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Understanding social–ecological interdependence using ecosystem services perspective in Bhutan, Eastern Himalayas

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Abstract. Biophysical and economic values are often used to aid understanding of the complex interplay between ecosystems, their services, and human well-being, but community values are rarely considered. In a case study of Barshong *gewog* in Bhutan, we used mapping methods that involved (1) local knowledge and perceptions collected using participatory rural appraisal tools, (2) a household survey, and (3) geospatial inputs, to understand the linkages between human well-being and ecosystem services at the local level, as perceived by the community. The study identified three major ecosystems—forest, agriculture, and freshwater—that contribute highly to local livelihoods. Collectively, these ecosystems provide a wide range of goods and services, including 22 provisioning, 13 regulating, 4 supporting, and 6 cultural services. About 85% of the households depend directly upon provisioning ecosystem services for their livelihoods and income. The study also identified the importance of the ecosystems in terms of three value domains—ecological, socioeconomic, and cultural.

Key words: community perceptions; dependence; ecosystem services; land use; participatory approaches.

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Introduction

Ecosystem services are defined as the conditions, processes, and components of the natural environment that provide tangible and intangible benefits for sustaining and fulfilling human needs (Daily 1997) and have been broadly adopted as a conceptual framework for addressing the connections between humans and nature (Burkhard et al. 2010, Díaz et al. 2015). They are also considered as products of the coupled and nested social–ecological systems on which humans depend for the various goods and services that contribute to their well-being (MEA 2005, Daw et al. 2011, Reyers et al. 2013, Hicks et al. 2015). This anthropocentric approach to nature promotes a new way of thinking about the contribution of the environment to human well-being (Costanza et al. 1997, Daily and Matson 2008, Scholes et al. 2013, Chaudhary et al. 2015). The concept of ecosystem services has risen to prominence in recent years, with recognition based on ecological, social, and cultural, as well as economic, values (Chan et al. 2012, Maes et al. 2012, Castro et al. 2014). Ecosystem services have also been identified as an important concept for poverty alleviation in communities, which are more dependent on ecosystems for their livelihoods (Pereira et al. 2005, Grêt-Regamey et al. 2012, Sandhu and Sandhu 2014, Suich et al. 2015). The growing popularity of the ecosystem services concept can be seen primarily as a reaction to the long-term neglect of the role of biophysical and ecological integrity in societal systems, and partly as a response to the growing degradation of the

ecosystems which provide these valuable services (Boyd and Banzhaf 2007).

Mountain ecosystems occupy close to 24% of the terrestrial surface and are home to 12% of the world's population (Huddleston and Ataman 2003). They have ecological, aesthetic, and socio-economic significance, not only for the people who live within them but also for those beyond (Rasul et al. 2011, Grêt-Regamey et al. 2012). About 10% of the world's population depend directly on mountain resources for their livelihoods and well-being, and an estimated 40% depend indirectly on these resources for goods such as food, timber, and medicine and a wide range of services such as fresh air and water, climate regulation, carbon storage, and the maintenance of aesthetic, cultural, and spiritual values (Schild 2008, Sandhu and Sandhu 2014). The Hindu Kush Himalayan region (HKH) is one of the largest and most assorted mountain settings in the world, covering 4.3 million km^2 of land from Afghanistan in the west to Myanmar in the east. The region is well known for its geo-hydrological, biological, cultural, and aesthetic values (Brooks et al. 2006). It also has a growing number of rural poor who are directly dependent on the ecosystem services for their livelihoods (Pant et al. 2012, Bawa and Seidler 2015). At the same time, the mountain environment is highly fragile and susceptible to environmental and non-environmental stressors, which can have serious implications for livelihoods (Macchi and ICIMOD 2010, Sharma et al. 2010, Gerlitz et al. 2012). Efforts have been made to provide a scientific basis for using the concept of ecosystem services to support conservation in specific mountain areas, including the HKH (Rasul et al. 2011, Grêt-Regamey et al. 2012). However, little attention has been paid to participatory research or the concerns of local people as users and providers of the services (Chettri and Sharma 2009, Rinzin et al. 2009, Chaudhary and Bawa 2011, Karanth and Nepal 2012), especially in mountain areas where development threatens ecosystems and local dependence on ecosystem services is comparatively high (Garrard et al. 2012, Turner et al. 2012).

Bhutan has been in the frontline of holistic approaches toward ideas of progress and gives equal importance to non-economic aspects of well-being through its philosophy of Gross National Happiness (GNH). The concept of GNH has often been explained on the basis of its four pillars—good governance, sustainable socioeconomic development, cultural preservation, and environmental conservation (Brooks 2010)—and how these are practiced (Rinzin et al. 2009, Singha 2012). At the macro-economic level, Bhutan's development agenda under the concept of GNH envisions a green and self-reliant economy with a strategic focus on major sectors, including hydropower and tourism that are highly dependent on natural resources and ecosystem services (Norbu 2012). More than 69% of Bhutan's population are subsistence farmers who rely heavily on natural resources and ecosystem services for their livelihoods (RGoB 2010). An ecosystem valuation carried out in Bhutan estimated benefits of USD 4,944 million derived from ecosystem services, of which 53% benefits the well-being of people outside the country's political boundaries (Kubiszewski et al. 2013).

Despite their local, national, and global significance, the importance of the ecosystem services generated in Bhutan has been little studied and is poorly recognized. Apart from a few experimental studies (Kubiszewski et al. 2013, ICIMOD and RSPN 2014), there has been no serious effort to enhance understanding of the significance of the ecosystem services and their values (Rasul et al. 2011, Kubiszewski et al. 2013). There is a need to enhance holistic understanding about the state, dynamics, and values of the ecosystem services in the region. Valuation is needed to improve recognition of the ecological, social, and economic trade-offs made between ecosystem services and other contributors to human well-being and enable decisions on trade-offs to be made—a difficult but critical process. Assessments and sustainable management of ecosystem services require an understanding of local people's perceptions of the qualities, quantities, spatial scales, and dynamics of the ecosystem services in order to form a bridge between ecological and social systems (Nahlik et al. 2012). Understanding the social dimension of ecosystem services, including how people acquire and use the services and perceive the benefits they derive in their own frame of reference, is crucial. The perceived benefits that people gain from ecosystems are the reasons why they may or may not engage in behaviors and activities that ensure the continuous supply of desirable ecosystem services (Asah et al. 2014).

The main aim of the present study was to understand the social–ecological linkages between a rural population and the local ecosystem services based on an assessment of the major ecosystems and priority services as perceived by the local people, with a special interest in their relevance for livelihoods. We addressed this through a detailed case study using multiple assessment approaches for ecosystem services and combining and validating information obtained at different scales by means of (1) participatory rural appraisal (PRA) tools and techniques to collect local knowledge and perceptions, (2) household surveys, and (3) remote sensing and geographic information system-based geospatial analysis. We used the following research questions to reveal the interplay between ecosystems, ecosystem services, and local livelihoods from the perspective of a rural mountain community:

1. What are the major ecosystems found in the study area and how do local people perceive their importance in terms of ecological (biophysical), socioeconomic, and cultural aspects?
2. What are the major ecosystems services provided by these ecosystems and how important are they in terms of local people's well-being?

