

## Assessment of forest ecosystem services in Khaling Gewog, Bhutan

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**Abstract:** Communities inhabiting fragile mountain ecosystems of high Himalayas are constantly exposed to threats of growing environmental change. The ecosystem services assessment can determine the locations of ecosystem production sites and also quantify the ecosystem services and goods. Such assessment can estimate changes in service provision over time and also understand the impact of patterns of land use, climate and environmental variation on the production of ecosystem. The main objective of the study was to determine the most frequently used ecosystem goods in Khaling *gewog*. Amount of ecosystem services accessed in the past one year prior to study period was also quantified. Ecosystem valuation was conducted using some of the quantified ecosystem goods using market based approach. Water and fuel wood was the most utilized ecosystem goods. The estimated annual economic value of some ecosystem goods produced by forest ecosystem in Khaling *gewog* was Nu. 21.6 million (1US\$ =54 Nu. Bhutanese currency).

**Keywords:** Ecosystem, goods, services, valuation, forest.

### Introduction

Forests ecosystem deliver various ecosystem goods and services beyond timber extraction, fuel wood and other non-wood forest products. Forests play key role in watershed management, carbon sequestration, regulate flood, filtering polluted air, and regulate micro-climatic conditions. For instance, Dudley and Stolton (2003) reported the importance of forest protected areas to drinking water. According to them, water quality was higher with less sediment and fewer pollutants in forested catchment, than in non-forested catchments. Decrease in forest cover and degradation of forest ecosystem might endanger the benefits that communities derive from such ecosystems.

Ecosystem functions refer to various processes occurring in different ecosystems which results in production of goods (such as food and water) and services (like pollination and waste assimilation) which directly or indirectly benefits the human population (Costanza *et al.* 1998). For instance wetland plants can utilize nutrients from wastewater released into the wetland system. Water purification and waste treatment can be regarded as services derived from the wetland ecosystem, while purified water as a result of nutrient absorption function of wetland is defined as ecosystem goods, utilized by human population.

Broadly ecosystem services can be categorized into supporting services like nutrient cycling, provisioning services like providing food, regulating services like flood regulation and cultural services (Alcamo and Bennett, 2003). *Daling Tsho*, an alpine lake to the north of Khaling *gewog* is regarded as residing place for their protective deity (known as *Meme Dangling*). The place is well known for camping and pilgrimage site for all the rural communities. People frequently visit the area and perform various cultural festivals to make offerings to their protective guardian. Such services could be regarded as cultural services which plays significant cultural role. Nevertheless, the current study was focused on provision services with special focus on forest ecosystem. So, in this study the term ecosystem goods and services refer to forest ecosystem goods and services.

Millennium Ecosystem Assessment (2003) highlights the importance of ecosystems' functions to the Earth's life-supporting systems by providing ecosystem goods and

services (Alcamo and Bennett, 2003). However the values of such natural capital are often not recognized by policy makers. Identifying ecosystem services and conducting valuation on ecosystem services and goods is becoming an effective tool to understand multiple benefits provided by the natural environment (Guo *et al.*, 2001). Failing to incorporate the values of biodiversity and natural capital in decision making has resulted in investments which have huge negative impacts, which in turn can affect the well-being of the human population (Hirsch *et al.*, 2011; Maes *et al.*, 2011). Thus, human system and ecosystem are intricately linked to each other.

Often economic valuation of any goods and services is based on the concept of total economic value which is based on use values and non-use values. Use values can be further divided into direct use values, indirect use values and option values. Direct use values can be derived from the actual price paid for an ecosystem goods or service, for instance paying for timber, firewood and others forest products (Hirsch *et al.*, 2011). Direct market valuation was done for the ecosystem goods extracted by communities of Khaling *gewog* in the past one year prior to study period (December 2011). According to Hirsch *et al.* (2011) market based approach can be applied for valuation of provisioning services such as timber or water.

The impacts of climate change are already visible in the Greater Himalayas. Rapid reduction of glaciers is the most widely reported impact of climate change in the region (Bajracharya *et al.*, 2007). Climate models predicts continuous warming and increased precipitation at higher elevations (Xu *et al.*, 2009), which can significantly alter Bhutan's biodiversity. The cascading effect of climate change can modify the ecosystem processes, thus resulting in reduction of ecosystem services often which are sources of the livelihood for majority of the local communities.

