innonagk	NPR 1,000	non-agricultural and non-forest income of the household
landoper	ha	operated (cultivated) agricultural land of the household
irrigat	%	irrigated land of the household as a percentage of the operated agricultural land
vliter	%	average literacy in the VDC
tibeto	dummy	Tibeto-Burman ethnicity = 1, other = 0
incrop	NPR	income from major crops

Economic Value of Forest Ecosystem Services

Economic value of provisioning services

The forest ecosystem provides several provisioning services. The pre-feasibility report listed more than 200 NTFPs from the 22 VDCs of the three districts that are harvested from the corridor area – including community forest, private forest, and national forests – and used locally. However, only a few have commercial value and are traded (NCDC 2005). The major provisioning services are timber and other wood; biomass for animal husbandry such as fodder, grass, and leaf litter; raw materials for cottage industries, such as bamboo (*Phyllostachys* spp.) and lokta fibre (bark of *Daphne cannabina*); foods such as mushrooms (*Agaricus* spp.), bamboo shoots, other vegetables, edible fruit, and honey; and medicinal plants such as chiraita (*Swertia chirayita*), Himalayan yew or lauth salla (*Taxus baccata*), valerian or sugandhawal (*Valeriana jatamansi*), prickly ash or timur (*Zanthoxylum armatum*), and asparagus or shatavari (*Asparagus racemosus*). Biodiversity is the core value that generates the services.

Ecosystem services at the household level. Local people, particularly those living near the forest ecosystem and earning their livelihood from traditional agriculture, are highly dependent on ecosystem services from the forest. The estimated annual value of harvested products is summarized in Table 5; further details are provided in Annex 1.

The villagers living in the corridor area of the Kangchenjunga landscape harvest poles, fuelwood, and timber from general forest, community forest, and private forest (Regmi 2008). Poles played a relatively minor economic role. The average value of the poles harvested was NPR 311 per household, with the highest value in Ilam and the lowest in Taplejung. Among the wood products, the largest value came from fuelwood. Virtually all households in the district use fuelwood for cooking. The average value of the fuelwood harvested was NPR 6,885 per household per year with the highest value in Taplejung, which is the coldest district. The average value of timber harvested was NPR 4,779 per year, but with a higher standard deviation than for poles and fuelwood reflecting the more variable needs of individual households. The total annual value of the wood products harvested per household was NPR 11,974.

The farmers harvest many forest products as biomass for animal husbandry and for use in the farming system rather than for direct consumption. These forest-based intermediate inputs include leaf fodder and grass for livestock feed, leaf litter for livestock bedding, biomass for crop mulching and composting for crop fertilization, and small timber for agricultural tools. Of these, tree fodder generated the highest average annual value (NPR 23,864) followed by grass (NPR 18,471), leaf litter (NPR 2,154), and wood for agricultural tools (NPR 166), to give a total of NPR 44,655 per household per year, more than three times the value of the wood products harvested. The value of collected tree fodder and grass was highest in Ilam, which is famous for milk production.

Bamboo and lokta are harvested for domestic use as well as for cottage industries. Bamboo is used for many household purposes including construction of houses or animal sheds and weaving baskets. Lokta is the raw material for hand-made Nepalese paper, which is famous for its strength and tradition. The paper also repels insects and has a very long life. All legal and archaeological documents used to be written on lokta paper. Lokta

Table 5: **Estimated value of provisioning services from forest ecosystem** (NPR/household/year)

Product	Taplejung (n_1 = 150)	Panchthar (n_2 = 150)	Ilam (n_3 = 150)	Average (n = 450)
Timber and wood	10,873	16,582	8,230	11,895
Biomass for animal husbandry	17,254	38,814	58,337	38,135
NTFPs	96	263	193	184
Wild edibles	167	341	132	213
Medicinal plants	1,147	3,635	3,413	2,732
Total	29,537	59,635	70,305	53,195

Source: Household survey 2010 weighted average.

is also used by households to make rope. The commercial value of these products was quite low, however, on average NPR 85 per household per year for bamboo and NPR 27 per household per year for lokta – a total of NPR 112.