The Study Area

The case study was carried out in Barshong *gewog* (sub-district) within Tsirang *dzongkhag* (district) in the south-central part of Bhutan in the Eastern Himalayas. Barshong lies between 250 and 1600 m above sea level and has a total area of 21.2 km^2 divided into five administrative *chiwogs* (Barshong Toed, Barshong Moed, Chhunythang, Gangtokha, and Toisang) with a total population of 1710 (GNHC 2013). The most commonly used local dialects are Lhotshamkha, Tamang, Mongar, and Subba. This is a relatively isolated and sparsely populated area of rugged mountain terrain which lies within reach of some of the richest and least disturbed ecosystems in Bhutan.

Most of the area is under forest, mainly broadleaf and chir pine, with some agricultural land (Fig. 1). The favorable and diverse agro-ecological characteristics provide the *gewog* with a high potential for cultivation of many different types of cereal as well as horticultural crops. The major cereal crops are maize, millet, and paddy, and the principal cash crops are oranges and vegetables. Livestock rearing is also important, contributing both food for consumption and cash income from the sale of surplus dairy products. The *gewog* has basic rural facilities including an agricultural extension center, a livestock extension center, forest range office, a basic health unit with an outreach clinic, community information center, and a primary school; most of the *chiwogs* are connected to the national electric grid. Barshong is connected to the rest of the *dzongkhag* by an 11-km farm road.

Methods

During the study, various methods (both qualitative and quantitative) were used to assess the major ecosystems and their services in the study area, and people's dependency on and perceived benefits from these services. Two main types of indicators based on people's perceptions were considered vital: (1) state indicators describing which ecosystems are important for providing services and (2) performance indicators describing how people consider services in terms of their use in a sustainable way. The state indicators were considered under the four categories of ecosystem services—provisioning, regulating, supporting, and cultural—following the Millennium Ecosystem Assessment Framework (MEA 2005). A detailed literature review for the area focusing on socioeconomic and ecological aspects, with a particular focus on resource use patterns, was used as a basis for preparing a list of potential ecosystem services. These were then grouped into four categories following MEA (2005). As the information about services was to be linked with the well-being of the local community, the importance of the ecosystems providing services was considered in terms of their ecological, social, and cultural values (Raymond et al. 2009, Castro et al. 2014). The overall methodological framework is shown in Fig. 2; the tools used to collect primary data are described in more detail below.

Participatory rural appraisal

Our aim was to incorporate the value perceived by the actual users of the ecosystem services in the assessment (Carpenter et al. 2009). We used PRA tools and techniques, including key

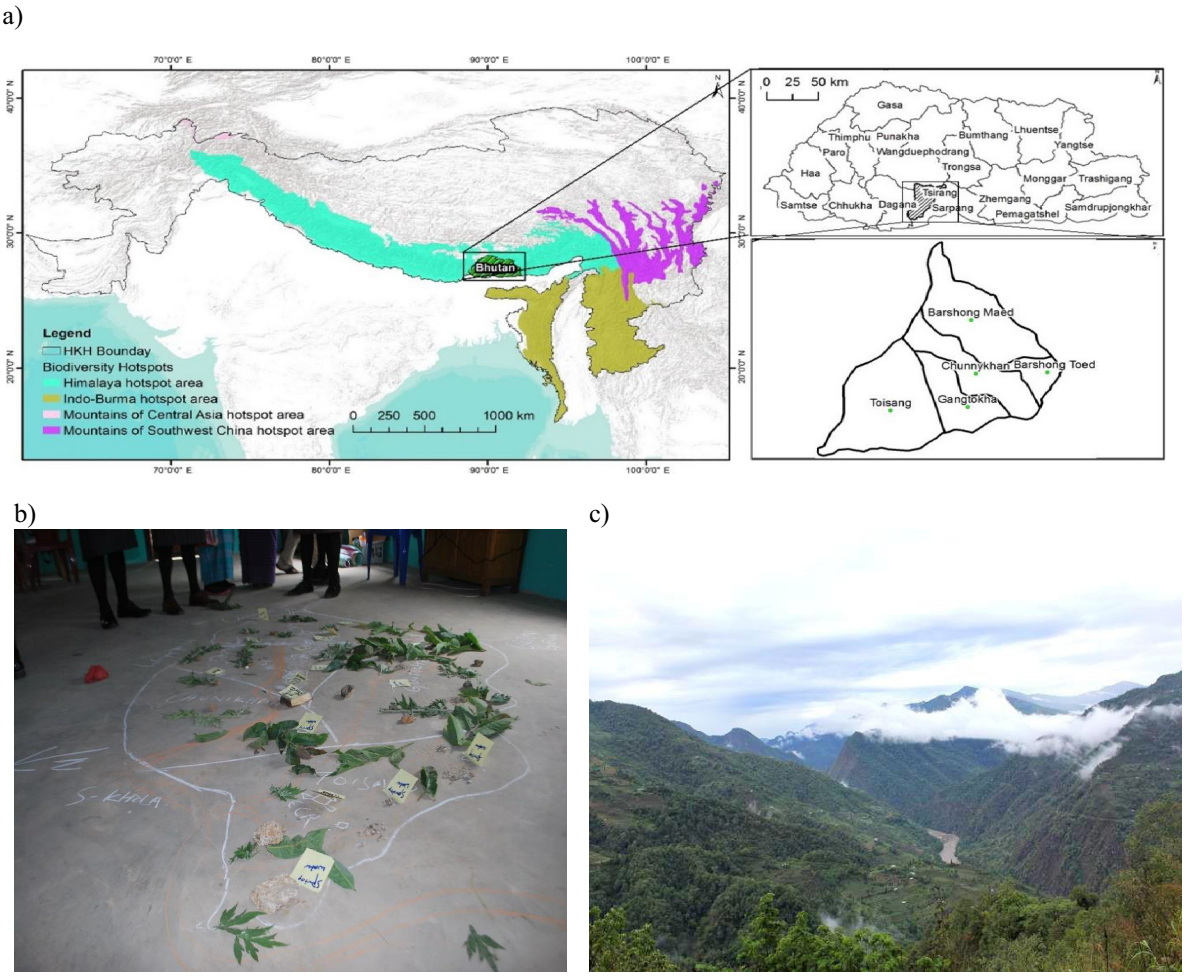

Fig. 1. The study area: (a) location, and land use and land cover, (b) participatory resources mapping, and (c) photographic view.

informant discussions, focus group discussions, and community resource mapping, to document local knowledge and perceptions about the major ecosystems, priority goods and services, perceived state and values, and related issues, following the approaches outlined by other authors (Chaudhary and Bawa 2011, Paudyal et al. 2015, van Oort et al. 2015). The use of various PRA tools was important to extract information regarding major ecosystems and their services from the community in their own frame of reference, as there is a very limited information available in the literature for the study site about the state of ecosystems, availability of ecosystem services, and people's dependence on them for subsistence and income.

