Applied Geography 69 (2016) 25–34

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

# Assessments of ecosystem service indicators and stakeholder's willingness to pay for selected ecosystem services in the Chure region of Nepal

Pratima Bhandari [a], Mohan KC [b], Sujata Shrestha [c], Achyut Aryal [d], Uttam Babu Shrestha [e, *]

[a] Institute of Forestry, Pokhara Campus, Tribhuvan University, Nepal
[b] REDD Implementation Center, Ministry of Forest and Soil Conservation, Nepal
[c] Department of Biology, University of Massachusetts Boston, USA
[d] Institute of Natural and Mathematical Sciences, Massey University, Auckland, New Zealand
[e] Institute for Agriculture and the Environment, University of Southern Queensland, Toowoomba, Australia

A R T I C L E I N F O

*Article history:*
Received 9 August 2015
Received in revised form
3 February 2016
Accepted 6 February 2016
Available online 1 March 2016

*Keywords:*
Ecosystem services
Nepal
Himalaya
Payment for ecosystem service
Watershed

A B S T R A C T

The Chure region of Nepal—the area sandwiched between the hills in the north and the plains in the south—is considered an ecologically fragile, structurally weak, and highly erosion-prone region. The forest in the Chure region provides several ecosystem services to people living in the downstream areas. However, assessment and quantification of ecosystem services in this region are very limited. This study, conducted in a watershed of the Chure region of western Nepal, combined local users' perspectives with experts' opinions to identify and rank ecosystem services based on land use types, to investigate the downstream users' willingness to pay for ecosystem services, and to explore the socio-economic factors affecting their willingness to pay. The study found that forests offered the highest number of ecosystem goods and services in this area. Local people were familiar with 10 different ecosystem services provided by the watershed and ranked drinking water service at the top. The downstream beneficiaries would be willing to pay a higher amount for drinking water service than they were currently paying if the quality of the service and its sustainability were assured. The amount they were willing to pay for ecosystem services increased significantly with monthly income. The results of this study are useful for other areas in which an upstream–downstream linkage exists and the upstream communities play a crucial role in maintaining ecosystem functions and the resulting supply of ecosystem services to the downstream communities.



## 1. Introduction

Ecosystem services, defined as the benefits that humans obtain from natural ecosystems (Daily, 1997), have received significant attention in global environmental policies in recent years (CBD, 2010; MEA, 2005; Perrings, Duraiappah, Larigauderie, & Mooney, 2011; TEEB, 2010). The concept of an ecosystem service highlights the role of natural ecosystems in providing goods and services for human well-being, economic development, and poverty alleviation (Nelson et al., 2009; Turner & Daily, 2008). This concept has been used as a policy instrument in biodiversity conservation and natural resource management (Burkhard, Kroll, Müller, & Windhorst, 2009; Fisher & Turner, 2008; Koschke, Fuerst, Frank, & Makeschin, 2012; Seppelt, Dormann, Eppink, Lautenbach, & Schmidt, 2011). Therefore, the identification and valuation of ecosystem services supports decision making and policy aimed at biodiversity conservation and sustainable development (Burkhard et al., 2009; Fisher & Turner, 2008; Koschke et al., 2012; Seppelt et al., 2011). However, the assessment of ecosystem services in developing countries, where people are dependent on natural ecosystems such as forests and rangelands for their livelihoods (Shrestha & Bawa, 2014) is limited due to the lack of appropriate data, methods, tools, and management framework (Paudyal, Baral,

* Corresponding author.
*E-mail addresses:* pratimabhandari13@gmail.com (P. Bhandari), mohankc.forestry@gmail.com (M. KC), sujata.shresth@yahoo.com (S. Shrestha), savefauna@gmail.com (A. Aryal), ubshrestha@yahoo.com (U.B. Shrestha).

http://dx.doi.org/10.1016/j.apgeog.2016.02.003

Burkhard, Bhandari, & Keenan, 2015).

Critical ecosystem services in developing countries are generated from forests, agroforests, farmlands, and rangelands that are managed by low-income people (Milder, Scherr, & Bracer, 2010; Molnar, Scherr, & Khare, 2004). About 400–500 million people in developing countries are dependent on forests for their livelihoods (Charnley & Poe, 2007). Large areas of forest in developing countries are managed or owned by local communities in various forms of community-based management practices such as community forestry (White & Martin, 2002). Since the implementation of the community forestry program in Nepal three decades ago (Shrestha, Shrestha, & Shrestha, 2010), community forestry has become a dominant forest management practice. Local communities currently manage about 1.7 million hectares of forest and about 35% of the population of Nepal is involved in the community forestry management program (DoF, 2015).

Community-managed forests in Nepal have been instrumental in fulfilling the local communities' subsistence needs for the various ecosystem goods (timber, fodder, and fuel) and in providing services (watershed protection, erosion protection, ground water recharge, and water purification) to local as well as distant communities (Birch et al., 2014; Oort et al., 2014; Shrestha et al., 2010). Likewise, Nepal's community forests have significantly contributed to climate change mitigation through the sequestration of carbon (Pandey, Cockfield, & Maraseni, 2016). Community forests also play an important role in preventing forest degradation and restoring degraded forests in many watersheds of Nepal (Birch et al., 2014; Paudyal et al., 2015). Therefore, to incorporate all of the potential benefits provided by community forests to local, regional, and global communities, an ecosystem services framework might be useful because the concept of ecosystem services emphasizes the multiple benefits of ecosystems to human well-being (MEA, 2005). Further, quantifying ecosystem services also helps to explore the prospect of 'payment for ecosystem service' (PES) in community-managed forests.

The PES scheme is a market-based mechanism in which the beneficiaries (buyers) of ecosystem services pay the communities or land owners (sellers) for maintaining the ecosystem that provides goods and services to the beneficiaries (Ferraro & Kiss, 2002; Wunder, 2005). Incentives provided under the PES scheme for 'best practices' is thought to be more motivational and effective than imposing ineffective sanctions for 'bad practices' (Van Hecken, Bastiaensen, & Vásquez, 2012). However, the notion of PES is also subject to considerable criticism (Redford & Adams, 2009). For example, in some cases the commodification of ecosystem functions as ecosystem services to humanity may prove harmful to biodiversity conservation (Peterson, Hall, Feldpausch-Parker, & Peterson, 2010). Nevertheless, PES schemes are gaining momentum, with several active programs of PES globally, although the outcomes of such projects are mixed (Kinzig et al., 2011; Pattanayak, Wunder, & Ferraro, 2010; Schomers & Matzdorf, 2013). PES schemes have supported water quality improvement in Ecuador (Quintero, Wunder, & Estrada, 2009) and forest cover enhancement in Costa Rica (Arriagada, Ferraro, Sills, Pattanayak, & Cordero-Sancho, 2012). On the other hand, a PES scheme in Mexico promoted a short-term utilitarian view of conservation at the cost of decreased intrinsic motivation (Rico García-Amado et al., 2013). PES schemes for carbon (Corbera, Soberanis, & Brown, 2009) and biodiversity (Sanchez-Azofeifa, Pfaff, Robalino, & Boomhower, 2006) can be large in size and cover a huge geographical area, whereas PES schemes for water and related hydrological services are generally smaller in size and focus on local watersheds (Lopa et al., 2012; Muñoz-Piña, Guevara, Torres, & Braña, 2008; Simelton & Dam, 2014; Turpie, Marais, & Blignaut, 2008). Further, a PES scheme for drinking water or hydrological services is easy to monitor, has straightforward financial benefits to payers, and is valued greatly by local people (Van Hecken et al., 2012).