The villagers harvest some wild edibles from the forest to eat raw or cooked, including wild mushrooms, young bamboo shoots, other vegetables, wild fruit, and honey. The main vegetables harvested are neguro (*Diplazium esculentum*, an edible fern), watercress (*Nasturtium officinale*), and chinde (*Pentapanax leschenaultiana*), and the main fruits are chestnut (*Castanopsis indica*) and kharane (*Symplocos ramosissima*). The value of edible fruit and honey harvested from the forest was much smaller than that of the other products. The commercial value of all of these per household per year was quite low: NPR 52 for mushrooms, NPR 48 for bamboo shoots, NPR 84 for other vegetables, NPR 10 for edible fruit, and NPR 28 for wild honey – a total of NPR 221 per household, with the highest amount in Panchthar and the lowest in Ilam. Notwithstanding the low monetary value, these products help farmers to maintain their traditional food habits and provide nutritional supplements, especially vitamins and minerals.

Medicinal and aromatic plants support healthcare in local communities, are a source of traditional medicines, and can be a direct source of income. The major medicinal plants harvested are chiraita (*Swertia chirayita*), Himalayan yew, valerian, prickly ash (timur), and asparagus. Koirala (2003) also reported the harvesting of bikhma (*Aconitum palmatum*), kutki (*Picrorhiza scrophulariiflora*), pakhanbed (*Bergenia ciliata*), chinfing (*Heracleum nepalense*), panch aunle (*Dactylorhiza hatagirea*), and other rare species of medicinal plants from the alpine rangeland which provide additional income. Only chiraita generated a substantial value as reported in the survey (average NPR 3,153 per household per year) as it can be easily collected and readily sold. The other products generated values of a few rupees per household to give a total average of NPR 3,182 per household per year from medicinal plants.

The value generated from the different provisional services by a typical household is provided in Table 6. In the study area, only a few items among medicinal plants and NTFPs contributed directly to household income; the other provisioning services generated value through direct consumption or intermediate consumption within the integrated farming system. The value of biomass for animal husbandry was equivalent to 72% of household income, and that of timber and wood was equivalent to 22%. Although the value of medicinal plants was relatively low, they are important because they help to generate cash income. The results show that the value of the biodiversity is strongly linked to livelihoods and has a very high leverage for poverty reduction.

Aggregate value of the provisioning services. The aggregate value of the provisioning services was estimated from the total number of households dependent on the corridor area. The results are shown in Table 7.

The aggregate value of timber and other wood products was NPR 1,396 million with the highest value generated in Panchthar and the lowest in Taplejung. The greatest value was contributed by biomass for animal husbandry – a total of NPR 5,206 million per year, with the highest value in Ilam and the lowest in Taplejung. Raw materials like bamboo and lokta gave an aggregate value of NPR 13 million and wild edibles close to NPR 26 million.

Table 6: **Wellbeing received from provisioning services of forest ecosystems as a percentage of total household income**

Forest product	Value of provisioning services	
	NPR/household	% of total household income from forest ecosystem
Timber and wood	11,895	22.4
Biomass for animal husbandry	38,135	71.7
NTFPs	184	0.3
Wild edibles	213	0.4
Medicinal plants	2,732	5.1
Total	**53,195**	**100.0**

Source: Household survey 2010

Table 7: **Aggregate value of the provisioning ecosystem services received from forest ecosystems in the three districts** (million NPR)