Key informant discussions were conducted with the district level authorities including the Senior Forest Ranger from Tsirang *Dzongkha*, Administrative Head and staff of Barshong *gewog*, and community leaders representing the five *chiwogs* of Barshong *gewog*. There were 11 participants during the key informant discussion. These community experts had in-depth knowledge and understanding and provided insight into the locally important ecosystems, perceived state and importance of ecosystem services, and degree of incorporation of community knowledge and values in local development planning. The two focus group discussions (one man and one woman) with 12 participants in each group followed the same setup but with more representation from

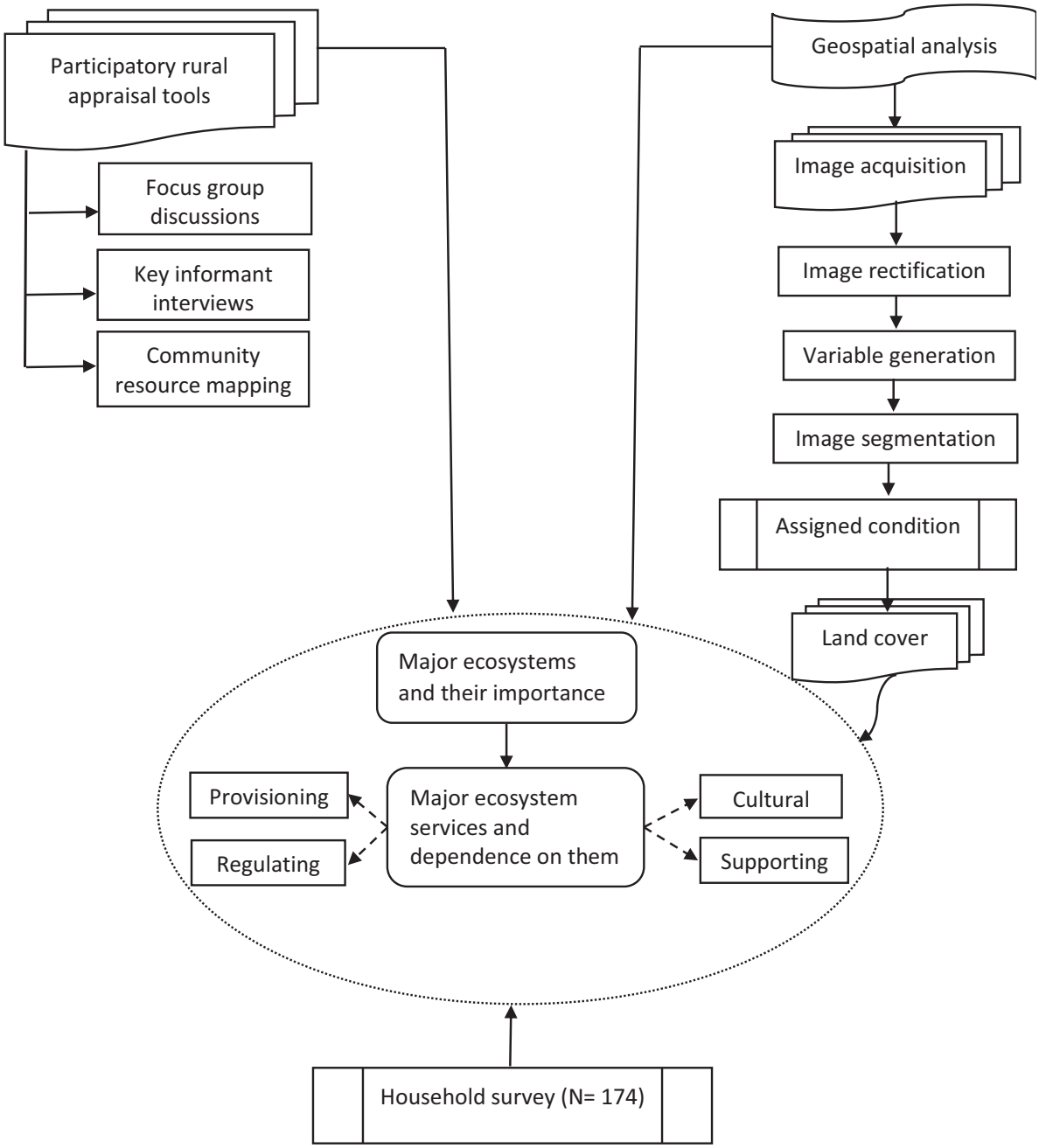

Fig. 2. Overall methodological framework.

the community, including women and people from diverse socioeconomic backgrounds. Gender-based focus group discussion was carried out to see if there was any preference of services based on gender roles. Discussions were prompted by open-ended questions and revealed that the major ecosystem services recognized and prioritized at local level are those that affect livelihoods. Following the focus group discussions, the local community, with facilitation from key informants, prepared a resource map of Barshong *gewog*. The resource map provided a rapid visual representation of the major ecosystems present in the *gewog*.

Household survey

A household survey was carried out covering all 174 households in Barshong *gewog*. Surveying all households ensured full representation of the community in terms of ecosystem use and dependence, and excluded the possibility of disproportionate representation of particular stakeholder groups or users of ecosystem services. In general, household heads were interviewed, or if they were not available, then other adult household members with knowledge about the household characteristics and pattern of resource use. The consent was taken from the respondents before the interview.

The questionnaire used was designed to elicit information on both the state of ecosystem services and people's dependence on them. It covered household demographic and socioeconomic attributes, major ecosystems and their importance in providing ecosystem goods and services, priority ecosystem goods and services contributing to economic well-being, and social, cultural, and ecological value of ecosystems. Importance was taken as the perceived importance for people's subsistence livelihoods and well-being (including security, the basic materials for viable livelihoods, freedom and choice, health, and good social relations) and categorized into very important, important, moderately important, less important, and not important. Dependence was taken as the ecological, socioeconomic, and cultural contribution obtained from ecosystem services by a household, and categorized from highly dependent to not dependent based on the extent to which the household depended on the ecosystems for their subsistence livelihood and household income. The argument behind segregating the perceived importance and dependence was that the community may perceive certain ecosystem as highly important, yet their dependency on that ecosystem may vary based on the availability of its services.

Ecosystems were classified as high ranking—services widely used and essential for local subsistence and income; medium ranking—preferred, but which households could do without if not available; and low ranking—with usage optional. The importance and dependence differed among households. A frequency distribution approach was used in the analysis which counted how often respondents answered positively to each list of goods and services. Socially, culturally, and ecologically important ecosystems were also identified and their perceived values ranked in a similar manner. Socio-economically important ecosystems and services were defined as those that are important for subsistence livelihoods and economy; culturally important were defined as those that are important in tradition and culture such as sacred plants, animals, wetlands, and sacred groves; and ecologically important were defined as those that are important for ecological balance and resilience based on various research work in the region and elsewhere (Castro et al. 2014, Chaudhary et al. 2016, 2017).