Communities inhabiting fragile mountain ecosystems of high Himalayas are constantly exposed to growing environmental change. The main drivers of change are extreme and unpredictable climatic conditions affecting ecosystem ability to functioning and deliver its services (Maes *et al.*, 2011; Xu *et al.*, 2009), which is further put under pressure from rising population. Identification and quantification of various ecosystem goods and services accessed by the general public, followed by their

economic valuation is very important to make vulnerability assessment of ecosystems.

Thus this study might provide more insight while developing the national adaptation and mitigation strategies against the climate change. Such assessment study can provide baseline information for estimating changes in service provision over time and also understand the impact of patterns of land use, climate and environmental variation on the production of ecosystem goods and services (Maes *et al.*, 2011). Change in ecosystem's ability to provide goods and services can directly impact the human well-being. Based on type of ecosystem products that the communities extract from their locality, the vulnerability of the community can also be understood.

Main objective of the study was to determine the most frequently used ecosystem goods in Khaling *gewog* (Sub-district) in eastern Bhutan. The spatial locations for harvesting ecosystem goods were also identified. Amount of ecosystem goods accessed in the past one year prior to study period was also quantified. Ecosystem valuation was conducted on some of the quantified ecosystem goods using market based approach. Based on literature review, vulnerability of the community to climate change was also discussed in brief. People's perception about change in quantity of natural resource base over the years was also enquired.

#### Materials and Methods

The study was conducted in Khaling *gewog* which has population of 3,046 (PHCB, 2005), located in the periphery of biological corridor connecting Sakteng Wildlife Sanctuary and Khaling Wildlife Sanctuary, Bhutan. The villages are surrounded by rich broadleaf forest with dense shrubs and undergrowth.

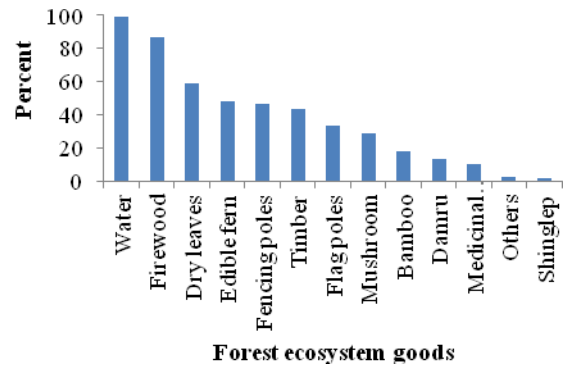
Data was collected using standard structured questionnaire. The data was collected by face to face interviews with the head of the households. It was collected from the sample of 210 households. Accesses to provisional forest ecosystem services like timber, firewood and other non-wood forest products namely edible ferns, mushrooms, medicinal plants, bamboo and *Elatostema* sp. (locally known as *damru*) were enquired for each household in relation to past 12 months prior to the study period (December 2011). Further information related to irrigation, water sources and respondents perception about any visible change in quantity of natural resources were collected.

Using SPSSv19 frequency distribution table was run to determine the most accessed ecosystem goods and also to determine the hotspots for deriving such resources. Amount of ecosystem goods accessed were quantified and their valuation was done according to standard methods using market based approach, which was determined the value based on their market price. The standard units and prices were used as per Royalty on Forest Produce (2006), provided by Ministry of Agriculture and Forests (MoAF), Bhutan.

#### Results and Discussion

**1. The most frequently used ecosystem goods:** Water has been found to be the most accessed among various ecosystem goods (Fig. 1). Extraction of water resources

for drinking purposes contributed the most, since almost 80% of the population do not irrigate their agricultural fields. Fuel wood was the second highest ecosystem goods utilized. Bhutan is one of the highest per capita consumers of fuel wood in the world. In 2005, Bhutan consumed almost 0.7 million tons of fuel wood which accounts to 57.7% of total primary energy supply (MoEA-Bhutan, 2009). Thus very high consumption of fuel wood is understandable in rural communities. However with the Royal Government of Bhutan aiming at 100% rural electrification the scenario might change in the coming years (MoEA-Bhutan, 2009).