The effective design of a PES mechanism requires not only knowledge about the relationships between ecological function and the resulting ecosystem services but also a clear understanding of the role of local communities and their insights about the benefits and tradeoffs of PES schemes (Kinzig et al., 2011; Simelton & Dam, 2014). The involvement of local stakeholders in ecosystem services assessment is crucial for selecting appropriate ecosystem service indicators, evaluating possible management options through ranking of different ecosystem services, and the validation of different management options (Ananda & Herath, 2009; Seppelt et al., 2011). Further, better understanding of the behavioral and governance dimensions of local communities is required before initiating a PES scheme as a policy option (Muradin et al., 2010). This is relevant in the context of Nepal, where PES schemes for the hydrological services of watersheds and the carbon sequestration service of forests have been receiving attention in the policy sector as a means of promoting the sustainable management of watersheds and forests (Khatri, Paudel, Bista, & Bhandari, 2013; Regmi et al., 2009).

This current study was conducted in the Northern watershed (NW) of Chure region of Nepal, where the potential of PES schemes for hydrological and other ecosystem services is large. The study aimed to combine local users' perspectives with experts' opinions to identify and rank various ecosystem service provisions at watershed level, based on the land use types. It also investigated the willingness to pay (WTP) of the downstream beneficiaries for ecosystem services such as drinking water provided by the watershed as a result of protection by upstream conservators. Finally, the socio-economic factors affecting the WTP for ecosystem services were explored.

## 2. Materials and methods

### 2.1. Study area

The study was conducted in the semi-urban areas of Birendranagar municipality and the adjoining Gadi and Jarbuta village development committees (VDCs) of Surkhet district, mid-western Nepal, which covers a total area of 9427 ha (see Fig. 1). The region comprises 12,029 households in Birendranagar municipality, 1,837 households in Jarbuta VDC, and 685 households in Gadi VDC, with a population of 47,914, 8,580, and 3,050 respectively (CBS, 2014). Birendranagar municipality is the major trading center of the mid-western region of Nepal and is undergoing rapid urbanization. The Northern watershed, situated in the northern part of the Birendranagar municipality, provides various ecosystem services (including drinking water) to about 60,000 residents living downstream in the Birendranagar municipality and in Jarbuta, Latikoili, and Uttarganga VDCs. Due to the significant contribution of this watershed in delivering various ecosystem services, it was declared a protected watershed in 1988 by the late King Birendra during his visit in that region (the municipality is named after him). It has been protected through the active involvement of local governmental and non-governmental agencies, as well as community forest user groups (CFUGs), which are local, community-based natural resource management groups formed under the community forestry program of Nepal and responsible for the protection, management, and distribution of forest resources. Community forestry, which was initiated about 30 years ago, is now the major forest management program in Nepal. Various forest-related policies, such as the Master Plan for the Forestry Sector (1989), Forest Act (1993), Forest Regulations (1995), and Forestry Sector Policy (2000), were prepared and implemented to support the

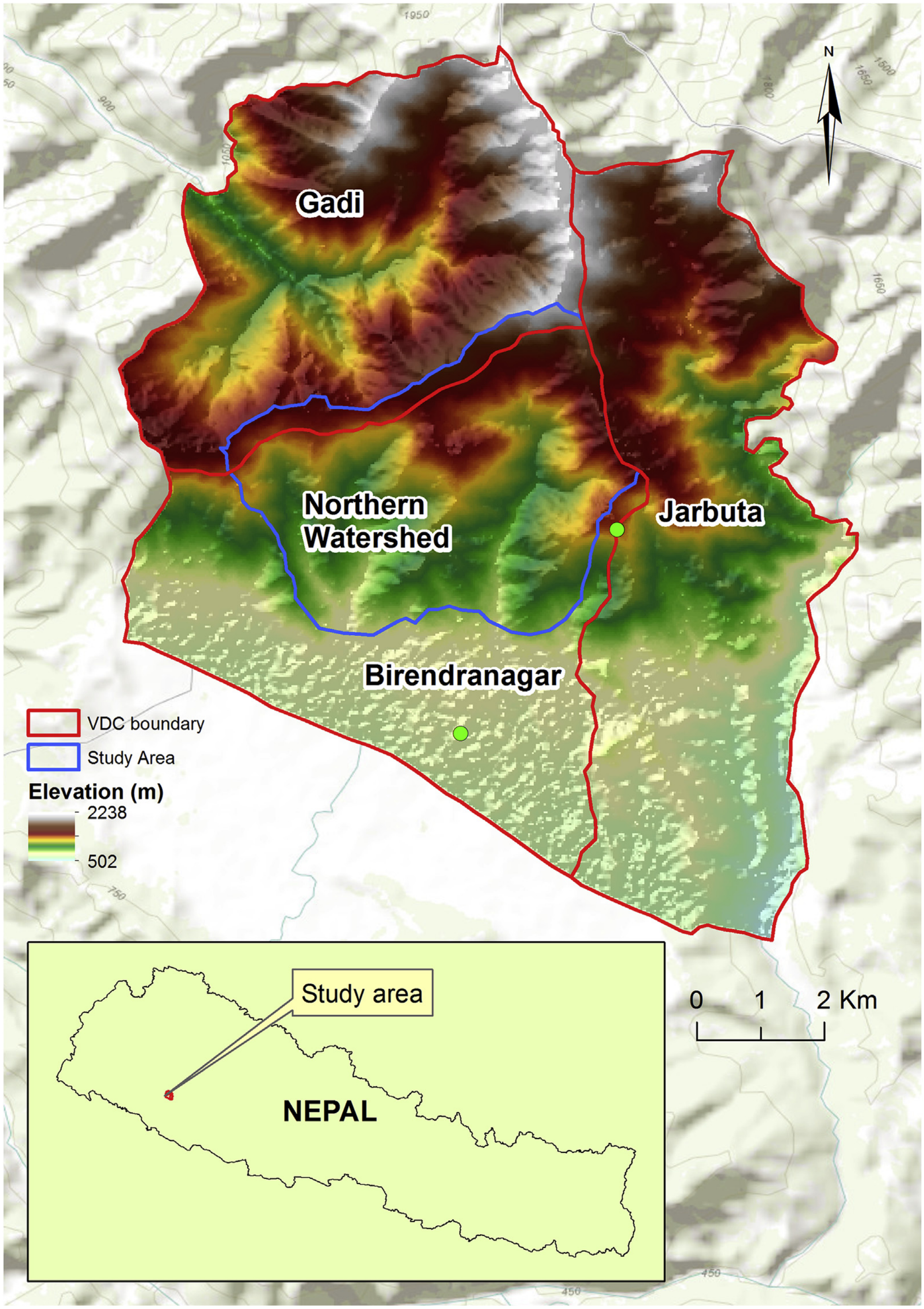


**Fig. 1.** Map of the study area.

community forestry program in Nepal. Eleven CFUGs, comprising a total area of 2043 ha with 4606 households upstream, have been involved in protecting the NW (DoF, 2015).