Geospatial analysis

Geospatial analysis was used to identify the major land-use and land-cover types in the study area. Medium spatial resolution Landsat 8 surface reflectance Level 2 satellite images with row 041 and path 138 for 14 December 2014 were acquired from USGS Global Visualization Viewer (GLOVIS https://glovis.usgs.gov) and analyzed using eCognition developer software (Trimble, Munich, Germany) for object-based image analysis. Object-based image analysis provides a methodological framework for machine-based interpretation of complex classes defined by spectral, spatial, contextual, and hierarchical properties. It yields better classification results with a higher degree of accuracy than pixel-based methods, as it uses both spectral and spatial information (Lang et al. 2011). A hierarchical classification scheme was used with six major land classes; the detailed methodology is described in Chaudhary et al. (2016). Briefly, eCognition Developer software was used to divide the image into objects that were similar in terms of selected attributes using indices like the land and water mask (LWM) was then created, during class modeling, through band ratio and texture information based on spectral values and vegetation indices like the Normalized Difference Vegetation Index (NDVI). In a pre-processing stage, the NDVI image was created using customized features: NDVI = (NIR − RED)/(NIR + RED). The LWM was then created by using the formula IR/Green × 100. The image objects were classified according to their attributes, such as NDVI, LWM, layer value and color, and relative position to other objects using user-defined rules. Objects with an area smaller than the defined minimum mapping unit were merged with other objects. The results

from the land-cover maps were then integrated with the results of the household survey. This research is also based on our other studies from the region with similar methodology applied (Chettri et al. 2013, Chaudhary et al. 2017).

Results

Socioeconomic characteristics

Barshong *gewog* has 62% male and 38% female population with a mean household size of 3.8. Half (51%) of the population is under 51 yr of age. Around 67% of the population are non-literate (56% of women and 44% of men) while 33% have completed some level of primary, secondary, or non-formal education. Only one person has a higher education degree. More than 80% of the population are Lhotsampas; the remainder are Sharshops, Trongsaps, Khengpas, and Ngalongs.

Livelihood strategies

Local livelihoods are based on a combination of farming, livestock rearing, wage and salaried labor, and remittances. Nearly 85% of respondents were farmers, and around 15% were engaged as wage laborers, salaried employees, or in other occupations, including small businesses and trades. More than 35% of the households had an annual income of <BTN 20,000 (USD 291), while 8% had an annual income of more than BTN 100,000 (USD 1,456; Table 1).

The total area of agricultural land was divided into three categories: wetland/irrigated land, dryland (rainfed), and orchard. All households owned at least one type of agricultural land, with an average of 1.2 ha of dryland, 0.5 ha wetland, and 0.2 ha orchard (Table 2). Households grow a diverse range of cash and food crops, including four cash crops (ginger, oranges, tapioca, and chilies), four types of grain (maize, millet, paddy, and buckwheat), and pulses (Table 3). The PRA and a household survey revealed that in terms of area, maize is the main crop (102.4 ha) followed by millet, and orange as a main cash crop. Chili was only cultivated by three households as a main crop and buckwheat by one.

Table 1. Household income.

Income†	Frequency (N)	Percentage (%)
<BTN 20,000 (USD 291)	62	35.6
BTN 21,000 ≥ 49,000 (USD 306–714)	49	28.2
BTN 50,000 ≥ 99,000 (USD 728–1,442)	49	28.2
≥BTN 100,000 (USD 1,456)	14	8
Total	174	100

† USD 1 = 60.15 BTN in 2014.

Table 2. Land ownership by type.

Land type	Area owned per household (ha)			
	Mean	Standard deviation	Minimum	Maximum
Wetland (irrigated)	0.5	0.5	0	3.2
Dryland (rainfed)	1.2	0.9	0	5.6
Orchard	0.2	0.2	0	2.0

The main types of livestock are cattle, poultry, goats, and pigs. Around 90% of households own cattle, 74% poultry, 72% goats, and close to 33% pigs. Very few households own sheep or horses. Households use stall feeding, grazing, or a combination of both to feed their livestock, with stall feeding preferred for goats and pigs, and a combination of cattle and poultry.

Major ecosystems and their perceived importance

The major land-cover types by area were forest (86%), cultivated land (11.5%), rivers, ponds, streams, and other water bodies (1.1%), fallow land (0.5%), and farm roads (0.2%; Fig. 3). The PRA and the household survey also identified forest, agriculture, and freshwater as major ecosystems contributing strongly to livelihoods and the economy. The local community irrespective of gender considered all three ecosystems—forest, agriculture, and freshwater—to be either very important (63%, 66%, and 81%, respectively) or important for their livelihoods and well-being (Fig. 4).

Table 3. Major crops.

Crop	Area (ha)
Maize	102.4
Finger millet	62.2
Paddy	26.2
Orange	21.9
Pulses	11.6
Ginger	6.0
Tapioca	5.5
Chili	0.3
Buckwheat	0.2

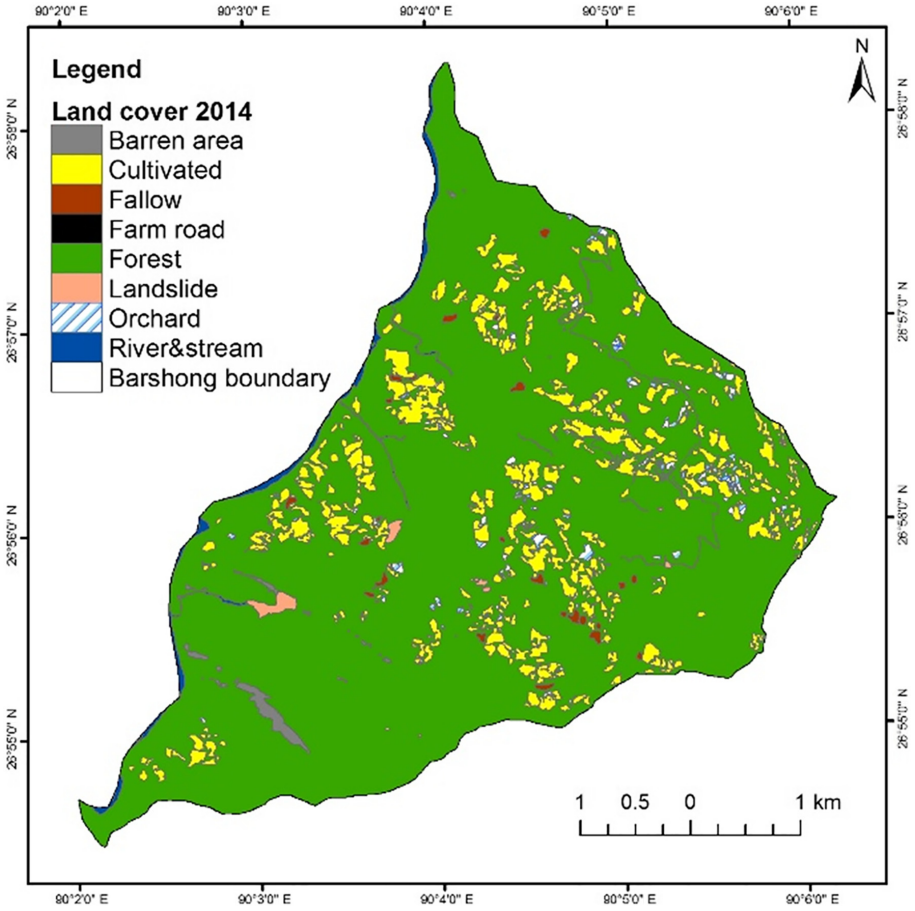

Fig. 3. Land use and land cover in Barshong *gewog*.

