WORKING PAPER 245

Community values and perceptions of ecosystem services of high-altitude old-growth oak forests of Bhutan Himalayas

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1 Introduction

Bhutan is a small country situated in one of the most diverse ecosystems of the Eastern Himalayas. Ranging in elevation from a little less than 100 m a.s.l. at its southern border to over 7000 m a.s.l. in the north, and covering only 38,394 km^2 in area, this ecologically diverse country has 71% of its total geographical area under forests (FRMD 2016).

The natural resources found in these forests, along with the freshwater ecosystems, are regarded as the most valued ecosystem goods and services in Bhutan (Baral et al. 2017; ICIMOD 2017; Kubiszewski et al. 2013). Forest ecosystems and their services play a crucial role in the country's realization of gross national happiness (GNH) (Sears et al. 2017). Close to 60% of Bhutanese people are rural and largely agrarian, and about 70% of the population is dependent on subsistence agriculture and livestock farming, which relies heavily on the forests and their resources. The forests are traditionally used as grazing grounds. Large herds of domestic cattle and migratory cattle are grazed there, while the fresh water from the forests is a source of drinking water and irrigation. Forest fodder and leaf-litter collection for cattle bedding constitutes a major activity for the farming communities, and also plays a major role in nutrient transfer from forests to agricultural fields (Roder et al. 2003) thereby maintaining soil fertility with minimum chemical fertilizer inputs. Fuelwood collected from the forests is a primary source of energy providing 58% of the total energy consumed in Bhutan (DOE 2009).

There are 11 forest types in Bhutan (MoAF 2016), with distribution strongly correlated to elevation and annual precipitation (Wangda et al. 2006). Among these are the evergreen oak forests, covering 315 km^2 and spanning over only 1% of Bhutan's land area. Evergreen oak forests have a special link to the farming communities throughout the Himalayas (Moktan 2014; Naudiyal et al. 2017; Shrestha 2003; Singh et al. 2012).

The most important and highly utilized forests for temperate farmers (2200 m to 3500 m a.sl.) are the high-altitude old-growth oak forests, dominated by *Quercus semecarpifolia*. These and adjacent ecosystems are historically grazed by large herds of migratory and sedentary cattle due to their location adjacent to the alpine meadows which were traditionally used as grazing grounds. The livelihoods of communities in the upper mountains is directly dependent on agriculture and livestock farming. They obtain timber, fuel wood, fodder and manure from the oak forests. Thus, due to their strong connection with the farming systems, these forests are vital to the wellbeing of people living in the temperate regions of Himalayas (Gajendra et al. 2011; Shrestha 2003). Oak forests are also indispensable for the protection of watersheds as they are strongly correlated with the quantity and quality of mountain springs (Shrestha 2003; Singh et al. 1989; Singh et al. 2012; Singh et al. 1986).

In the Bhutan Himalaya, cows and yaks are the main grazers. Traditionally, cows graze these forest during the summer months (June–August), while yaks graze during the winter months (December–February). The evergreen leaves of the *Q. semecarpifolia* serve as an important fodder resource during the dry winters when ground vegetation is largely absent due to severe cold weather. The wood of *Q. semecarpifolia* is known for its strength, durability and permanence, and it is highly sought after for firewood, agricultural implements, charcoal and sericulture (Singh et al. 1997).

Recent rapid population growth and economic development in Eastern Himalayan countries have put severe pressures on forest ecosystems, and particularly on these high-altitude old-growth oak forests (Shrestha 2003; Shrestha et al. 1996; Singh et al. 2010; Singh et al. 2012; Singh 1998; Singh et al. 1986). These pressures are caused by unsustainable wood extraction, excessive forest grazing and a changing climate, and there is concern that the reduction or even loss of important species may affect the forests' provision of ecosystem services critical to local livelihoods and regional

security. For example, Sherestha and Paudel (1996) reported that degradation of brown oak forests in Nepal threatened livestock farming due to fodder scarcity. They also reported noticeable declines in populations of wild dove and barking deer, animals that feed on the acorns of this species. In Kumoan Himalayas, India, degradation of these oak forests is correlated with drying and other changes in springs from underground water sources (Singh et al. 1989). The degradation of these important high-elevation forest ecosystems will result in the deterioration of ecosystem services if proper forest management strategies are not taken in a timely manner. This could include changes in community norms and practices related to land use, agriculture and forests, policy reform, and carrying out restoration measures that promote the regeneration and growth of these forests.

This paper reports our research on community perceptions of these forests and their ecosystem services. The study was carried out as a part of the international Sloping Lands in Transition (SLANT) project, led by CIFOR with collaborators in Asia and Africa (https://www.cifor.org/slant/).

2 Methods

2.1 Study area

For the current study, we selected seven villages in two districts in Western Bhutan: Thimphu District and Wangduephodrang District (Figure 1; Table 1). Villages were selected for inclusion based on their uniformity in landscape and elevation, proximity to the old-growth oak forest and their strong dependence on the ecosystem services of the forest. The forests associated with the study sites were dominated by brown oak (*Quercus semecarpifolia*) and mixed with conifers such as blue pine (*Pinus wallichiana*) at the lower elevations and spruce (*Picea spinulosa*) and hemlock (*Tsuga dumosa*) at the higher elevations, with some other temperate broadleaf species.