This study combined both quantitative and qualitative approaches and applied tools from social and spatial sciences for data collection. Satellite imagery was used to produce a land use/land cover (LULC) map of the study area and expert knowledge was utilized to identify the appropriate indicators of ecosystem services. Household surveys, focus group discussions, and field observations were conducted to collect data on the locals' perspectives on ecosystem services and to document the community's WTP for the ecosystem services.

### *2.2. Land use/land cover (LULC) classification*

A cloud-free satellite image of Landsat 8 (Scene = LC81430402014339LGN00), with spatial resolution of 30 m, was acquired on 5 December, 2014 from the United States

Geological Survey's website (http://glovis.usgs.gov/). The satellite image was cropped for the study area and classified into six LULC classes (forestry, agriculture and agroforestry, water body, bush, grassland, and built-up areas), using the supervised classification method in ArcGIS 10.2. Sixty-six polygons were created as training areas, based on the different combinations of the Landsat bands displayed in red, green, and blue (RGB). A signature file for a supervise classification was created, based on the training areas. To examine classification accuracy, 300 reference points were created randomly across the study area. The classification of each random point was validated by using Google Earth. Values were calculated for overall accuracy and kappa value. The classification had an overall accuracy of 94.3%, with a kappa value of 0.923. This level of accuracy was considered acceptable.

### 2.3. Indicators selection for ecosystem services

The potential indicators of ecosystem services for the six different LULC classes of the study area were identified through an opinion survey with experts who were familiar with the concept of ecosystem services and field conditions. Twenty local experts (11 officers from the Ministry of Forest and Soil Conservation of Nepal, three from local non-governmental organizations, four from the institute of Forestry, Tribhuvan University, and two from the Conservation Unit of the President Chure Conservation Program) were asked to score the capacity of the different land covers identified on our map to provide various ecosystem services on a 0–5 relative scale (0 = no capacity, 1 = very low capacity, 2 = low capacity, 3 = medium capacity, 4 = high capacity, and 5 = very high capacity) (Burkhard et al., 2009, 2012). This expert-based assessment of ecosystem service, called 'the matrix model', is one of the most popular ecosystem services assessment techniques (Burkhard et al., 2012; Jacobs, Burkhard, Van Daele, Staes, & Schneiders, 2015). Following the evaluation framework of the matrix model, a matrix of LULC types on the y-axis and ecosystem services on the x-axis were created, based on the experts' scores, to determine the capacity of the different LULC classes to provide various ecosystem services. Their responses were grouped into four categories: provisioning, regulating, supportive, and cultural services, based on the Millennium Ecosystem Assessment classification (MEA, 2005).

Indicators of ecological integrity, which is defined as 'preservation against non-specific ecological risks that are general disturbances of the self-organizing capacity of ecological systems' (Barkmann, Baumann, Meyer, Müller, & Windhorst, 2001; Müller, 2005), include abiotic heterogeneity, biodiversity, biotic water flows, metabolic efficiency, energy capture, reduction of nutrient loss, and storage capacity. According to Burkhard et al. (2012), these indicators are useful in determining whether the condition of an ecosystem is improving or being degraded over time. In this study, there was no response from the local experts regarding the ecological integrity of the ecosystem—they may have had limited understanding of those indicators. However, the objective of this research was to assess the capacity of various landscapes to provide ecosystem services based on the LULC data with expert estimates, rather than to examine the temporal dynamics of ecosystem.

The matrix model was first proposed by Burkhard et al. (2009) and significantly modified and improved later (Burkhard et al., 2012; Stoll et al., 2015). Customized versions of this model have been used in various geographic locations and different socio-ecological and political contexts (Jacobs et al., 2015). The subjective judgment of experts—and *a priori* chosen sets of ecosystem services—used in this method have often been criticized (Stoll et al., 2015). However, the inclusion of multiple opinions from a broad range of experts with different professional backgrounds, skills, affiliations, and experience could reduce uncertainties by increasing confidence in the final results (Jacobs et al., 2015). Despite some limitations, the matrix model provides a foundation for research in ecosystem service, especially in data-poor regions such as Nepal, where ecosystem service is a new knowledge frontier for the local communities and policy makers. To overcome the model's limitations, the experts consulted for this research came from diverse backgrounds and affiliations, thus minimizing subjectivity, and a consensus rule, using the average (mode) of their scores, was used to produce the final matrix. Their opinions were complemented by the perceptions of people in the local communities, collected though household surveys.

### 2.4. Household survey

Household surveys were conducted among 238 (5.16% of CFUGs affiliated households) randomly chosen respondents from households affiliated with the 11 CFUGs mentioned earlier. These households comprised 96 upstream land managers (from Gadi and Jarbuta VDCs) and 142 downstream beneficiaries (from Birendranagar municipality). Interviews were conducted either on the farm or at the respondent's residence during October and November 2014, using structured and semi-structured questionnaires. The interviews began with an explanation of the objectives of this study and some background information about ecosystem services.

The interview questionnaire was in three parts. The first part focused on information related to the socio-economic status (age, gender, education, occupation, and income) of the households (see Table 1). Questions in the second part measured the respondents' familiarity with the concept of ecosystem services and devised rankings based on the importance to them of the various ecosystem services. The third part dealt with their WTP for the ecosystem services provided by the watershed—only the 142 respondents from the downstream communities were asked the questions in this part.

To estimate the amount of money that downstream beneficiaries would be willing to pay for ecosystem services or watershed services, the contingent valuation method (CVM) was used. This is an interview technique widely used to estimate the monetary value that people ascribe to certain environmental or public goods (Lankia, Neuvonen, Pouta, & Sievänen, 2014; Mitchell & Carson, 2013).

To generate as much realistic information as possible and to verify the participants' responses, three types of questions were used to collect data on WTP: 'open-ended', 'bidding game', and 'payment card' (Loomis, Brown, Lucero, & Peterson, 1996; William, Russell, Rodriguez, & Darling, 1999). Open-ended questions were used to enumerate the various types of ecosystem services obtained from the NW and to document the beneficiaries' WTP for specific ecosystem services (e.g., drinking water). With regard to the bidding game questions, they were first asked in the general questionnaire whether they knew the specific ecosystem services (e.g., drinking water) they were getting from the NW and whether or not the supply/quality of some ecosystem services had declined (e.g., 'Is there enough drinking water?'). If they responded that the water supply was insufficient, they were asked how they managed this problem.

To understand the user's maximum WTP for sufficient and sustainable ecosystem services, a hypothetical situation was created (e.g., 'If you got sufficient drinking water, how much would you be willing to pay for it?'). A list of the ecosystem services obtained from the watershed was developed and WTP values for those services were fixed, based on their current payment situation (e.g., monthly payment for drinking water). Finally, downstream users were asked to choose a WTP point estimated from a list of values (payment cards of different values). The data collected from