The respondents' perception of the socioeconomic, cultural, and ecological importance of the ecosystems is shown in Fig. 5. More than 90% of respondents considered that all three ecosystems—forest, agriculture, and freshwater—had a very important socioeconomic value as a result of their contribution to subsistence livelihoods and the local economy. More than 50% also considered freshwater and forest ecosystems to have a very important ecological value, although 18% thought they were not at all important for this. More than 30% considered that forest and freshwater ecosystems had a very important cultural value.

Dependence on major ecosystems and their services

Nine sources of household income were identified (Table 4). About 85% of total households depended directly on the income from primary sectors that were based on provisioning type ecosystem services. All respondents also reported using the freshwater ecosystem for drinking, bathing, and irrigation purposes, while 93% used agricultural land and 91% forests for their livelihoods and income (Fig. 6).

Types of ecosystem service

A total of 45 ecosystem services were identified in the study area: 22 provisioning, 13 regulating, 4 supporting, and 6 cultural (Table 5).

Provisioning services.—The local communities used eight different provisioning services from the forest ecosystem (Fig. 7). Almost all used timber/poles (98%), fuelwood (96%), and forage (87%) for livestock (grazing and fodder), many collected edible fruit and vegetables (46%) and mushrooms (26%), and a few collected small amounts of fiber,

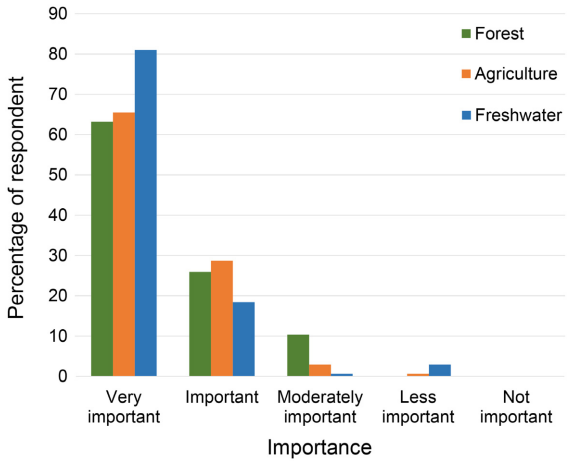

Fig. 4. Perceived importance of major ecosystems.

dye, and medicinal and ornamental resources. Most also used provisioning services from the agricultural ecosystem, including forage and fodder for livestock (92%), vegetables (90%), cereals (70%), and rice (paddy, 67%), and from the freshwater ecosystem, including water for drinking and bathing (95%) and water for irrigation (78%). Provision of food and raw materials from the freshwater ecosystem was low, with only 24 households using fish as a source of food.

Regulating services.—The majority of respondents were aware of the intangible benefits that ecosystems provide to humankind. They placed a high value on intangible services from the forest ecosystem in terms of erosion/flood control (94%), climate regulation (88%), maintaining soil stability (83%), soil fertility (78%), and seed dispersal (78%), carbon sequestration, pollination, nutrient recycling, and groundwater recharge (Fig. 8). The agricultural ecosystem was identified as important for erosion/flood control (57%), pollination (53%), and nutrient enrichment, soil stability, soil fertility, and climate regulation (all 45%).

Supporting services.—The majority of respondents placed a high value on the supporting services provided by the forest ecosystem in terms of habitat for species (99%), ecosystem resilience, the hydrological cycle, and soil formation and also recognized the importance of supporting services from both the freshwater and agricultural ecosystems (Fig. 9).

Cultural services.—The main cultural service recognized was aesthetic beauty, with 97% recognizing the value of this from the forest ecosystem,

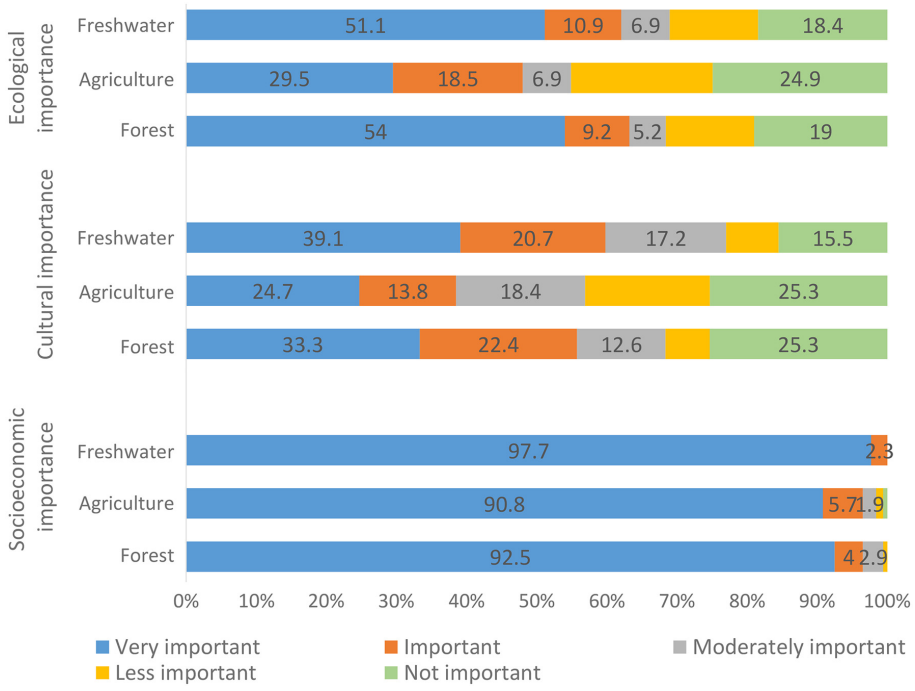

Fig. 5. Perceived social, cultural, and ecological importance of ecosystems.

Table 4. Sources of income.

Primary (85%)	Secondary (12%)	Tertiary (3%)
Crops, vegetables, and fruit	Wage labor	Remittances
Livestock and livestock products	Salaried employment	Development aid projects
Forest products	Small business	Government social benefit schemes

38% from the freshwater ecosystem, and 35% from the agricultural ecosystem (Fig. 10). The service of nature worship from forest was also valued (40%), but <20% of respondents recognized the value of ecosystem services provided for ecotourism, education, recreation, or spiritual enrichment.