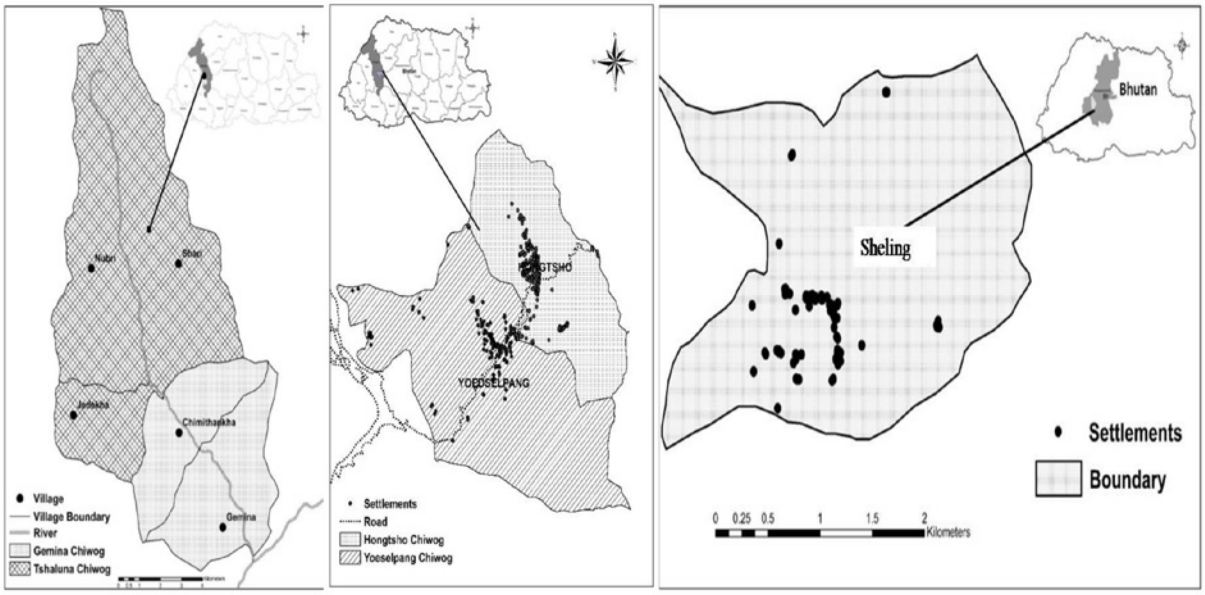

Figure 1. Area showing six villages in Thimphu and one village in Wangduephodrang.

Table 1. Description of the study sites.

Village name	District	Altitude (m.a.s.l.)	Coordinates	Main source of income
Sheling	Wangdue	2539	27º 23’ 24.19” N 89º 58’ 41.26” E	agriculture (potatoes), forests
Jadingkha	Thimphu	3036	27º 27’ 02.61” N 89º 30’ 18.69” E	agriculture, livestock, forests
Shari	Thimphu	2681	27º 27’ 28.98” N 89º 31’ 32.87” E	agriculture, livestock, forests
Nubri	Thimphu	2776	27º 27’ 37.41” N 89º 31’ 15.38” E	agriculture, livestock, forests
Chimithankha	Thimphu	2618	27º 26’ 36.30” N 89º 31’ 37.51” E	agriculture, forests
Gemina	Thimphu	2459	27º 25’ 36.41” N 89º 32’ 58.31” E	business, livestock, agriculture
Yusipang	Thimphu	2830	27º 28’ 09.15” N 89º 42’ 04.12” E	agriculture, forests, livestock

2.2 Data collection

We used three participatory rural appraisal approaches in these villages: focus group discussion (FGD), household interviews and key informant interviews, focusing on the significance of these forests to communities and households. While we aim to eventually quantify some of the ecosystem services provided by these forests, in this study we report only on the quality of the services as reported by villagers and other key stakeholders. Our surveys were developed and carried out by a multidisciplinary team comprising foresters, researchers and extension agents. The use of participatory tools to qualitatively assess the value of forests is rapid and reflects on-the-ground realities, which will give researchers a sense of the range and importance of the ecosystem services provided by these forests to the local people, and the trends and threats that require immediate attention (Baral et al. 2013).

We used structured perception questionnaires at the household (HH) level to assess the important ecosystem services of these forests and to gather views of rural communities in the study area who are dependent on the old-growth oak forests. A total of 84 households were included in the study. The participants were chosen on a random basis and generally the head of the household who made decisions for the family was interviewed. The average age of the farmers was 52 years for men and 43 years for women (Table 2).

We interviewed nine key informants in total: local range officers and officials from the forest department (5), a representative from one NGO (1) and staff at research institutes (3) who are actively involved in the forest management and conservation (see Table 2). The key informants were asked open-ended questions about their perceptions of the ecosystem services of these forests, the drivers of change to these services, and current management practices.

We held nine FGDs during April–June 2017 to get a general idea of the local views on the ecosystem services, trends in resource availability and threats to the forest, and recommendations for management interventions. Ecosystem services were identified by members of the group and listed on the charts through a participatory resource mapping exercise (Figure 2). Through a participatory mapping exercise, we ensured that all the members within the group contributed equally and the information gathered represented the perceptions of the whole group rather than only one or two spokespeople (van Oort et al. 2015). Group size was kept between 5 and 10 members to allow all members to participate in the discussion. The group members were from middle-aged to elderly men and women with good knowledge on oak forest utilization. All the participants indicated a strong dependence on the old-growth oak forests and ecosystem services for their livelihood. To avoid non-uniformity and to ease the resource mapping within the group, households utilizing the same local forests and ecosystem services were grouped together.