**Table 1**
Socio-economic characteristics of the respondents.

| Socio-economic characteristics of the households | Total number (%) | Upstream respondents (%) | Downstream respondents (%) |
|---|---|---|---|
| Sex of the respondent | | | |
| Male | 98 (41.2) | 47 (49.0) | 51 (35.9) |
| Female | 140 (58.8) | 49 (51.0) | 91 (64.1) |
| Age category (years) | | | |
| 18-36 | 90 (37.8) | 29 (30.2) | 61 (43.0) |
| 37-51 | 99 (41.6) | 32 (33.3) | 67 (47.2) |
| 52 and above | 49 (20.6) | 35 (36.5) | 14 (9.9) |
| Education | | | |
| Illiterate | 85 (35.7) | 49 (51.0) | 36 (25.4) |
| Primary | 61 (25.6) | 29 (30.2) | 32 (22.5) |
| Secondary | 60 (25.2) | 15 (15.6) | 45 (31.7) |
| College and higher | 32 (13.4) | 3 (3.1) | 29 (20.4) |
| Occupation | | | |
| Farmer | 180 (75.6) | 88 (91.7) | 92 (64.8) |
| Services | 45 (18.9) | 3 (3.1) | 42 (29.6) |
| Seasonal labor | 6 (2.5) | 4 (4.2) | 2 (1.4) |
| Others | 7 (2.9) | 1 (1.0) | 6 (4.2) |
| Monthly reported income (NRs) | | | |
| 1001–5000 | 29 (12.2) | 22 (22.9) | 7 (4.9) |
| 5001–10000 | 70 (29.4) | 36 (37.5) | 34 (23.9) |
| 10,001–20,000 | 101 (42.4) | 35 (36.5) | 66 (46.5) |
| 20,001–50,000 | 38 (16) | 3 (3.1) | 35 (24.6) |

the household surveys were analyzed in Statistical Package for Social Sciences (SPSS) 22 and R.

## 3. Results and discussions

### 3.1. Land use/land cover classification

The major LULC types in the study area included forest, bush, settlement, agriculture, grassland, and water body (see Fig. 2). Forest was the most predominant LULC type, covering 3,406 ha (36.13% of the area). Bush was the second most dominant LULC type, covering 2,427 ha (25.75% of the area), followed by settlement (1,390 ha—14.74%). Agriculture and agroforestry, grassland, and water body were the least dominant LULC types, covering 1,092 ha (11.58%), 940 ha (9.97%), and 172 ha (1.82%) respectively. In the study area, forests were dominated by *Shorea robusta*, *Pinus roxburghii*, *Syzygium cuminii*, *Lagerstroemia parviflora*, and *Bauhinia variegate*, and were managed by the local CFUGs. Bush areas were degraded forested areas with many shrubby species and scattered trees, whereas grasslands were normally the open areas used for livestock grazing.

### 3.2. Assessment of ecosystem services

The ecosystem services that are provided by an ecosystem depend on the ecosystem structure and function, represented by the different LULC types (Burkhard et al., 2012). The matrix of the different land covers' capacity to provide ecosystem goods and services, based on the experts' opinion, is shown in Fig. 3. The rows of the matrix had six LULC classes, and the columns had 26 different ecosystem service indicators linked with LULC types. Forests, with a total score of 80, offered the highest number of ecosystem goods and services, as compared with other LULC types in the study area, followed by agricultural and agroforestry areas. Of the 26 different indicators of ecosystem services, forests received the highest score (5) in six ecosystem services (two in provisioning, three in regulating, and one in supportive). Those services were timber, local climate regulation, carbon sequestration, air quality regulation, erosion control, and biodiversity. Forests also received the second highest score (4) in nine other ecosystem services. The experts' scores suggested that forests played an important role in regulating the environment as well as supporting the livelihoods of the local people by providing wide range of provisioning services.

Agricultural and agroforestry areas had the second highest score (61), and the highest overall score in its capacity to produce food and horticultural crops, including vegetables. The agricultural area in the study was not purely an agricultural system; it also had some remnant trees at the edge of a terrace, which provided fodder and played a role in erosion control. Thus, this category had plant species other than crops, as reflected in the responses of the experts.

Grasslands were open areas near the forests or agricultural lands on which the local communities grazed their livestock. Grassland received only one high score, for livestock grazing. Overall, human-dominated landscapes and settlements received a very low score except for cultural services such as religious shrines, temples, and playgrounds.

Birch et al. (2014) used a rapid assessment tool to study ecosystem services in the Phulchoki Mountain Forest of central Nepal and also found that forests provided maximum ecosystem benefits, compared with other land uses. Similar results have been found in Germany (Kroll, Müller, Haase, & Fohrer, 2012) and Bangladesh (Sohel, Mukul, & Burkhard, 2014).

### 3.3. Local perceptions of ecosystem services

The local communities' perceptions of ecosystem services, particularly the watershed services provided by the NW, were analyzed (see Fig. 4). The responses of the local people were placed in the 10 different ecosystem services categories used in the MEA: namely, forest resources, air quality regulation, landscape beauty, biodiversity protection, water purification, erosion/landslide control, local climate regulation, carbon sequestration and storage, pollination service to agriculture, and nutrient cycling. All of the respondents were familiar with the role of the watershed in providing water and forest products, as those services and goods were vital for their subsistence livelihoods. Every respondent mentioned that they brought at least one forest product, such as timber, fuel wood, fodder, wild fruits, mushrooms, medicinal plants, poles, and leaf litter, from the NW. The diverse responses related to forest products were placed under a single category—forest resources. Three major products derived from forests