Discussion

The ecosystem service concept has been embraced as a way to communicate societal dependence on ecological life support systems (Daily 1997, MEA 2005, Braat and de Groot 2012). Much of the work on ecosystem services to date has focused strongly on their biophysical assessment, classification, and economic valuation (Berbés-Blázquez 2012, Chaudhary et al. 2015). There have been few studies on social–ecological perspectives of services, which require a different approach to evaluation that draws on a wide range of social science tools and methods (Fagerholm et al. 2012, Plieninger et al. 2013). However, there has been wide recognition of the need to include community perspectives in ecosystem assessments in order to understand better the distribution of impacts and benefits resulting from natural resource use (Raymond et al. 2009, Brown 2013, Baral et al. 2014), and studies that integrate natural and social science perspectives are becoming more common (Raymond et al. 2009, Chan et al. 2012, Plieninger

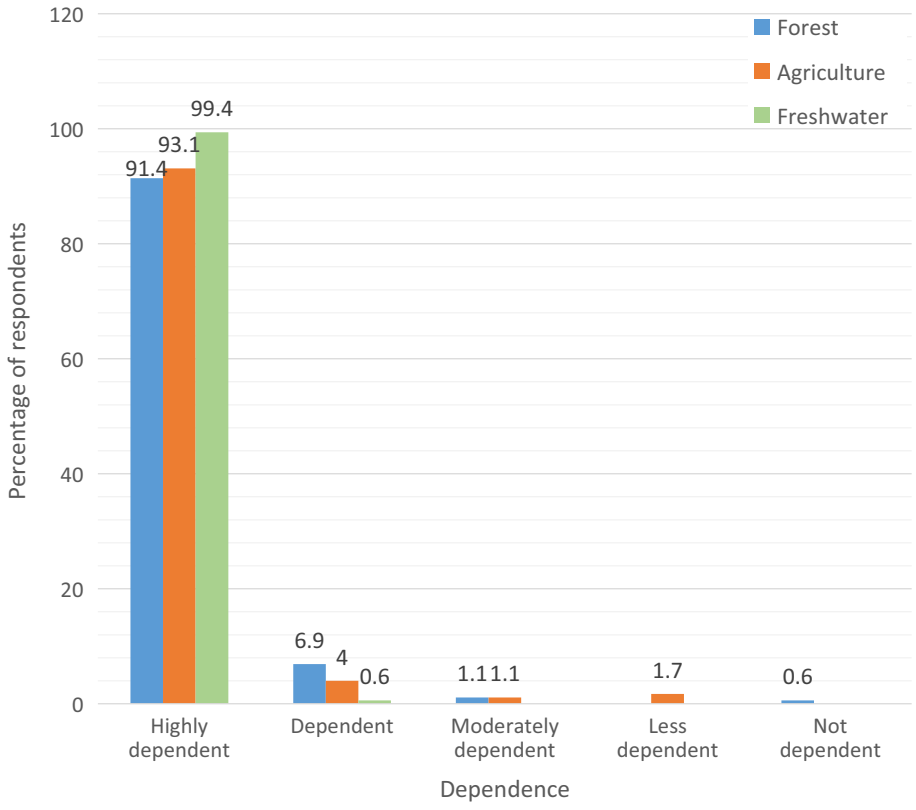

Fig. 6. Community dependence on major ecosystems.

Table 5. Goods and services provided by the various ecosystems.

Type of service	Services recorded
Provisioning (22)	Fuelwood, fodder, grazing, timber/poles, leaf litter, medicinal plants, ornamental plants, wild edible fruit and vegetables, mushrooms, fiber, thatch, bushmeat, dyes, paddy, cereals, vegetables, fish, drinking water, bathing water, irrigation water, boulders, and sand
Regulating (13)	Carbon sequestration, climate regulation, flood control, groundwater recharge, nutrient enrichment, pest regulation, pollination, seed dispersal, soil fertility, soil stability, water treatment, water purification, and water retention
Supporting (4)	Ecosystem resilience, species habitat, hydrological cycle, and soil formation
Cultural (6)	Aesthetic beauty, ecotourism, education and research, recreation, nature worship, and spiritual enrichment

et al. 2013, Castro et al. 2014, Martín-López et al. 2014, Paudyal et al. 2015, van Oort et al. 2015).

Studies that incorporate community perceptions, values, attitudes, and beliefs may generate more meaningful insights into the contribution of ecosystem services to human well-being than purely biophysical assessments (Martín-López et al. 2012). The combination of local perceptions and knowledge with scientific input allows for a holistic, contextual analysis of locally relevant ecosystem services (Seppelt et al. 2011). While the literature provides a comprehensive overview of the different services related to specific ecosystems, local knowledge is essential as it typically results in a very different, and more locally relevant, list of services to consider (Fagerholm et al. 2012, Malinga et al. 2013). However, social preferences for ecosystem services depend on who is involved, where they live, and how they interact with their landscape (Garrard et al. 2012, Paudyal et al. 2015). Thus, the context-dependent criteria used in this study are expected to give a more precise understanding of the relevance of ecosystem services for the well-being of the Barshong communities.

As an agrarian community, around 69% of the Bhutanese population in rural areas depends directly or indirectly on local ecosystems for their subsistence (Kubiszewski et al. 2013). This is consistent with the findings of earlier studies carried

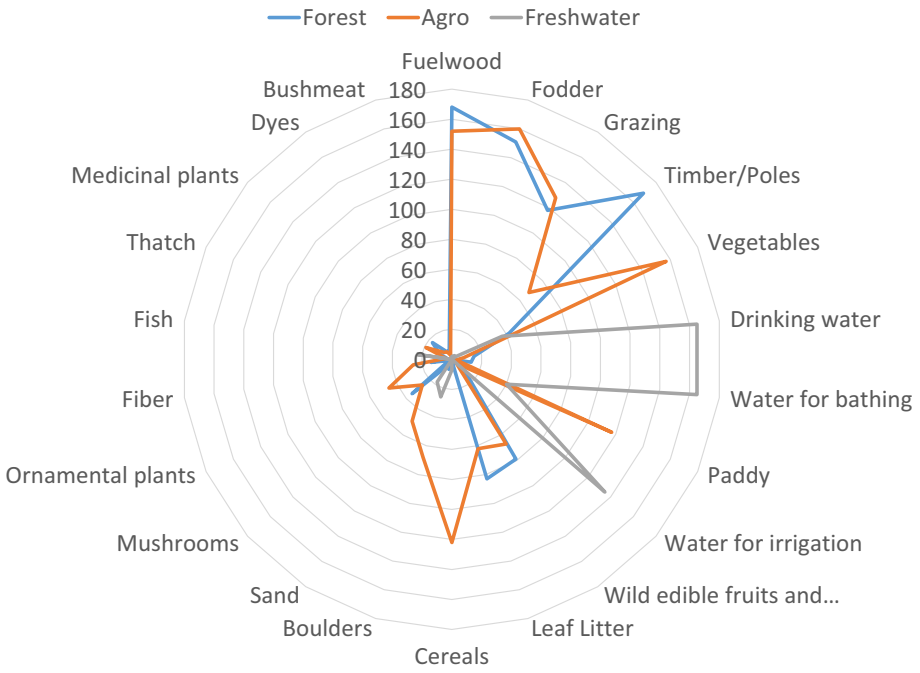

Fig. 7. Number of respondents using the provisioning services provided by the major ecosystems.