Perceptions of the availability of ecosystem services in the past, present and future were collected along with drivers of change and traditional knowledge or local practices which can be adopted for managing these resources based on local context. Ranking of the important ecosystem services based on preferences and priorities were also recorded. Prioritization of ecosystem services were conducted through questions based on which services respondents valued the most in their community. Each

Table 2. Respondents involved in the survey by gender.

SN	Occupation	Men		Women		Total respondents
		Number	Average age	Number	Average age	
1	Farmers	33	52	51	43	84
2	Key informants	9	43	-	-	9

Figure 2. Focus group discussions, including participatory resource mapping, in the study villages.

FGD listed up to five ecosystem services and ranked them according to importance. Every group was facilitated by a moderator with two others, who recorded the key information discussed.

For systematic listing of ecosystem services, as well as to ease data enumerators and local communities, we classified all the ecosystem services into four major groups following the Millennium Ecosystem Assessment (2005). These are provisioning services, regulating services, supporting services and cultural services (MEA 2005).

2.3 Data analysis

Descriptive statistics consisting of frequencies and percentages are presented based on the stakeholder's responses. Quantification of some of the ecosystem services at the household level on a yearly basis was also estimated to understand the extent of dependence on these services. There were discrepancies in the unit used for collecting these products. Some used head loads while bigger farmers used truck loads. Based on general experience, as well as field verification, the following standards were derived and used in the paper.

Firewood: 1 head load (HL) = 50 kg; 1 truck load = 72 HL

Leaf litter: 1 head load (HL) = 50 kg; 1 truck load = 60 HL

3 Results and discussion

The local communities in the study areas showed strong dependence on the local forest ecosystem and its services. A total of 22 broad ecosystem service types were identified and were grouped under the four categories of the Millennium Ecosystem Assessment (2005) (Table 3). Details of these services are provided for each of the four broad categories.

3.1 Provisioning ecosystem services

3.1.1 Freshwater services

Household and key informant interviews revealed that fresh water and its services from the forests are the ecosystem services most valued by the local communities. FGDs further confirmed this and reported that water has decreased every year. Water in the study areas was mainly used for household consumption and agricultural purposes. The main water bodies in the study area were fresh streams. These streams originate from a network of smaller springs, which are derived from groundwater under the forest floor. In total, approximately 19 perennial streams were recorded from the study area. Communities also use the water for rotating the prayer wheels (prayer mills); this is strongly associated with spiritual wellbeing and contentment of the villagers. In the past, one of the major water uses was to run traditional water mills for grinding grains. However, water mills have declined significantly over the last few decades due to replacement by easily operated electric mills. Most of the water mills are now non-operational or in a ruined state.

Ranked as the top priority ecosystem service throughout the study area (Table 4), freshwater availability in many areas has shown a declining trend over years (Table 5). The communities perceived that the decline will be more pronounced in the next few decades as they believe that water sources are drying out everywhere else, too. The decline in the availability of fresh water was mainly attributed to forest disturbances due to logging and other developmental activities, such as the construction of road and transmission lines (31%) in this study. Approximately 16% of the stakeholders perceived that the decline in water availability was due to drought and gradual warming trend observed over the years, while around 4% related it to other geological events, such as earthquakes. Water availability in two study sites, Sheling and Yusipang, has not changed; however, with increasing population and changes in consumption patterns coupled with climatic changes it was perceived to be likely to decline in future. The two villages have good forest cover dominated by oaks at their water sources with some small-scale disturbances.

3.1.2 Wood products

Timber and firewood production from the forests was ranked as the second and third most important ecosystem services by the communities (Table 4). Timber is usually allotted at a subsidized rate to rural communities for construction of houses and maintenance, with a fixed volume allowed to each registered household (head of the household). The current forest rules state that timber for house construction and renovation is allotted once every 12 years, while timber for construction and renovation sheds, storerooms and watch towers is issued once in every 25 years period. The volume of timber allotted is about 70 m^3 (= 2500 cubic feet). Timber species in the area are *Tsuga dumosa*, *Picea spinulosa* and *Pinus wallichiana*. Timber availability is perceived to have declined over the years (82%) and people related the decline to overextraction by outsiders.

Table 3. Ecosystem services indicated by local villagers in the study region, with description and potential indicators relevant to the study area and measurement units. Ecosystem services based on MEA ecosystem services group.

Ecosystem service category	Type of ES	Description of ES	Indicator of ES	Measurement units
Provisioning services	Freshwater	Water available for drinking, irrigation and hydropower	Number of springs, ponds and streams; volume of water; hydroelectric infrastructure capacity	No. site^{-1}; volume of water flow (m^3); hydroelectric generator capacity (kWh)
	Timber production	Timber stock at harvestable age in the forests	Number of large and mature trees per ha of dense forest	No. of commercial trees HH^{-1}
	Firewood	Presence and abundance of preferred firewood species	Number of fuel wood species, volume of fuel wood	HL HH^{-1}
	Food production	Provision of food from forests: berries, wild fruits, mushrooms, wild vegetables	Amount of food materials	kg HH^{-1}
	Leaf litter	Leaf litter collected for cattle bedding	Amount of leaf litter collected	HL HH^{-1}
	Grazing land	Area available in the forests for grazing	Number of grazing animals in the forest	No. HH^{-1}
	Forage production	Forage production potentiality from forests and grasslands for local livestock	Number of fodder species	HL HH^{-1}
Provisioning services	Local medicines	Variety of tree, shrub and herb species with biomedical value	No. of species of medical value and harvestable amount	kg HH^{-1}
	High-value NWFP	Non-timber forest products with bioprospecting or high commercial value	No. of species and production potential	Nos. HH^{-1} or kg HH^{-1}
Regulating services	Fresh air regulation	Trees provide fresh oxygen and also absorb dust particles/ toxins from atmosphere	Total leaf area; amount of pollutant in air	Air quality (ppm of key pollutants)
	Carbon sequestration	Atmospheric carbon capture by trees, shrubs and herbs	Increasing forest cover and increase in biomass	ha^{-1} year^{-1}
	Groundwater recharge	Vital role of vegetative forest cover in regulating water flow and retention of water	Ground water recharge rate (net amount of water availability throughout the year downstream)	Volume of water
	Natural hazard regulation	Forests act as a natural buffer, helping to protect from strong winds, landslides and other disasters	No. of landslides and other natural hazard cases per year	No. year^{-1}
	Water purification	Pure water running in streams	Quality of purified water	Macroinvertebrates