Forest product	Taplejung (n_1=24,760)	Panchthar (n_2=37,260)	Ilam (n_3=54,565)	Total (n=116,585)	Contribution (%)
Timber and wood	**269.21**	**617.84**	**449.06**	**1,396.00**	**19.9**
Poles	3.40	6.80	26.08	36.21	
Fuelwood	209.15	240.84	369.58	802.66	
Timber	56.66	370.19	53.40	557.13	
Biomass for animal husbandry	**427.22**	**1,446.21**	**3,183.15**	**5,206.10**	**74.3**
Fodder	188.70	683.82	1,843.81	2,782.18	
Grass	218.95	681.89	1,179.14	2,153.46	
Leaf litter	16.44	70.75	155.10	251.12	
Agricultural tools	3.13	9.75	5.10	19.34	
NTFPs	**2.37**	**0.99**	**10.51**	**13.05**	**0.2**
Bamboo	2.37	0.99	7.31	9.94	
Fibre (lokta)	0	0	3.20	3.11	
Wild edibles	**4.13**	**12.70**	**7.22**	**25.81**	**0.4**
Mushrooms	0.64	2.22	2.88	6.03	
Bamboo shoots	0.72	3.26	1.02	5.59	
Vegetables	1.92	4.35	3.06	9.75	
Edible fruits	0.84	0.27	0.27	1.16	
Honey	0	2.60	0	3.28	
Medicinal plants	**28.40**	**135.43**	**186.22**	**371.01**	**5.3**
Chiraita	28.4	135.42	182.68	367.56	
Himalayan yew	0	0	0.03	0.03	
Valerian	0	0.01	0.38	0.37	
Prickly ash	0	0	2.78	2.70	
Asparagus	0	0	0.35	0.34	
Total	**731.33**	**2,213.17**	**3,836.16**	**7,011.97**	**100.0**
% contribution by district	11	33	56		

Source: Household survey 2010

The total value generated from medicinal and aromatic plants was NPR 371 million, of which NPR 368 million was from chiraita, with the greatest amount generated in Ilam and the least in Taplejung. These medicinal plants are exported. The study only took into account the benefits realized by the local harvesters, but along the value chain, exporters, importers, medicine companies, medicine wholesalers, retailers and patients all benefit from these products.

The total value of the provisioning services of forest biodiversity to the local people in Taplejung, Panchthar, and Ilam districts was more than NPR 7,000 million, close to three-quarters of which was contributed by biomass for animal husbandry.

Economic value of regulating services

Forest ecosystems provides a variety of regulating services that affect local, regional, and global communities. At present, the most widely discussed regulating service of forest ecosystems is carbon sequestration (Huang and Kronrad 2001; Olschewski and Benítez 2005; Zbinden and Lee 2005; Pagiola et al. 2004, 2007; Rasul 2009). The regeneration and growth of trees and plants adds to the stock of carbon in the conservation area, with annual net capture appreciably larger in the areas of primary forest. The annual value of the carbon sequestration services

Table 8: **Value of forest carbon sequestration in the proposed corridor**

Land use	Area ('000 ha)	Carbon sequestration index[a]	Total index (area x CSI)	Value of carbon sequestration services (million NPR/year)
Agricultural land (annual crops)[b]	139.84	0.0	0	0.00
Forest area (primary forest)	297.24	1.0	297,240	1,582.80
Pasture (natural pasture with low tree density < 30 trees/ha)	45.08	0.3	13,524	72.02
Other (settlements, water, rock, slope)	176.43	0.0	0	0.00
Total	**658.59**			**1,654.82**

[a] Carbon sequestration index (CSI) and price per unit of the index (USD 75/unit) from Pagiola et al. 2007

[b] Does not include carbon sequestration in fruit trees, fodder trees, and farm forestry

from the study area was estimated to be NPR 1.65 billion (Table 8), of which close to 96% was generated from the forest ecosystem and the remainder from pasture.

Economic value of supporting services

Farm production can be directly related to wellbeing, thus the productivity method was considered to be effective for evaluating the supporting ecosystem services. The mean ecosystem extent, the indicator for forest biodiversity, was 1,780 ha per VDC. The agroecosystem also affects farm production. Species richness was taken as the index for agrobiodiversity. The species density was constructed using the number of major crops reported by households. The major crop species recorded from irrigated land were paddy (*Oryza sativa*), wheat (*Triticum aestivum*), potato (*Solanum tuberosum*), and maize (*Zea mays*), and the crop species recorded from rainfed upland were maize, finger millet (*Eleusine coracana*), potato, soybean (*Glycine max*), mustard (*Brassica rapa*), peas (*Pisum sativum*), beans (*Phaseolus vulgaris*), cauliflower (*Brassica oleracea* var. *botrytis*), radish (*Rhaphanus sativus*), cabbage (*Brassica oleracea* var. *capitata*), cardamom (*Amomum subulantum*), and tea (*Camellia sinensis*) – 15 species in all. A similar number (18) was reported in a biodiversity inventory study in a similar district (Sankhuwasabha) (SEEPORT 2003, p 39).