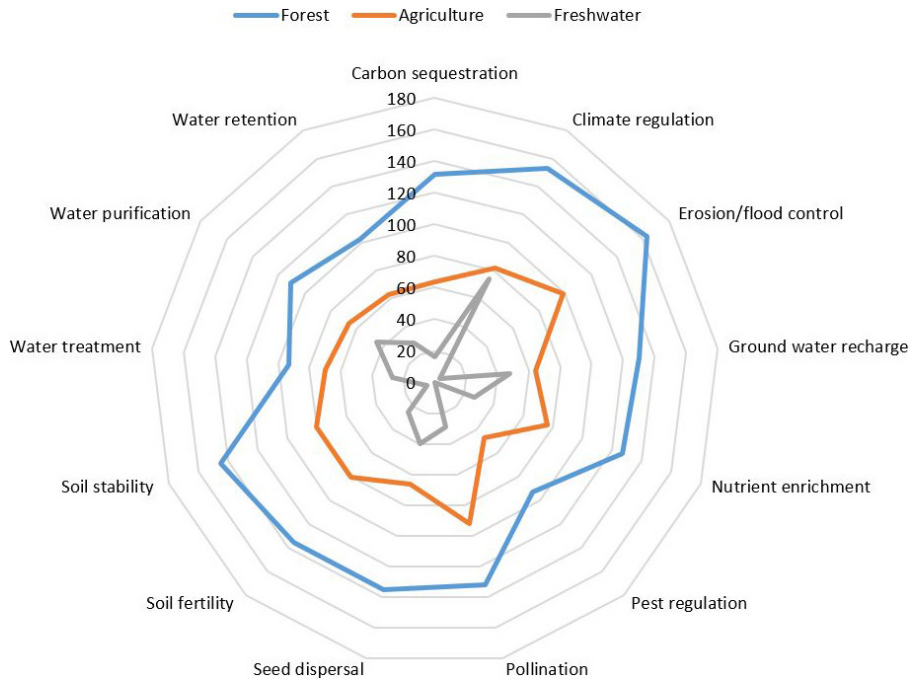

Fig. 8. Number of respondents affirming the regulating services provided by the major ecosystems.

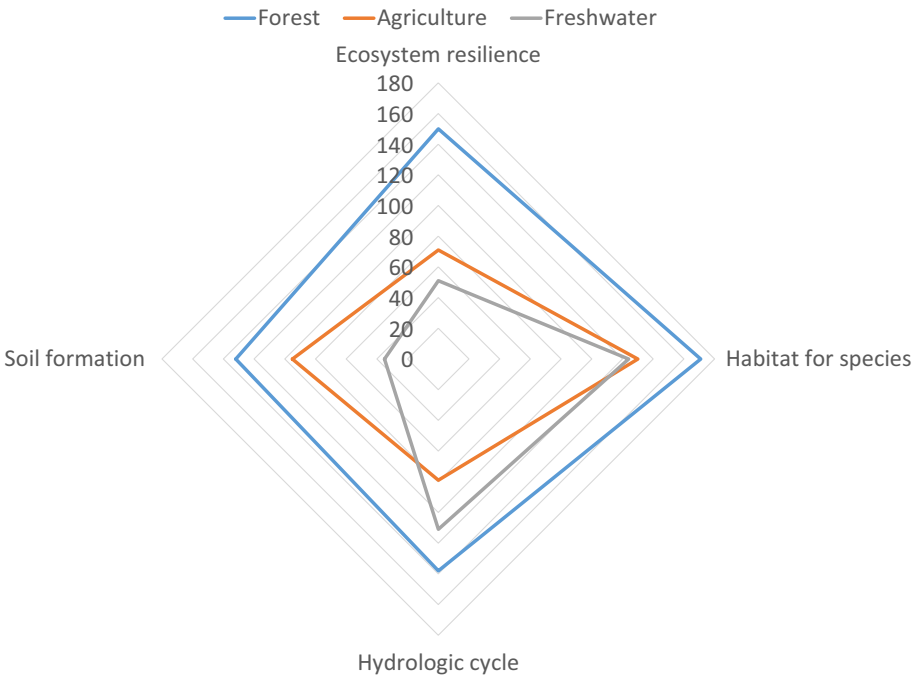

Fig. 9. Number of respondents affirming the supporting services provided by the major ecosystems.

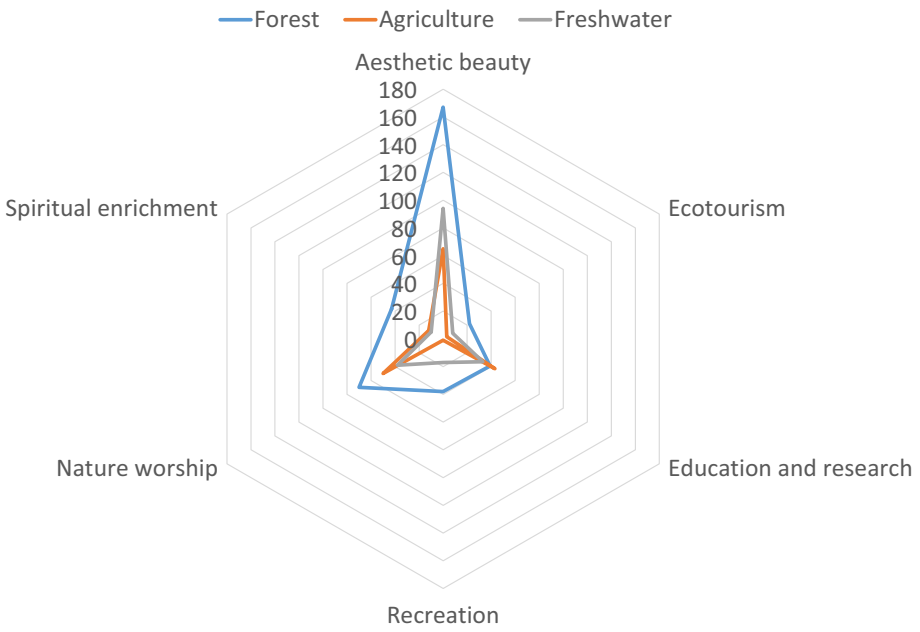

Fig. 10. Number of respondents using the cultural services provided by the major ecosystems.

out in similar mountain agrarian settings (Paudyal et al. 2015, van Oort et al. 2015). The lack of industrial activity and stable job opportunities mean that the majority of people are still largely dependent on ecosystem services for their livelihoods and income (Mikulcak et al. 2013).