continued on next page

Table 3. Continued

Ecosystem service category	Type of ES	Description of ES	Indicator of ES	Measurement units
Regulating services	Disease regulation	Reduced diseases by regulating fresh air and water purification	Number of people affected by water and air borne diseases	No. of incidents year^{-1}
	Crop pollination	Increased production of crops from larger population of bees and other insects that help pollinate forests and agricultural crops	Number of pollinators	No. of species observed
	Soil protection	Does forest help in soil protection and conservation? Landslide prone areas covered by vegetation	Incidences of landslides, soil erosion or degradation	No. year^{-1}
Habitat/ supporting services	Biodiversity/ habitat	Provides refuge to a large number of plants and wild animals	Observed/reported recurrence of wild animal and plant species in the forests	Diversity ha^{-1}
	Maintenance of genetic diversity	Invasiveness/alien/native species	Appearance of new plants and animals	No. ha^{-1}
Cultural services	Spiritual and religious values	Presence of temples and religious sites	Locations of temples and spiritual sites; no. of people visiting these locations	No. of visitors year^{-1}
	Aesthetic values	Enjoyment of a landscape's scenic beauty	No. of visitors appreciating the visual quality of the landscape	No. year^{-1}
	Recreation and ecotourism	Opportunity for recreation and ecotourism	No. of recreation sites; no. of visitors	No. of visitors year^{-1}

Due to cold winters, the communities in our study area consume considerable amounts of fuelwood for heating as well as cooking. A household collected about 1–2 truckloads (8–16 m^3) of firewood every year. The respondents considered that the local trend in the availability of firewood is decreasing every year (75%). *Quercus semecarpifolia* is the most favored species for fuelwood because of its high calorific value. Realizing the rapid decline in oak population in 2000s, the government of Bhutan has imposed a ban on felling this species (Moktan 2014). The villagers now resort to lops and tops of this species and others, such as *Pinus wallichiana*, *Tsuga dumosa* and *Rhododendron* spp. Villagers, as well as key informants, stressed the need to assess whether such initiatives by the government is helping the regrowth of these forests.

The respondents perceive that the decrease in timber and fuel wood is due to over extraction both by locals and outsiders, coupled with low and longer regeneration and recruitment periods. The villagers expressed difficulties in finding required timber sizes in their forests, which is more time consuming than it was in the past. Road access to the forests has also escalated the problem, as it gives illegal access to the resources. Reducing both illegal access and the allocation of resources to outsiders were common suggestions from the communities to reduce resource depletion. Further, a proposed long-term solution is to declare the forests close to the settlements as community forests, so that community members can carry out monitoring and management.

Table 4. Prioritization of ecosystem services based on which natural asset the FGD participants value the most in their community. Letter in brackets show the MEA ecosystem service categories.

Location	Ecosystem services ranking based on stakeholder's priorities				
	First	Second	Third	Fourth	Fifth
Sheling	Freshwater services (P)	Firewood (P)	Spiritual and recreational values (C)	Litter for cattle bedding (P)	Natural hazard regulation, e.g. Protection from wind damage (R)
Jedingkha	Freshwater services (P)	Firewood (P)	Timber (P)	Food, NWFP, e.g. bamboo for basket making and income generation (P)	Fodder and grazing ground services (P)
Shari	Freshwater services (P)	Ground water recharge (R)	Firewood (P)	Food and income generation (P)	Timber (P)
Nubri	Freshwater services (P)	Timber (P)	Firewood (P)	Fodder (P)	Fresh air regulation (R)
Chimithankha	Freshwater services (P)	Firewood (P)	Timber (P)	Grazing and fodder (P)	Food e.g. Mushroom and income generation (P)
Gemina	Freshwater services (P)	Air regulation (R)	Firewood (P)	Timber (P)	Spiritual and recreational values (C)
Yusipang	Freshwater services (P)	Timber (P)	Firewood (P)	Biodiversity and habitat (S)	Food e.g. Mushroom and income generation (P)

Note: Letters in the parenthesis () indicate the broad category of MEA ecosystem service assessments within which the services fall; P = provisioning, R = regulating, S = supporting and C = cultural services.

> "In the past, about 20 years back, we could fetch our timber requirement for house construction and renovation from the nearby forests about 10–15 minutes walking distance from the house. Now we have to travel more than 5–6 hours by trucks looking for firewood and timber."
>
> Gyem Tshering, 45 years, Shari, Tsaluna Non-wood forest products

Almost all the households in the study area directly accessed the forests to collect non-wood forest products (NWFP), such as mushrooms, medicinal plants and fungi, wild fruits and other edible wild vegetables.