The mean species richness reported by the households was 3.20 with a narrow confidence interval (Table 9). There were several confounding factors in the estimation, in particular village characteristics, household characteristics, and individual characteristics of the respondent. Approximately 77% of households had road access to their VDC. The average age of the respondents was 44; 20% were female. Among the respondents, only 18% had an education level above higher secondary. The average non-agricultural and non-forest household income was close to NPR 30,000. Farming was the main occupation; the average cultivated land was about 1.50 ha, of which 14% was irrigated and the remainder rainfed. The literacy rate was nearly 59%; 71% of the people belonged to Tibeto-Burman ethnic communities and the remainder were Indo-Aryan. The average crop income was NPR 12,723 per household per year. Crop income is the welfare variable affected by the ecosystem services involving biodiversity of the landscape.

The effects of biodiversity indices on the welfare variable for local people were explored using the survey data from the nine VDCs. Sampling weights were used to reduce the effects of sampling design. The results show that each unit increase in the species density of the agroecosystem increased crop income by NPR 3,260 per household, and each unit (ha) increase in the ecosystem extent increased the crop income by NPR 1.2 per household (Table 10).

The results shown were corrected for the effects of confounding factors of village conditions (road access and village level literacy rate), respondent effects (age, gender, and education) and household characteristics (non-agricultural income, cultivated land units, availability of irrigation, and ethnicity). Age, gender, and ethnicity did not significantly affect the value of the supporting services. Thus the identity of the respondent did not bias the estimation. The effect of education on crop income was significant and controlled for the purpose of the estimation.

Table 9: **Descriptive statistics of independent and dependent variables**

Variable	Unit	Mean	Standard error	95% confidence interval range	
Sppdensity	number	3.20	0.05	3.10	3.29
Ecoextent	ha	1,780	0.00	1,780	1,780
Vroad	dummy	0.77	0.00	0.77	0.77
Age	years	43.53	0.72	42.11	44.96
Female	dummy	0.20	0.02	0.16	0.24
Higher	dummy	0.18	0.02	0.14	0.22
Innonagk	NPR 1,000	29.75	3.23	23.41	36.09
Landoper	ha	1.50	0.01	1.37	1.64
Irrigat	dummy	14.18	0.95	12.33	16.04
Vliteracy	%	58.65	0.00	58.65	58.65
Tibetoburman	dummy	0.71	0.02	0.66	0.75
Incrop	NPR	12,723	1,007	10,744	14,701

Sample size (*n*) = 450, population size (*N*) = 5,530

Source: Household survey 2010

Table 10: **Effects of crop diversity and forest area on crop income of the farm households**

Explanatory variable	Coefficient	Standard Error	*t-value*	P>	95% Confidence Interval	
Sppdensity	3,259.926***	860.38	3.79	0.000	1,568.97	4,950.86
Ecoextent	1.20*	0.64	1.87	0.062	-0.06	2.46
Vroad	7,980.89***	2,429.16	3.29	0.001	3,206.71	12,755.07
Age	-22.16	56.14	-0.39	0.693	-132.49	88.18
Female	-992.43	2,169.12	-0.46	0.648	-5,255.52	3,270.66
Higher	6,172.64*	3,247.14	1.90	0.058	-209.16	12,554.44
Innonag	-27.10**	13.81	-1.96	0.050	-54.24	0.04
Landoper	119.10***	39.00	3.05	0.002	42.45	195.76
Irrigate	122.76*	68.20	1.80	0.073	-11.29	256.81
Vliteracy	417.20***	134.94	3.09	0.002	151.99	682.40
Tibetoburman	1,008.24	2,138.30	0.47	0.638	-3,194.28	5,210.76
_cons	-35,553.59***	8,737.80	-4.07	0.000	-52,726.49	-18,380.69

Note: Number of observations (households) = 450; number of strata (VDCs) = 9; number of PSUs (households) = 450; population size = 5,530; $F(11, 431) = 11$; prob > $F = 0.000$; $R^2 = 0.216$; $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P<0.001$)