Our study shows that the people in Barshong *gewog* are highly dependent on the natural ecosystems and their services for their subsistence livelihoods and income. The communities derive a vast array of goods and services from these ecosystems; 85% of households depend directly on local provisioning services for their livelihoods with forest, agriculture, and freshwater ecosystems perceived as the most important. More than 90% of respondents considered that all three ecosystems had a very important socioeconomic value as a result of their contribution to subsistence livelihoods and the local economy.

All respondents depended on the freshwater ecosystem, rating it most important of all ecosystems, 93% depended on the agricultural ecosystem, and 91% on the forest ecosystem. Drinking water quality and quantity were valued highest of all services, together with fuelwood. The importance of water for irrigation was also strongly reflected in the survey results. Respondents who lacked water for irrigation ranked agricultural land as less important, while those with access to generous levels of electricity ranked their reliance on forest as lower, as electricity replaced fuelwood. The studies by Tshering et al. (2012) and van Oort et al. (2015) in similar livestock-rearing agrarian communities also found that communities considered the freshwater ecosystem even more important than forest and agriculture.

More than half of the respondents considered that freshwater and forest ecosystems had a very important ecological value in terms of providing habitat for biodiversity, regulating fresh air and clean water, and providing nutrient enrichment to the soil, among others, whereas few respondents thought these ecosystems have no ecological value. This could be due to the lack of knowledge and awareness regarding the contribution of these ecosystems in ecological balance and resilience. People also placed a high cultural value on freshwater ecosystems. Water is deeply entwined with the values of Bhutanese culture, from offering freshwater to the gods every morning, through worshipping at sacred lakes and rivers and bathing for self-sanctification, to the prayers and rituals performed to respect and care for the rain, freshwater is of high significance.

Although the freshwater ecosystem was perceived as the most important, the communities obtain most of their goods and services from the forest ecosystem, followed by the agricultural ecosystem. Forest, agriculture, and livestock are closely interdependent and play a very central role in the subsistence agricultural system practiced in Bhutan (Tshering et al. 2012), and the agricultural ecosystem is perceived as only slightly more important than forest. Agriculture is the most important source of income (more than 80% of households depend exclusively on agriculture for their income and almost 90% rear livestock), while communities depend on forest for a wide range of services that play an important role for both subsistence and trade, and support livestock and agricultural activities, climate regulation, erosion/flood control, and cultural values (Chettri et al. 2013, ICIMOD and RSPN 2014, Paudyal et al. 2015, Bhandari et al. 2016).

Communities linked provisioning services mostly to those goods and services from which they fulfill their basic needs (fuelwood, fodder, timber, vegetables, cereals, and paddy) and earn income (Chettri and Sharma 2009, Pant et al. 2012, Paudyal et al. 2015, Bhandari et al. 2016). Regulating services were associated more with matters related to health and the health of the physical environment (e.g., climate regulation and carbon sequestration), security in the sense of being safe from natural disasters (e.g., erosion and flood control), and the provision of materials for a good and healthy life (e.g., water and air purification, groundwater recharge). Supporting services were linked with maintaining a healthy environment and having predictable surroundings, for example, maintaining habitat for species. The importance of cultural services mostly related to aesthetic beauty and nature worship, although other services like recreation, a sense of place, cultural heritage, and social traditions were also often cited. Even though the importance of cultural services is recognized (Tengberg et al. 2012, Paracchini et al. 2014), it is difficult to link particular changes in social–ecological systems unequivocally to particular changes in cultural benefits (Chan et al. 2012). At the same time, there are many other non-material and intangible services like spiritual enrichment, cultural identity, ideals, recreation, and psycho-physical health that communities receive from nature that are also a very important source of well-being and directly affect the quality of life in Bhutan (Brooks 2010). These ecosystem services not only provide a biogeochemical context for species and ecosystem preservation, but also a socio-cultural context for human society (Chiesura and de Groot 2003).

The perception, values, and beliefs of people can vary due to a complex set of factors, including individual needs, cultural traditions, access to ecosystem services, and sources of household income (Martín-López et al. 2012). The value that local people place on ecosystem services often helps to raise public support for protecting the ecosystems. Identifying those values and services is crucial while designing interventions, as neglecting them can produce unintended consequences and impede the achievement of program goals (Chan et al. 2012).

The novel feature of the study presented here lies in the use of relatively simple participatory tools to assess the linkages between livelihoods and ecosystem services at a local level, as perceived by the community, in one of the least explored areas of the Eastern Himalayas. However, the study should be interpreted within the limitations of the methodological approach. We were limited to identification of the utilitarian aspect of ecosystem services and did not attempt to identify the key linkages between environmental quality and human well-being, and the impact that changes in the quantity and quality of ecosystem services may have on livelihoods. We also made no attempt to assess the relationship between perceptions and the actual (quantitative) use of goods or services such as timber production, water yield and quality, forage, and carbon sequestration.

Conclusion

Ecosystem services play a crucial role in the livelihoods of mountain communities who depend directly upon agriculture and forest products for sustenance and income. Through a detailed case study, we revealed the major ecosystems, priority goods and services, and their perceived importance and relevance for local livelihoods in Barshong *gewog* in a remote rural area of Bhutan. The study also identified the importance of ecosystems in terms of three value domains—ecological, social, and cultural. For the study, we used a series

of ecosystem services assessment approaches to ascertain people's perceptions including PRA tools and techniques, a household survey, geospatial inputs, and literature analysis.

The results of the study indicate that the people of Barshong *gewog* depend highly on freshwater, agriculture, and forest ecosystems for their livelihoods and economy. These ecosystems provide a wide range of goods and services, including 22 provisioning services, 13 regulating services, 4 supporting services, and 6 cultural services. Specifically, around 85% of households depended directly on local provisioning services for their livelihoods and income. People gave high socio-economic value to freshwater, agriculture, and forest ecosystems as a result of their large contribution to local livelihoods and income; a high ecological value to forest and freshwater ecosystems as a result of their importance in providing habitat for biodiversity, water and air purification, and nutrient enrichment; and a high cultural value to the freshwater and forest ecosystems.

The study will help increase understanding of the complex interaction between humans and the environment in a little explored area of the Eastern Himalaya, and highlights the contribution of ecosystem services to local livelihoods and the economy by using participatory approaches. Participatory approaches are important for engaging and informing local communities about the state of ecosystems and their services. Using participatory approaches to identify major ecosystems and priority goods and services provides a useful way of engaging local communities in discussions about ecosystem services. Most decisions that directly affect ecosystem management are made locally, and these decisions are influenced by the biophysical and socio-cultural values associated with the services. Taking locally perceived values into consideration in decision-making processes can help to ensure the sustainability of ecosystem management interventions.

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