Mushrooms were the most widely collected item from the forest. Respondents reported collecting 32 kinds of mushrooms for household consumption and sale. The area is rich in mushroom resources, particularly the highly priced matsutake (*Tricholoma matsutake*). A household collects an average of 10 kg of mushroom per year. The quantity of mushrooms collected for sale in the local markets fluctuated largely across study sites, as well as among the households in the study area (Figure 3) depending on the availability of resources and occupation of farmers. Among the villages, residents in Yusipang collected the highest amount of mushroom with an average of 19 $kgHH^{-1}yr^{-1}$ for domestic

consumption and sale. Sheling (16 kg) and Chimithankha villages (14 kg) were the next highest collectors of mushroom. In the high season for mushrooms, the people of these communities dedicate most of their time to collecting.

The other villages collected less than 10 kg per household per year for consumption, with the minimum in Gemina village (1 $kgHH^{-1}yr^{-1}$). The residents attributed their low dependence on the wild mushrooms to poor mushroom resources in the area, as well as availability of other income sources. The village is located close to a rapidly growing business town driven by industrial growth and thus residents are moving toward small-scale businesses, market gardening and livestock.

FGDs revealed that there is strong competition for mushrooms among both residents and collectors from outside. While the forest remains open access, the participants felt that such practices lead to overexploitation of forest resources and urged the transfer of governance of the local forests and the resources to the local residents for community-based resource management. Common-pool resource management mechanisms and institutions, such as community forestry, have proved to be effective in regulating and managing valuable natural resources by communities in Bhutan (Brooks 2010). Such a move would not only ensure sustainable use of local resources but would also create a sense of ownership and belonging among the local residents. This would, in turn, help in the conservation of their local forests thereby safeguarding their resources and also helping to reduce rural–urban migration. We support the current initiative of Royal Government of Bhutan to decentralize the management of natural resources to the grass-root communities through the community forestry programs.

Except for a few highly priced mushrooms, the participants perceived that food production by these forests has remained same over the last 10 years (Table 5). Brooks (2010) reported that communities living near a similar forest type in Western Bhutan share this view on the supply of forest mushrooms. However, consumption patterns by the rural communities for these resources have declined sharply. For example, households in Gemina, which is close to the urban area and markets, did not collect mushrooms at all because they were able to purchase them from the local markets. Similar trends were also reported in the harvest of local medicines, wild vegetables, and wild fruits. Wild fruits and berries are occasionally eaten while passing by, mostly by children, and people reported that their collection has declined significantly while the production from the forests remained same. Local medicinal plants, which were widely used in the past for treatment of various ailments, are now hardly used due to access to modern medicines (Table 5*). It is thus predicted that with economic growth and the availability of various service options in the market, the dependence on these products will decline over time. There is some concern that even knowledge of these resources will decline, and thus documenting indigenous knowledge and practices would add value and preserve the knowledge base for transmission to future generations.

3.1.3 High-value non-wood forest products

Table 6 shows some NWFPs of high commercial value that were collected by rural communities and sold in the markets thereby contributing to additional income generation and enhancement of rural livelihoods. Some of these services were common to all the sites (e.g. *Exidia* mushroom, *Paris* plant roots), while few others were localized to a single study site (Table 6). For example, making and selling baskets from bamboo is traditionally practiced by people living in Jedekha village to earn additional income. On average, a household makes 10 baskets per year. Around 100 bamboo culms are required to make four bamboo baskets. A bamboo basket fetches about Nu. 800-1000 (approx. US$13–16) in the local market. However, the bamboo availability from the forests has declined significantly due to mass bamboo dieback following mast flowering a few years ago. Communities feel that strengthening propagation techniques and sustainable harvesting methods for the bamboo will ensure long-term ecosystem services and conservation goals.

Similarly, rhizomes of *Paris polyphylla* are in great demand for medicines to cure wide range of ailments from diarrhea to cancer (Shah et al. 2012). Dried rhizomes of the plants fetch about Nu. 5000 (approximately US$84) per kilogram. Every household in the study area earned between Nu. 900 (approx. US$15) and Nu. 25,000 (approx. US$416) per year depending on the quantity collected. A common concern about this resource expressed by the villagers is the lack of a proper market. Most of the products are bought by intermediaries, leading to a lack of transparency and highly fluctuating prices. Strong competition for resource harvesting by both the local communities and outsiders are perceived to have resulted in overharvesting of this species.

Eighty-eight percent of the participants in the FGDs expressed concern about the declining availability of this resource in the forests (Table 5). They attributed this to the destructive practice of harvesting the plant before seed production, which may have long-term impacts on its regeneration and conservation. Studies on ecology of the species in Nepal and India have reported that poor germination and unsustainable harvesting techniques are the main threat to this plant (Madhav et al. 2011; Paul 2015). Involving the rural communities in conservation awareness programs and mass cultivation of the species in the farmlands will ensure the effective conservation of the species, as well as uplifting the local economy in the Himalayan region (Paul 2015).

Another product of high commercial value is the mushroom *Exidia* sp., locally known as the 'sisishamu', or black mushroom due to its black color, which in China it is considered to have medicinal value. The mushroom grows on the dry branches of *Rosa serecia*. A kilogram of the dry mushroom can be sold for as much as Nu. 20,000 (approx. US$335). Almost all the villages in the study collected the mushroom, although the quantities collected varied among households (Box 1). Removal of branches to collect the mushroom was a serious concern expressed by all the villagers, who recommended following proper harvesting practices that conserve the host plant (*Rosa sericea*). Households in Yusipang village collect most black mushroom with around 2–3 kg/household per year, which generates an income of Nu. 24,000–36,000 per year (US$400–600). Yusipang village also collects the most matsutake mushroom (*Tricoloma matsutake*). A household collects about 20 kg of matsutake; those not used for household consumption are sold to the local markets. Due to their high commercial value and overharvesting by local residents and outsiders, the availability of these resources is declining rapidly throughout the study area (Table 5).