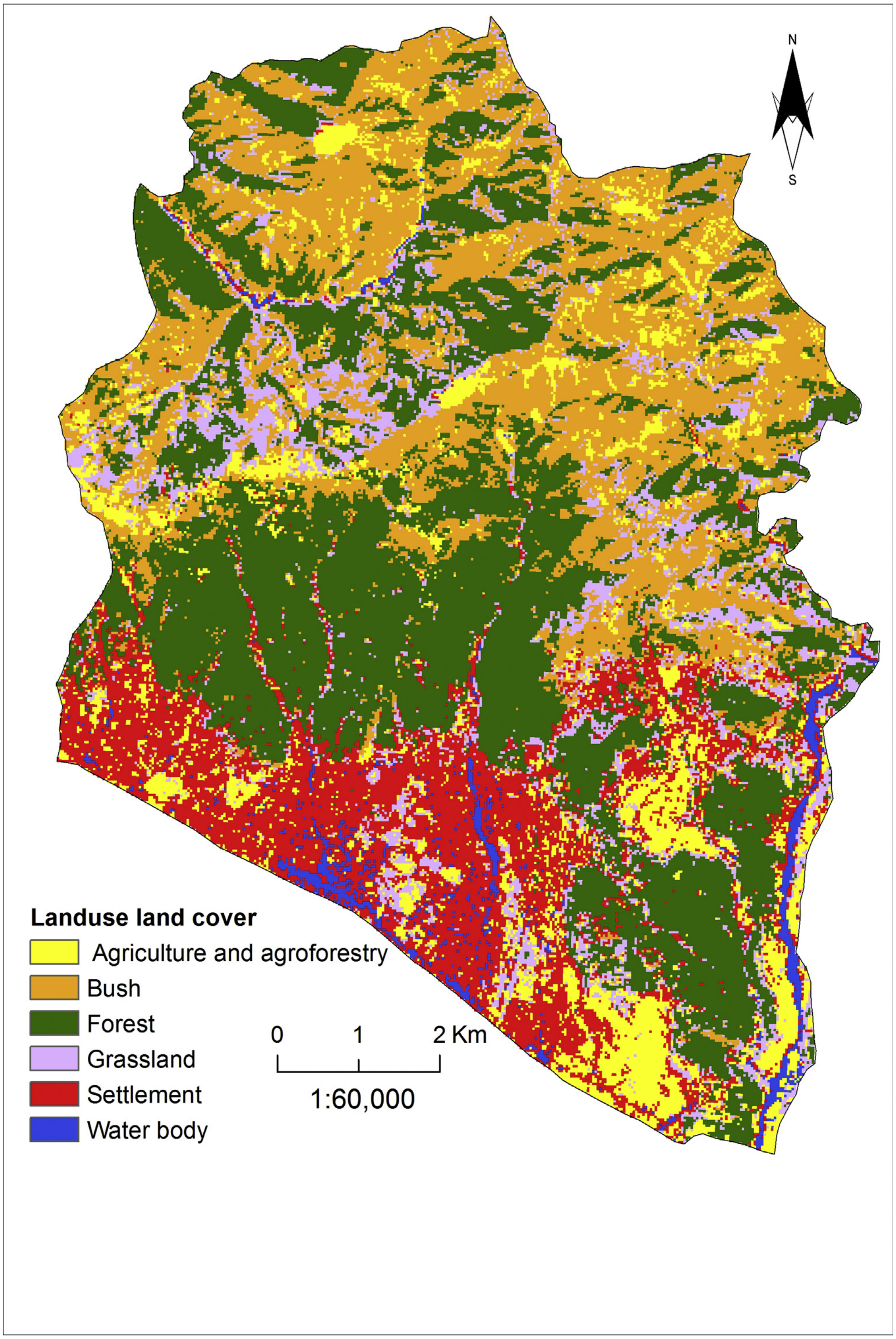


**Fig. 2.** Land use/land cover types of the Northern watershed.

were fuel wood (mentioned by 85% of respondents), fodder (84%), and timber (26%).

After forest resources, the majority of respondents were familiar with air quality regulation (89%), landscape beauty (84%), and biodiversity protection (60%). Their responses, which included 'purify air' and 'cleanse ambient environment', were placed under 'air quality regulation'. Responses that were placed under 'biodiversity protection' included 'habitat for wild plants and animals', 'habitat for trees and grass', and 'habitat for birds'. Only one respondent (out of 238) mentioned nutrient cycling as one of the roles of the NW. The majority of the respondents who expressed their familiarity with the role of the watershed in local climate regulation and carbon sequestration and storage were the members of CFUG's executive committee, who had had opportunities to participate in awareness training and workshops run by governmental and non-governmental agencies.

Although the local peoples' perceptions of ecosystem services provided by the NW could be categorized under 10 different

| Land use and land cover types | Ecosystem services: Provisioning | | | | | | | | | | | | | | | Regulating | | | | | | | Supportive | Cultural | | | Total score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Timber | Fuel wood | Fodder | Wild fruits/foods (Mushrooms, bamboo shoots) | Medicinal plants | Livestock grazing | Construction materials (sands boulders) | Poles | Freshwater | Leaf litter | Agricultural crops | Horticultural crops | Genetic resources | Ornamental resources | Local climate regulation | Carbon sequestration | Air quality regulation | Flood protection | Erosion control | Nutrient regulation | Water purification | Pollination | Biodiversity | Recreation and aesthetic | Spiritual and religious service | Meeting place | |
| Forest | 5 | 4 | 4 | 3 | 1 | 2 | 0 | 4 | 3 | 4 | 0 | 0 | 2 | 0 | 5 | 5 | 5 | 4 | 5 | 4 | 3 | 4 | 5 | 4 | 4 | 0 | 80 |
| Agricultural and agroforestry | 0 | 2 | 4 | 0 | 1 | 2 | 0 | 3 | 3 | 2 | 5 | 5 | 1 | 0 | 4 | 3 | 3 | 3 | 4 | 3 | 3 | 4 | 2 | 4 | 0 | 0 | 61 |
| Water body | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 4 | 3 | 0 | 21 |
| Bush | 0 | 3 | 3 | 1 | 1 | 4 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 3 | 0 | 0 | 0 | 35 |
| Grassland | 0 | 1 | 2 | 0 | 0 | 5 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 3 | 0 | 0 | 32 |
| Buildup areas | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 5 | 15 |

| | |
|---|---|
| No capacity | 0 |
| Very low capacity | 1 |
| Low capacity | 2 |
| Medium capacity | 3 |
| High capacity | 4 |
| Very high capacity | 5 |

**Fig. 3.** Matrix for the assessment of the various land use and land cover types' capacities to provide selected ecosystem goods and services identified by local experts.

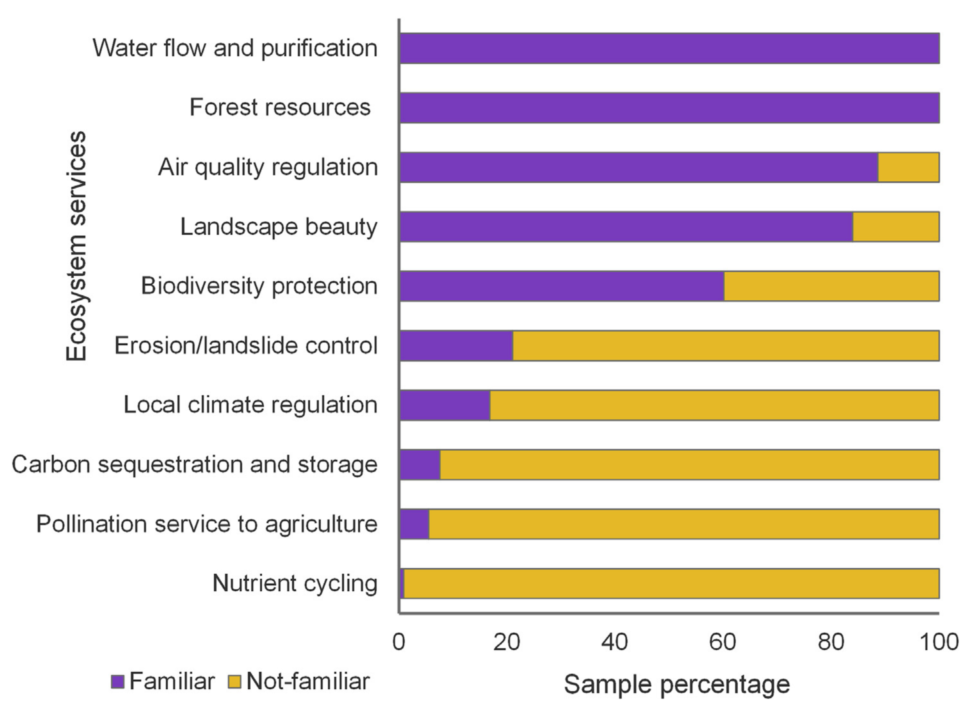


**Fig. 4.** Local people's familiarity with various ecosystem services provided by the watershed.

ecosystem services, the perceived importance of those ecosystem services was varied. The respondents ranked the individual ecosystem goods and services that they were familiar with, starting with 1 for their first choice or highest rank and numbering the goods and services down to their last choice or lowest rank, according to their importance to them. Due to incomplete responses caused by the respondents' unfamiliarity with every ecosystem service category, only the frequency scores from 1 to 6 were counted. The respondents did not provide a score for nutrient cycling, pollination service, carbon sequestration and storage, and local climate regulation.