Source: Household survey 2010

Table 11: **Crop income in the sampled VDCs in the proposed corridor area**

Variable	Unit	Taplejung	Panchthar	Ilam	Total
Crop income	NPR/household	1,667	17,528	11,892	12,723
Standard error	NPR/household	447	1,977	1,341	1,007
Total no. of households	number	24,760	37,260	54,565	116,585
Crop income in district	million NPR	41	653	649	1,343
Percentage of total	%	3	49	48	100.0

Source: Household survey 2010

Table 12: **Value of crop and forest ecosystem services estimated from the effect on crop income**

Variable	Unit	Taplejung	Panchthar	Ilam	Total
Species diversity of major crops	number	2.63	3.95	2.58	3.05
Ecosystem extent	ha/VDC	1,753	3,645	352	5,751
Average value of crop diversity	NPR/HH	8,574	12,877	8,411	9,943
Average value of forest biodiversity	NPR/HH	2,104	4,374	422	6,901
Total number of households	number	24,760	37,260	54,565	116,585
Intangible value of crop diversity	million NPR	212.29	479.80	458.94	1,151.02
Intangible value of forest biodiversity	million NPR	52.09	162.99	23.05	238.13

VDC = village development committee, HH = household
Source: Household survey 2010

The average crop income of the sample households was used to extrapolate total crop income. The estimated crop income in the three districts was NPR 31,087 million (Table 11), only 3% from Taplejung and the remainder split between Panchthar and Ilam. The small contribution from Taplejung district reflects its more alpine nature, with steep slopes, less arable land, a smaller number of households, and poor accessibility to markets.

The species density coefficient per household (Table 10) was multiplied by the average species density and the total number of households to estimate the intangible (aggregate) value of crop diversity on crop income. The intangible value of crop diversity across the three districts was estimated to be NPR 1,151 million (Table 12).

Table 13: **Total value of ecosystem services from the forest ecosystems**

Source of value	Value (million NPR)	Percentage of total
Value of provisioning services		
Timber and other wood	1,396.00	15.7
Biomass for animal husbandry	5,206.10	58.5
NTFPs	13.05	0.1
Wild edibles	25.81	0.3
Medicinal plants	371.01	4.2
Value of regulating services		
Carbon sequestration	1,654.82	18.6
Value of supporting services		
Increase in crop income	238.13	2.7
Total	8,904.92	100.00

Source: Household survey 2010

The ecosystem extent coefficient (Table 10) was multiplied by the average ecosystem extent and the total number of households to estimate the intangible value of the supporting services of forest biodiversity on household income. The intangible value of forest ecosystem services across the three districts was NPR 238 million (Table 12).

Total economic value of ecosystem services

The total economic value of ecosystem services from the forest ecosystem of the three districts is summarized in Table 13. The total economic value of the forest-based ecosystem services described from the three districts, namely, Taplejung, Panchthar, and Ilam, was estimated to be NPR 8.9 billion per year (approximately USD 125 million), equivalent to NPR 30,000 per hectare per year. The estimated value from carbon sequestration to the global community was NPR 1.65 billion. The estimate does not include cultural services. The major value was from the provisioning services, especially biomass for animal husbandry which contributed close to 60% of the total. The results show that the agricultural economy is closely integrated with the forest biodiversity and that any loss of biodiversity will directly affect the livelihoods of local people. Thus the forest and agroforestry ecosystems are very valuable assets for both rural households and the global community.

The estimate given here is the minimum value. A number of ecosystem services in the proposed area were not evaluated and are likely to increase the value. Nevertheless, the value estimated so far is high enough to indicate to policy makers the economic importance of developing suitable policy measures for conservation.

Discussions and Conclusion

It is not easy to obtain a reliable indicator for forest ecosystem services. According to the literature, the status of forest biodiversity can be derived from national monitoring programmes (Puumalainen et al. 2003), but the monitoring programme in the Kanchenjunga landscape is not sufficient to generate such information. There are few comprehensive inventories of species and populations in the protected areas in the eastern Himalayas (Chettri et al. 2010) and the benefits provided by conservation areas still receive little recognition.