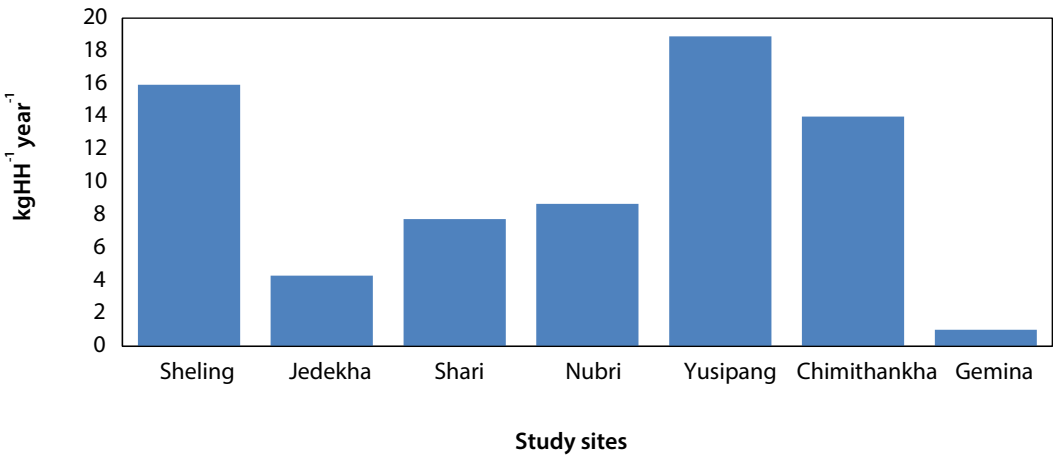

Figure 3. Mushroom collected for consumption and sale from the study area.

Table 5. Focus group discussion outcomes on perceived trends in the provisioning ecosystem services from old-growth oak forests in the study area. Ecosystem services are grouped into MEA ecosystem service categories. Some of qualitative scales are adapted from (Baral et al. 2013) while others are author's own elaboration.

Ecosystem Services	Sheling	Jedingkha	Shari	Nubri	Chimithankha	Gemina	Yusipang
Provisioning							
Fresh water	-	-	-	-	-	-	-
Timber	=	=	-	-	-	-	-
Firewood	=	=	-	-	-	-	-
Food production	=	=	=*	=*	=*	=*	+
Leaf litter	+	+	+	+	=	=	=
Grazing land	-	=	=*	=	=*	=*	=
Fodder	=	=	-	=	=*	=*	=*
Local medicines	=	=	=*	=*	=*	=*	=*
High-value NWFPS	-	-	-	-	-	0	- -
Regulating							
Fresh air regulation	=	=	=	=	+	=	=
Carbon sequestration	+	+	+	+	+	+	+
Groundwater recharge	=	-	=	-	-	-	=
Natural hazard regulation	=	=	=	-	=	+	=
Water purification	=	-	=	=	=	-	=
Disease regulation	=	≡	=	=	=	=	=
Crop pollination	=	0	=	-	=	=	-
Soil protection	=	-	=	=	=	=	=
Supporting							
Biodiversity / habitat for wild animals	+	+	+	-	+	+	-
Maintenance of genetic diversity	=	0	+	=	+	-	0
Cultural							
Spiritual and religious values	+	+	+	+	+	+	=
Aesthetic values	=	+	+	-	+	-	0
Recreation and ecotourism	+	+	+	+	+	+	+

Note: = no change, - declining trend, -- strongly declining, + increasing trend, 0 absence of ecosystem services.

*The production of services from the forests is perceived to have remained same but the utilization of these resources has declined.

Creating awareness in communities on proper harvesting guidelines followed by further research on the conservation and propagation of these species were proposed during the FGDs. The groups, as well as the key informants, feel that the transfer of forest management ownership to local communities could help to sustain these resources in the long run.

3.1.4 Livestock-related forest services

On average, each household in the study area owned seven cattle. The majority of farmers owned a mixture of improved and local cattle breeds, which were stall fed at home and sent out for forest grazing, respectively. The grazing animals consisted of cows, yaks and horses. The preferred fodder from the forests was grasses, bamboo, and lopped tender branches and leaves of oak. The evergreen oak foliage is mostly fed during dry winter months due to the unavailability of other fodder options. Villagers reported that fodder collection from these forests has declined as farmers started growing feed and fodder varieties directly on their farm lands. Villagers report that this practice is in response to the Bhutan government's initiative of increasing livestock productivity through the introduction of improved dairy cattle breeds, which require stall feeding.

Table 6. High commercial NWFPs collected by the local communities, resource availability trend and proposed management options by the FGDs based on their local practices and knowledge.