The average score of the perceived importance of the various ecosystem services is shown in Fig. 5. Drinking water was the first choice (highest score), with 62% of respondents ranking drinking water at 1. Water for agriculture was ranked the second highest, followed by forest products, land erosion, biodiversity protection, and landscape beauty. In other watersheds of Nepal that are managed by CFUGs, water has also been identified by local people as the most important ecosystem service (Oort et al., 2014). Unlike the ratings for drinking water, high variation was observed in respondents' ranking for 'forest products' and 'biodiversity protection'. Forest products could be critical for the communities who used fuel wood for cooking, collected fodder for livestock, and gathered herbs for medicinal purpose, but less important for the communities who were less dependent on forest products for their livelihoods. Often, watershed services with both market and non-market values were more numerous than had been appreciated by local communities (Dyson, Bergkamp, & Scanlon, 2003). In the case of NW, water services had a market value for designing and initiating a payment for an ecosystem services scheme.

### 3.4. Downstream communities' willingness to pay for ecosystem services

Three types of users of ecosystem services were seen in the study area: upstream land holders, who were conservators and users of selected provisioning services from the NW (timber, fuel wood, and fodder, but not drinking water); buffer zone dwellers, who were both conservators and service users; and downstream beneficiaries, who acquired benefits only (drinking water, water for irrigation, and soil erosion prevention) without making a significant contribution to the conservation of the NW.

Due to the wide variety of ecosystem services provided by the watershed, its sustainability was a prime concern for the downstream respondents. According to them, if upstream dwellers had not protected the watershed, the major impacts on downstream areas that could have occurred were natural disasters such as landslides (31%), scarcity of drinking water (29%), increased sedimentation on agricultural lands (22%), irrigation water scarcity (9%), negative effects on local tourism (6%), and reduced livelihood options (3%). Due to the protection of forest in the NW, a greater number of birds and wildife was visible now. Locals perceived that touristic activities such as bird watching and wildlife viewing, which provides livelihood benefits, would not be possible if the forest had not been protected. At the same time, locals also expressed concerns with regard to the diminishing quality of the ecosystem services due to the degradation of forests outside the community forests, although community forests had played a significant role in increasing the forest cover in the watershed.

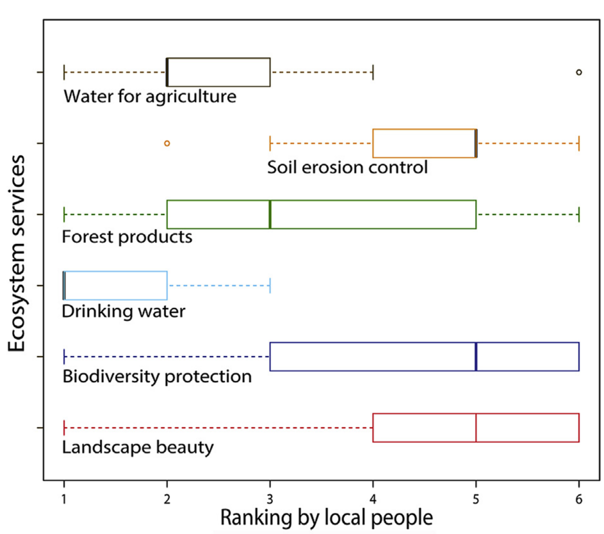


**Fig. 5.** Perceived importance of ecosystem services by the local people.

The PES scheme is a new market-based mechanism that has produced successful outcomes and had considerable appeal with, and acceptance by, local communities elsewhere (Schomers & Matzdorf, 2013). During the interview to collect their WTP for the ecosystem services derived from the watershed, the respondents were asked about their familiarity with the concepts and terminologies of PES given in the scholarly literature. Nearly all of the respondents (99.6%) said they had not heard about PES, even though the locals were currently paying for drinking water. The basic concepts of PES were explained, giving the example of the monthly payment for drinking water, and they were asked if they were potentially interested in a PES program. Surprisingly, all 142 downstream interviewees said they were willing to pay for ecosystem services if payment would ensure the quality and long-term supply of ecosystem services. The interviewees also responded the tentative amounts of willingness to pay for various ecosystem services.

The participants' responses on WTP for ecosystem services were grouped into four categories: WTP for drinking water; overall watershed service (e.g., forest resource, air quality regulation, water purification, and biodiversity protection); erosion/landslide control; and landscape beauty (see Fig. 6). All of the respondents said they were willing to pay for drinking water, whereas very few (only 12.7% of respondents) were willing to pay for landscape beauty. Similarly, all of the respondents were willing to pay for erosion/landslide control service, followed by WTP for overall watershed service (98.6%). Likewise, the amount they were willing to pay for drinking water was high, with a median value of NRs 250/month (NRs is Nepalese rupees; US \$1~NRs 99.00) as compared with the amount they were willing to pay for erosion/landslide control (NRs 100/month), overall watershed service (NRs 100/month), and landscape beauty (no median value). At the time of the survey, locals were paying an average NRs 150/month/household for drinking water.

When the effects of socio-economic factors (e.g., age, education, occupation, and income) on respondents' WTP for ecosystem services were examined using a multiple linear regression model, it was found that the amount of payment was correlated with the local's socio-economic status (see Table 2). A significant correlation was observed between the amount they were willing to pay with the monthly income of a household ($t = 9.5$, $P < 0.00$). On average, the lowest income family, with an income of NRs 1001–5000/month, said they were willing to pay NRs 300/month for various ecosystem services. The average total amounts that households were willing to pay for various ecosystem services were NRs 365 in households with a low income of NRs 5001–10,000; NRs 450 in households with an income of NRs 10,001–20,000; and NRs 600 in households with an income of NRs 20,001–50,000. This result was consistent with the widespread assumption of economic theory that income has a positive impact on WTP (Lankia et al., 2014).

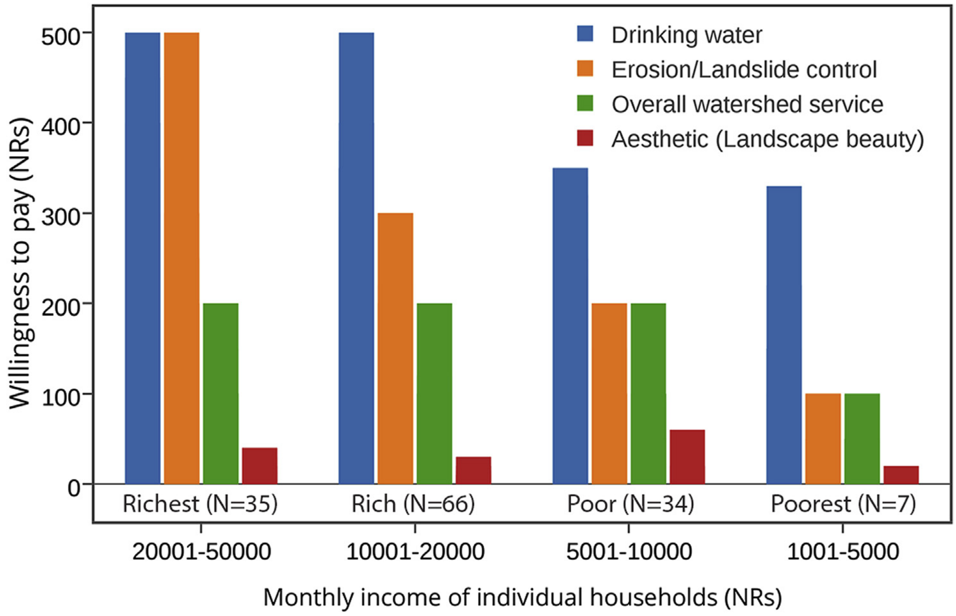


**Fig. 6.** Willingness to pay of downstream communities for various ecosystem services based on the monthly income.

**Table 2**
Multiple linear models of total amount of willingness to pay for the ecosystem services.

| Socio-economic variables | Coefficients estimate | Standard error | t | p value |
|---|---|---|---|---|
| (Constant) | 120.1 | 49.3 | 2.4 | 0.02 |
| Age (years) | 7.1 | 13.7 | 0.5 | 0.61 |
| Level of education | −6.0 | 8.1 | −0.7 | 0.46 |
| Occupation | −20.1 | 12.0 | −1.7 | 0.09 |
| Monthly income (NRs) | 102.2 | 10.7 | 9.5 | 0.00 |

$R^2 = 0.40$; $R^2$ adj $= 0.38$; $F = 23.03$; $P = 0.000$.