Even though many of the ecosystem services are intermediate in nature and do not enter directly into household income, the value of the provisioning services generated by the households was equivalent to 80% of the total household income (see Table 13). This indicates the importance of forest ecosystem services to local households and is consistent with the report by Constanza et al. (1997) which estimated that globally the value of all four types of ecosystem service is nearly twice the gross national product. Some other studies have attempted to carry out a valuation of the contributions of biodiversity to the ecosystem functionalities that increase productivity related to species richness or the number of species present in an ecosystem (Costanza et al. 2007). Traditional agriculture depends more on natural capital than on man-made capital – machines, greenhouses, fertilizer, and other inputs – and thus shows strong interactions between the forest ecosystem and the agroecosystem. Further studies will be necessary to explore the biophysical nature of these relationships and interdependencies.

The study described here used market and non-market valuation methods to estimate the monetary value of goods and services provided by the forest and agroecosystem in a proposed corridor within the Kangchenjunga landscape. The study used local market prices to determine the value of provisioning services – goods used from the forest ecosystems (see Annex II). These prices could be strongly affected by any marked reduction in the availability of the provisioning services, as can be assessed by their prices in neighbouring urban areas. For example, wild edibles that have no commercial value in the districts where they are freely available, can sell for substantial sums in more distant urban areas. Similarly, reduction in the availability of fodder or fuelwood, might lead farmers to look for substitute sources of feed and energy that can be purchased. Thus the equivalent value of forest provisioning services is likely to be much higher should these services be markedly reduced.

The economic benefits generated by provisioning, regulating, and supporting ecosystem services from the study area amount to around NPR 8.9 billion (USD 125 million) per year, or NPR 30,000 (USD 4,286) per hectare. As a comparison, the total value of forest ecosystem services flowing from the state of Uttarakhand in India was reported to be about INR 107 billion (USD 2.4 billion) per year (Singh 2007). However, the differences in the estimates are due to the larger size of the study area as well as consideration of other forms of carbon from the forests such as soil, leaf litter, etc. In the Kangchenjunga landscape, close to 80% of the benefits, NPR 7.1 billion per year, were derived from provisioning services, i.e., goods from the corridor that are used directly or indirectly, with an average estimated benefit per household of NPR 53,195 per year, equivalent to 80% of the total household income. The value of carbon sequestration services was also considerable at NPR 1.6 billion annually, close to 18% of the total value of the ecosystem services. The value of regulating and supporting services together accounted for about NRP 1.92 billion per year providing a benefit per household of about NPR 16,328 per year. These findings are consistent with several other studies in the region. For example, benefits to the local population provided by ecosystem services from Chitwan National Park in Nepal were estimated to be between NPR 60,145 per hectare per year (Sharma 1991) and NPR 9,843 per hectare per year (Dhital 2003).

The results show that the forest ecosystem of the study area provides immense economic benefits to local people, and that people living in the corridor are highly dependent on forest ecosystem services for their subsistence and wellbeing. Some of the benefits are not immediately visible in terms of direct household income, but they make an important indirect contribution in terms of commodities such as fodder for livestock and leaf litter for soil fertility. Local people's livelihoods will be severely affected if the flow of such services is reduced or discontinued.

The present analysis did not consider the benefits that arise from cultural and recreational services provided by the corridor as the relevant data were not available. Anecdotal evidence, however, suggests that the corridor is an important tourist attraction due to its scenic landscape and rich diversity of flora and fauna, including snow leopard, Himalayan black bear, musk deer, and red panda, and that this and the aesthetic, scenic, and heritage value provide considerable benefits in terms of recreational and cultural services. The study also made no attempt to estimate the value of other benefits to society at large such as biodiversity conservation, groundwater infiltration, flood moderation, and air filtration, although these are also likely to be considerable. Other limitations include the difficulty of estimating the price of provisioning services if these were to become scarce, and estimating the real contribution of supporting services which are intangible and difficult to quantify. Supporting services include, for example, values arising from nutrient recycling from the forest to farmland and soil formation by forest biodiversity. These services help to increase farm productivity, but they work through chains of ecosystem processes that are not yet fully understood and the change in productivity method used to assess their value must be seen as indicative.