High-value species	Parts used	Average income (USD/ HH/Yr)	Resource trend	Reasons	Recommended management options
Paris polyphylla	roots	295	--	low seed germination, increased collection trend (outsiders), unsustainable harvest practices,	Research on propagation techniques Community-based resource management Creation of awareness on the conservation and harvesting techniques among the collectors Domestication trials
Exidia sp.	mushroom	292	--	Competition from outside collectors, unsustainable harvest practices	Sustainable harvesting practices needs to be developed
Berberis	roots	250	=		Nursery techniques and plantation
Walnuts	fruits	250	-	Aging of mother trees and felling	Plantation programs
Tricholoma matsutake	mushroom	250	=	Fluctuates on yearly basis, competition from collectors	Community-based resource management
Bamboo	culms	175	-	Bamboo dieback	Research on propagation techniques
	Total	**1512**			

Note: = no change, - declining trend, -- strongly declining.

Box 1. Reasons cited for decline in resources and income

Kinley Dhendup, 57 years old, a farmer from Chimithankha village earned about Nu. 50,000 just from the sale of *Exdia* in 2015. However, in 2016, he could only earn about Nu. 25000, which is half of what he earned the previous year. He attributes the decline in his income to overexploitation of the resources and strong competition from outside collectors.

In some of the study villages, informants reported that limited grazing has led to a shift in the vegetation of previously open areas and meadows to bushes and colonization by blue pine. Almost 60% of the farmers in the survey perceived that forest coverage in their areas has increased. They suggested that the increase is a result of stringent forest rules and regulations on the harvesting of trees, ongoing plantation programs, drop in traditional subsistence agriculture and reduced grazing practices. The reduction in forest grazing is expected to help in reducing the grazing pressure on forests and improve regeneration (Bruggeman et al. 2016).

3.1.5 Leaf-litter collection

Leaf-litter collection for bedding for all breeds of cattle constitutes an important aspect of livestock farming. While it requires hard labor, it is regarded by local people as one of the most important services from the forests. Households in the study area collected on average 95 headloads (= 4750 kg) of leaf litter annually, varying from 30 (= 1500 kg) for small livestock farmers to 200 (= 10,000 kg) for larger livestock farmers. The leaf litter collected consists of pine needles mixed with oak leaves, which are collected from the forest floor in the winter months of December to March. The litter is used as cattle bedding, which after mixing with dung and subsequent decomposition forms an important manure addition to the soil of crop fields. The practice results in nutrient cycling and transfer from forests to agricultural fields, allowing the maintenance of soil fertility with minimum chemical fertilizer inputs (Roder et al. 2003).

Most farmers (86%) in our study preferred using blue pine needles for their cattle bedding, while 10% preferred a mixture of pine and oak leaves suggesting that the oak leaves result in nutrient-rich manure after decomposition. About 5% of the respondents collected only deciduous oak (*Q. griffithii*) leaves for their cattle bedding. Thirty percent of the respondents perceived that the trend in the availability of leaf litter from the forests has increased across the study sites, 62% said it has remained same, while a small fraction (8%) reported a decline. The amount of leaf litter collect from the forest floor by households was reported by all to have increased over the years, a trend attributed to the higher number of improved breeds, increased agricultural production and easy access to forests by new farm and forest roads.

3.2 Regulating ecosystem services

Regulating ecosystem services like fresh air regulation, groundwater recharge, carbon sequestration, soil protection and natural hazard control are intangible and difficult to observe or quantify in nature. Nevertheless, their importance to local wellbeing was recognized by the communities in the study area. Such regulating services are considered to be an important reward of a well-maintained forest ecosystem by the communities. Naudiyal et al. (2017) report similar positive perceptions of local communities on the regulating services from oak forests in Nepal. The most important reward being the conservation of soil and water, as also highlighted by many other studies (Sheikh et al. 2010; Singh et al. 1989).

In all of the FGDs, carbon sequestration by the forests was perceived to have increased over the years. The participants link this increase to an increase in forest coverage, mainly on barren lands and open meadows (77%, n = 9 groups). The open areas are believed to be succeeded by forest following the

gradual decline of shifting cultivation practices and grazing in this region. The remaining focus groups attributed the increase to huge conservation and mass plantation efforts.

These local perceptions about increasing forest cover in the region are consistent with studies that quantify forest cover change using remote sensing analysis. Bruggeman et al. (2016) reported an increase in forest cover in Bhutan after the 2000s and related it to land abandonment and gradual replacement by forests. Similar increases in forest cover were also reported by Gilani et al. (2015). All these studies indicate the increasing carbon stock in the forests. A study from Nepal Himalaya reported that these forests can store between 210 to 258.02 t ha^{-1} of carbon and can sequester between 3.7 to 4.8 t ha^{-1} yr^{-1}. Thus, high carbon stocks in the soil combined with above-ground biomass in this region serve as an important global carbon sink.

Another regulating service of the oak forests highlighted by the communities is ground water recharge. Shari villagers prioritized this as the second most important ecosystem service. The village currently faces water crisis, which they attribute mainly to disturbances of forest around their water source. Similarly, villagers in Nubri, which is located close to Shari village, also ranked this as one of the top five priority ecosystem services. These two villages attributed changes in water quality as well as quantity to logging activities in their forests.

A third regulating service of forests mentioned by the communities of Sheling is the reduction in the natural hazards, particularly wind damage. The village of Sheling is located in a valley and exposed to strong winds. The people believed that conserving trees near by their houses blocks the force of strong winds. The majority of participants perceived that the low incidence of natural hazards, such as landslides and strong winds, is due to the well-managed forest cover in their vicinity.

Finally, participants in the focus groups suggested that the conservation of forests as a home to bees and other pollinators, and birds, is important for agricultural crop productivity.