Further, the average amount of WTP was 4.89% of respondents' reported monthly income. Although the percentage was higher for the poorest household (10%) as compared with the richest household (1.7%), this is an internationally acceptable affordability figure (Vásquez, 2014). There was no significant correlation between the amount of WTP for ecosystem services with age, education, and occupation.

## 4. Conclusion

This study has highlighted the importance of a local watershed by documenting experts' opinions and local perceptions as well as the preferences of the local communities using the ecosystem services framework. This study successfully used the matrix model of ecosystem services in a localized context in a data-deficient region, where knowledge of ecosystem services among stakeholders was weak. The results indicated that drinking water was the most important ecosystem service of the area and local communities were willing to pay a higher amount than they were currently paying if the quality and sustainability of the ecosystem services were assured.

This result can help decision makers to make appropriate land and forest management decisions on a landscape that is undergoing a rapid change in LULC due to urbanization and population growth as it highlighted views of local users on various ecosystem services and their importance to them. Decision makers can take an appropriate policy decision to manage the Northern watershed in order to optimize certain ecosystem service that was highly valued by local communities. This study has also provided a case for upstream and downstream linkages in terms of the supply and demand of ecosystem services. This could be useful elsewhere, particularly in developing country such as Nepal where the upstream–downstream linkage is very common and upstream communities play a crucial role in maintaining ecosystem functions and the resulting supply of ecosystem services to the downstream communities.

The results of this study showed that the NW currently offers ecosystem services that have market value, such as water for drinking and irrigation, and non-market value, such as protection from soil erosion and landslide. The results with regard to the downstream communities' WTP for water services have provided valuable insights for designing and initiating a potential PES scheme, which may improve current forest management practices as well as support upstream land holders by creating economic opportunities.

## Acknowledgments

We are grateful to the local communities of the study area and the local experts who have helped us to carry out this study.

## References

Ananda, J., & Herath, G. (2009). A critical review of multi-criteria decision making methods with special reference to forest management and planning. *Ecological Economics, 68*(10), 2535–2548.

Arriagada, R. A., Ferraro, P. J., Sills, E. O., Pattanayak, S. K., & Cordero-Sancho, S. (2012). Do payments for environmental services affect forest cover? A farm-