Overall, the estimated values should be considered as indicative, providing a first, and probably low, estimate of the economic value of the services provided by forest ecosystems. Further studies are needed to estimate the value of other ecosystem services such as provisioning of water and genetic resources and regulating of environmental phenomena as well as to delineate the biophysical relations between the biodiversity stock and the flow of services and thus refine the estimation methods.

The methodology used in this study can be scaled up to the entire Kangchenjunga landscape to support regional collaboration in conservation, and can be applied in other areas of the Hindu Kush Himalayan region after modification to take into account the local conditions. The methods covered three types of ecosystem service and are thus quite comprehensive. The results give a more concrete value to the ecosystem services from the corridor and can help policy makers when making economic decisions on factors such as investment and resource allocation.

Policy Implications

The findings have a number of policy implications. Although the total estimate of the value of the ecosystem services is conservative, it shows clearly that the economic benefits supplied by the corridor are immense and that local people depend heavily on the ecosystem services for their livelihoods and wellbeing. If the flows of ecosystem services from the corridor deteriorate, this would adversely affect the lives and livelihoods of a large number of people who depend on the forests in a multitude of ways. Policy makers should take into account the value of the corridor in development planning and deciding resource allocations, and take adequate measures for conservation of the corridor to ensure that the flow of ecosystem services is sustained. Attention should be paid to continuing participatory approaches and including the decision making processes of the local people in conservation measures, to ensure that the local population receives adequate benefit from the ecosystem services through better management. Appropriate economic frameworks and mechanisms need to be developed that provide incentives to local people to support conservation measures that can improve their lives. As many of the benefits arising from the corridor, such as conservation of biodiversity, protection of endangered species, and carbon sequestration, go to society at large, the global community should come forward with technical and financial support for conservation of the corridor.

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Annexes

Annex 1: Estimated Value of Forest Ecosystem Provisioning Services (NPR/household/year)

Forest products	Taplejung (n_1 = 150)	Panchthar (n_2 = 150)	Ilam (n_3 = 150)	Average (n = 450)
Timber and wood	**10,873**	**16,582**	**8,230**	**11,895**
Poles	137	183	478	266
Fuelwood	8,447	6,464	6,773	7,228
Timber	2,288	9,935	979	4,401
Biomass for animal husbandry	**17,254**	**38,814**	**58,337**	**38,135**
Fodder	7,621	18,353	33,791	19,922
Grass	8,843	18,301	21,610	16,251
Leaf litter	664	1,899	2,842	1,802
Agricultural tools	126	262	93	160
NTFPs	**96**	**27**	**193**	**105**
Bamboo	96	27	134	86
Fibre (lokta)	0	0	59	20
Wild edibles	**167**	**341**	**132**	**213**
Mushroom	26	60	53	46
Bamboo shoot	29	87	19	45
Vegetables	78	117	56	84
Edible fruits	34	7	5	15
Honey	0	70	0	23
Medicinal plants	**1,147**	**3,635**	**3,413**	**2,732**
Chiraita	1,147	3,634	3,348	2,710
Himalayan yew	0	0	0.6	0
Valerian	0	0.2	6	2
Prickly ash	0	0	51	17
Asparagus	0	0	6	2

Source: Household survey 2010

Annex 2: Local Price of Forest Products

Product	Unit	Price (NPR/unit)
Timber and wood		
Pole	number	106
Fuelwood	backload	50
Timber	cu.ft	321
Biomass for animal husbandry		
Fodder	backload	55
Grass	backload	27
Leaf litter	backload	9
Agricultural tools	number	208
NTFPs		
Bamboo	number	24
Fibre (lokta)	kg	38
Wild edibles		
Mushroom	kg	66
Bamboo shoot	kg	26
Vegetables	kg	25
Edible fruits	kg	45
Honey	kg	200
Medicinal plants		
Cinchona	kg	262
Himalayan yew	kg	50
Valerian	kg	38
Prickly ash	kg	200
Asparagus	kg	200

Source: Household survey 2010

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