3.3 Supporting services

Habitat supporting services of the forests were perceived by respondents to have increased over time in the study areas. Residents report that the number of wild animals in the forests has increased as a result. The reasons for such an increase were perceived to be increased forest cover due to strong conservation policies and strict regulations.

Further, with socioeconomic development of local communities due to Bhutan government's market-oriented agriculture initiative, 77% of focus group participants felt that hunting for wild animals has dropped significantly in the past decade. The move is further driven by Buddhist religious sentiments of living in harmony with nature. However, 22% of the participants perceived that human–wildlife conflict has increased in the area, which leads to poisoning of wild animals by agitated farmers. As most of the animals damaging farmers' crops were deer, monkeys and wild boars, almost half of the participants viewed that this conflict is a result of the absence of top predators in the forest close to their home. A paper by Thinley et al. (2018) supports the view expressed by the farmers, as it was found that crop losses to wild herbivores were significantly reduced due to presence of tigers in the forests close to the villages.

> "From supporting our food production systems to purifying our air and water, to stabilizing our climate and providing us with spiritual sustenance and a host of other benefits, our natural ecosystems are ultimately the source of our health, happiness and material prosperity" - Dechen Dorji, Country Representative of WWF Bhutan.
>
> Source: wwfbhutan.org.bttp://www.wwfbhutan.org.bt/news_stories.cfm?uNewsID=300930

3.4 Cultural services

Participants in this study indicated that the high-altitude oak forests provide important cultural services that play an important part in the wellbeing of communities. The forests host religious sites, such as monasteries, meditation caves, pilgrimage sites and religious natural landscapes, that people visit frequently to offer prayers. Visits to these sites comprised an important practice in people's everyday life associated with beliefs, spiritual wellbeing and contentment. Certain areas in the forest were reported to be strongly protected as the home of local deities. An example is an individual tree of *Quercus semecarpifolia* known by the name "Gomju drake" (Figure 4, right). This mighty oak in the middle of Sheling village, Khotokha, has an approximate girth of 222 cm at breast height and is believed to be more than a thousand years old. Local people believe that a ferocious local deity dominates this tree, and that anyone who harms the tree purposely or even unknowingly experiences severe illness. This is an example of how local beliefs and mutual community respect help to conserve forests, and even individual trees. This individual serves as a mother seed tree for the area, and the tree hosts a great deal of biodiversity, with ferns, bryophytes and even other flowering plants growing on its trunk and branches. It also helps with water conservation and numerous other ecosystem services, such as carbon sequestration and storage.

People ensure that these places are not disturbed, as it is believed that disturbances may be bad omen for the community which will bring illness and low agricultural productivity. There are also important places in many of the study sites that have aesthetic and scenic beauty with high potential for ecotourism and recreation. Participants in the study reported that the number of tourists visiting such sites is increasing every year, which they attributed to easy road access. It was also believed that Bhutanese people now have more disposable income and leisure time allowing them to travel to visit these places. The communities proposed that such areas should be protected from development and expressed the need for more awareness and advertising to attract visitors.

Figure 4. Forests provide cultural support services which is an important ecosystem service. Left: A small stupa inside an old-growth oak forests used for worship by local communities in western Bhutan. Right: The tree known as "Gomju drake" is believed to be dominated by a ferocious local deity.

4 Conclusion

High-altitude old-growth oak forests along with adjoining ecosystems play a crucial role in sustaining agriculture and the livelihoods of people living in river valleys in Bhutan. These forests' critical importance to provide multiple ecosystem services is well recognized by local residents. The forests serve as a water store for villages, agricultural production and hydropower generation downstream; they are used for multiple purposes, such as grazing grounds, a source of food and fodder, medicines and income generation by local people. They also serve as an important habitat for large numbers of endemic plants and animals, and host numerous religious sites associated with the spiritual wellbeing, contentment and compassion attributes of Buddhist people. The conservation of these forests is therefore indispensable for continued supply of essential ecosystem services. The local people in the study area believe that community-based forest management through the transfer of forest management to local communities could be a way forward in ensuring local stewardship over their resources. This is also consistent with the existing plans and policies of the Royal Government of Bhutan to decentralize and empower local communities in natural resource management. The research also calls for concerted efforts by local communities, governmental bodies and global partnerships to restore and protect this important forest ecosystem.

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Many ecosystem valuation studies are conducted at regional and global scales without consideration of local values. Accordingly, the incorporation of research results into policy decisions faces implementation challenges at the local level. We examined communities' values and perceptions of ecosystem services provided by old-growth oak forests by using qualitative approaches, including focus group discussions, household questionnaires, participant observation and key informant interviews. Our survey consisted of people from 84 households in seven villages of Western Bhutan, who live next to the forests and utilize ecosystem services. Nine key informants, comprising local forest managers, NGO workers and researchers, were interviewed about the status of forest conservation and management in the study area. Our results revealed that these forests serve as a pool of essential resources and a natural incubator for spiritual wellbeing and cultural services. While forest grazing and livestock farming dominate these forests as important livelihood activities, fresh water and non-wood forest products of high commercial value were identified by all stakeholders as the most important ecosystem services for rural subsistence and income generation. Local communities believe that these forest resources and services will decline sharply in the future, becoming scarcer due to pressures from an increasing population and forest degradation caused by climate change. This is the first in-depth study on the ecosystem services from old-growth oak forests in Bhutan to document people's perceptions of ecosystem services, trends and management options that are imperative for developing management guidelines, strategies and policies. The study has wider implications for managing old-growth forests to maintain ecosystem services and the wellbeing of Bhutanese people and others in the Eastern Himalayas.

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