level evaluation from Costa Rica. *Land Economics, 88*(2), 382–399.
Barkmann, J., Baumann, R., Meyer, U., Müller, F., & Windhorst, W. (2001). Ökologische Integrität: Risikovorsorge im Nachhaltigen Landschaftsmanagement. *Gaia, 10*(2), 97–108.
Birch, J. C., Thapa, I., Balmford, A., Bradbury, R. B., Brown, C., Butchart, S. H., et al. (2014). What benefits do community forests provide, and to whom? A rapid assessment of ecosystem services from a Himalayan forest, Nepal. *Ecosystem Services, 8*, 118–127.
Burkhard, B., Kroll, F., Müller, F., & Windhorst, W. (2009). Landscapes' capacities to provide ecosystem services–a concept for land-cover based assessments. *Landscape Online, 15*(1), 22.
Burkhard, B., Kroll, F., Nedkov, S., & Müller, F. (2012). Mapping ecosystem service supply, demand and budgets. *Ecological Indicators, 21*, 17–29.
Central Bureau of Statistics (CBS). (2014). *National population and housing census 2011 (Village development committee/municipality), surkhet*. Kathmandu, Nepal: Government of Nepal, National Planning Commission Secretariat.
Charnley, S., & Poe, M. R. (2007). Community forestry in theory and practice: where are we now? *Annual Review of Anthropology, 36*(1), 301–336.
Convention on Biological Diversity (CBD). (2010). *Aichi biodiversity targets*. Available http://www.cbd.int/sp/targets/ Accessed 15.04.15.
Corbera, E., Soberanis, C. G., & Brown, K. (2009). Institutional dimensions of payments for ecosystem services: an analysis of Mexico's carbon forestry programme. *Ecological Economics, 68*(3), 743–761.
Daily, G. (1997). *Nature's services: Societal dependence on natural ecosystems*. Island Press.
Department of Forest (DoF). (2015). *Community forest users group database, management information system*. Kathmandu, Nepal: Community Forestry Division, Department of Forest.
Dyson, M., Bergkamp, G., & Scanlon, J. (2003). *Flow: The essentials of environmental flows*. Gland, Switzerland and Cambridge, UK: IUCN.
Ferraro, P. J., & Kiss, A. (2002). Direct payments to conserve biodiversity. *Science, 298*(5599), 1718–1719.
Fisher, B., & Turner, R. K. (2008). Ecosystem services: classification for valuation. *Biological Conservation, 141*(5), 1167–1169.
Jacobs, S., Burkhard, B., Van Daele, T., Staes, J., & Schneiders, A. (2015). 'The matrix reloaded': a review of expert knowledge use for mapping ecosystem services. *Ecological Modelling, 295*, 21–30.
Khatri, D. B., Paudel, N. S., Bista, R., & Bhandari, K. (2013). *REDD+ financing: What can we learn from the piloting of forest carbon trust fund in Nepal?*. Discussion Paper Series 12.1. Kathmandu: Forest Action Nepal.
Kinzig, A. P., Perrings, C., Chapin, F. S., Polasky, S., Smith, V. K., Tilman, D., et al. (2011). Paying for ecosystem services—promise and peril. *Science, 334*(6056), 603–604.
Koschke, L., Fuerst, C., Frank, S., & Makeschin, F. (2012). A multi-criteria approach for an integrated land-cover-based assessment of ecosystem services provision to support landscape planning. *Ecological Indicators, 21*, 54–66.
Kroll, F., Müller, F., Haase, D., & Fohrer, N. (2012). Rural–urban gradient analysis of ecosystem services supply and demand dynamics. *Land Use Policy, 29*(3), 521–535.
Lankia, T., Neuvonen, M., Pouta, E., & Sievänen, T. (2014). Willingness to contribute to the management of recreational quality on private lands in Finland. *Journal of Forest Economics, 20*(2), 141–160.
Loomis, J., Brown, T., Lucero, B., & Peterson, G. (1996). Improving validity experiments of contingent valuation methods: results of efforts to reduce and disparity of hypothetical and actual willingness to pay. *Land Economics, 72*(4), 450–461.
Lopa, D., Mwanyoka, I., Jambiya, G., Massoud, T., Harrison, P., Ellis-Jones, M., et al. (2012). Towards operational payments for water ecosystem services in Tanzania: a case study from the Uluguru Mountains. *Oryx, 46*(01), 34–44.
Milder, J. C., Scherr, S. J., & Bracer, C. (2010). Trends and future potential of payment for ecosystem services to alleviate rural poverty in developing countries. *Ecology and Society, 15*(2), 4.
Millennium Ecosystem Assessment (MEA). (2005). *Ecosystems and human well-being: Biodiversity synthesis*. Island Press.
Mitchell, R. C., & Carson, R. T. (2013). *Using surveys to value public goods: The contingent valuation method*. Routledge.
Molnar, K., Scherr, S. J., & Khare, A. (2004). *Who conserves the world's forests? Community-driven strategies to protect forests and respect rights*. Washington, D.C., USA: Forest Trends and Ecoagriculture Partners [online] URL http://www.rightsandresources.org/documents/files/doc_136.pdf.
Müller, F. (2005). Indicating ecosystem and landscape organisation. *Ecological Indicators, 5*(4), 280–294.
Muñoz-Piña, C., Guevara, A., Torres, J. M., & Braña, J. (2008). Paying for the hydrological services of Mexico's forests: analysis, negotiations and results. *Ecological Economics, 65*(4), 725–736.
Muradian, R., Corbera, E., Pascual, U., Kosoy, N., & May, P. H. (2010). Reconciling theory and practice: an alternative conceptual framework for understanding payments for environmental services. *Ecological Economics, 69*(6), 1202–1208.
Nelson, E., Mendoza, G., Regetz, J., Polasky, S., Tallis, H., Cameron, D., et al. (2009). Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment, 7*(1), 4–11.
Oort, B., Bhatta, L. D., Baral, H., Rai, R. K., Dhakal, M., Rucevska, I., et al. (2014). Assessing community values to support mapping of ecosystem services in the Koshi river basin, Nepal. *Ecosystem Services, 13*, 70–80.
Pandey, S. S., Cockfield, G., & Maraseni, T. N. (2016). Assessing the roles of community forestry in climate change mitigation and adaptation: a case study from Nepal. *Forest Ecology and Management, 360*, 400–407. http://dx.doi.org/10.1016/j.foreco.2015.09.040.
Pattanayak, S. K., Wunder, S., & Ferraro, P. J. (2010). Show me the money: do payments supply environmental services in developing countries? *Review of Environmental Economics and Policy, 4*(2), 254–274.
Paudyal, K., Baral, H., Burkhard, B., Bhandari, S. P., & Keenan, R. J. (2015). Participatory assessment and mapping of ecosystem services in a data-poor region: case study of community-managed forests in central Nepal. *Ecosystem Services, 13*, 81–92. http://dx.doi.org/10.1016/j.ecoser.2015.01.007.
Perrings, C., Duraiappah, A., Larigauderie, A., & Mooney, H. (2011). The biodiversity and ecosystem services science-policy interface. *Science, 331*(6021), 1139–1140.
Peterson, M. J., Hall, D. M., Feldpausch-Parker, A. M., & Peterson, T. R. (2010). Obscuring ecosystem function with application of the ecosystem services concept. *Conservation Biology, 24*(1), 113–119.
Quintero, M., Wunder, S., & Estrada, R. (2009). For services rendered? Modelling hydrology and livelihoods in Andean payments for environmental services schemes. *Forest Ecology and Management, 258*(9), 1871–1880.
Redford, K. H., & Adams, W. M. (2009). Payment for ecosystem services and the challenge of saving nature. *Conservation Biology, 23*(4), 785–787.
Regmi, B. R., Kafle, G., Adhikari, A., Subedi, A., Suwal, R., & Paudel, I. (2009). Towards an innovative approach to integrated wetland management in Rupa Lake Area of Nepal. *Journal of Geography and Regional Planning, 2*(4), 80–85.
Rio García-Amado, L., Pérez, M. R., & García, S. B. (2013). Motivation for conservation: assessing integrated conservation and development projects and payments for environmental services in La Sepultura Biosphere Reserve, Chiapas, Mexico. *Ecological Economics, 89*, 92–100.
Sanchez-Azofeifa, G. A., Pfaff, A., Robalino, J. A., & Boomhower, J. P. (2006). Costa Rica's payment for environmental services program: intention, implementation and impact. *Conservation Biology, 21*(5), 1165–1173.
Schomers, S., & Matzdorf, B. (2013). Payments for ecosystem services: a review and comparison of developing and industrialized countries. *Ecosystem Services, 6*, 16–30.
Seppelt, R., Dormann, C. F., Eppink, F. V., Lautenbach, S., & Schmidt, S. (2011). A quantitative review of ecosystem service studies: approaches, shortcomings and the road ahead. *Journal of Applied Ecology, 48*(3), 630–636.
Shrestha, U. B., & Bawa, K. S. (2014). Economic contribution of Chinese caterpillar fungus to the livelihoods of mountain communities in Nepal. *Biological Conservation, 177*, 194–202.
Shrestha, U. B., Shrestha, B. B., & Shrestha, S. (2010). Biodiversity conservation in community forests of Nepal: rhetoric and reality. *International Journal of Biodiversity and Conservation, 2*(5), 98–104.
Simelton, E., & Dam, B. V. (2014). Farmers in NE Vietnam rank values of ecosystems from seven land uses. *Ecosystem Services, 9*, 133–138.
Sohel, M. S. I., Mukul, S. A., & Burkhard, B. (2014). Landscape' s capacities to supply ecosystem services in Bangladesh: a mapping assessment for Lawachara National Park. *Ecosystem Services, 12*, 128–135.
Stoll, S., Frenzel, M., Burkhard, B., Adamescu, M., Augustaitis, A., Baeßler, C., et al. (2015). Assessment of ecosystem integrity and service gradients across Europe using the LTER Europe network. *Ecological Modelling, 295*, 75–87.
TEEB. (2010). *The economics of ecosystems and biodiversity: Mainstreaming the economics of nature: A synthesis of the approach, conclusions and recommendations of TEEB*, ISBN 978-3-9813410-3-4.
Turner, R., & Daily, G. (2008). The ecosystem services framework and natural capital conservation. *Environmental and Resource Economics, 39*, 25–35.
Turpie, J. K., Marais, C., & Blignaut, J. N. (2008). The working for water programme: evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa. *Ecological Economics, 65*(4), 788–798.
Van Hecken, G., Bastiaensen, J., & Vásquez, W. F. (2012). The viability of local payments for watershed services: empirical evidence from Matiguás, Nicaragua. *Ecological Economics, 74*, 169–176.
Vásquez, W. F. (2014). Willingness to pay and willingness to work for improvements of municipal and community-managed water services. *Water Resources Research, 50*(10), 8002–8014.
White, A., & Martin, A. (2002). *Who owns the world's forests? Forest tenure and public forests in transition*. Forest Trends. Washington, D.C.: Center for International Environmental Law.
William, J. V., Russell, C. S., Rodriguez, D. J., & Darling, A. H. (1999). *Willingness to pay: Referendum contingent valuation and uncertain project benefits. Sustainable development Department Technical papers series; ENV-130* (pp. 9–11). 1300 New York Avenue, N.W. Washington, D.C: Publications, Environment Division, Inter-American Development Bank, 20577.
Wunder, S. (2005). *Payment for ecosystem services: Some nuts and bolts*. CIFOR Occasional Paper, 42.