**Fig. 1.** Different types of forest ecosystem services accessed by communities of Khaling in year 2011 (N=210) (*Shinglep* – Wooden shingles used as roofing material)

Collection of dry leaf litter was the third highest ecosystem goods extracted by the rural communities. Collecting dry leaf litter from the forest to produce farmyard manure is very popular in Bhutan. The farmyard manure directly affects the agricultural productivity especially staple food crops like maize and potato.

In the past majority of the rural households use wooden shingles and bamboo as roofing materials for their houses. However most of the households now use metal roofing which has drastically reduced the demand for wooden shingles. This was clearly depicted in the graph above, which shows shingles was the least utilized ecosystem goods. Nevertheless Bamboos are still used as fencing materials, building materials for animal sheds and for making temporary sheds.

Agriculture is the main source of livelihood for rural communities in Bhutan. Almost 64% of the respondents depend on their farm products as the main source of income in year 2011. Rice, maize and potatoes were the major crops cultivated.

**Table 1.** Irrigation of field crops

Crops	Frequency (HHs)	%
Paddy	38	18
Maize	2	1
Potato	2	1
No irrigation	168	80

There was a significant difference among crop types that the communities irrigate  $X^2(3) = 205, p < 0.05$ . As shown in

Table 1, maximum households irrigate their paddy fields. Rice is usually grown in wetlands, thus showing as the most irrigated crop, while 80% of the respondents do not irrigate their agricultural fields. Average total wetland holding was  $0.17 \pm 0.32$  acres per household while mean dry land owned by household was  $2.50 \pm 6.31$  acres.

The farm produce were the main source of income for all the respondents, which was further evident from the fact that ecosystem goods were only extracted for their personal consumption only. More than 95% of the respondents collected those ecosystem goods for personal consumption only. However in such farming community with 80% agricultural practices carried without irrigation facilities is very vulnerable to climate change impacts. Studies reported that in rain-fed agriculture cropping intensity was found very low and yield are on average less than half of irrigated yield especially for food grains (Kerr, 1996). This can pose serious threat to the food security of the community which completely depends on rain-fed agricultural system.

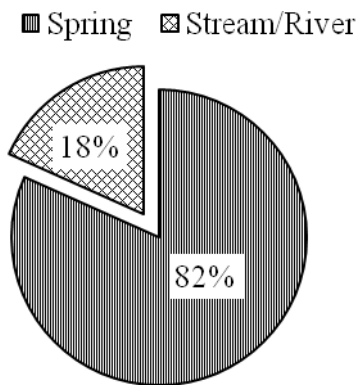


Fig. 2. Main sources of drinking water supply

Many small streams flowing next to the villages were observed; however spring water accounts to more than 80% of their drinking water supply followed by streams/river (18%) (Fig.2). No households have accessed drinking water from ponds and lakes. Majority of communities depending on spring water implies that people have access to safer drinking water supply since water resources extracted from river or streams might contain higher amount of sediments and other organic matter during rainy season.

**2. Location of harvesting sites:** It was very difficult to determine the hotspots for extraction of ecosystem goods and services under Khaling *gewog*. The main underlying reason could be due to proximity of rich forest diversity next to each and every village. All the respondents accessed those resources from nearby forested areas. Thus no common place for extraction of these resources was detected. Further variability on the place names among villages and lack of clear cut boundary has added more confusion. For further studies use of GPS is highly recommended solution of the issue.

**3. Valuation of forest ecosystem:** Simple environmental valuation of quantifiable ecosystem goods using market based approach revealed that the ecosystem in Khaling *gewog* is worth Nu. 21.6 million per year (Table 2). The valuation excludes ecosystem services which couldn't be

quantified and also those quantifiable services, whose rate were not reflected in royalty rate for rural timber and non-timber forest products for rural use maintained by MoAF Bhutan. Thus the actual economic value of the natural resource base will be much higher than what was reported here. Thus degradation of ecosystem services in a way represents loss of the capital assets.

Estimated value of contributions from harvesting timber for construction and other timber resources in Bumdeling wildlife Sanctuary (BWS), Bhutan was Nu. 14.02 million, while non-timber resources contributed 7.52 million. The total value of contributions at the local level from resource use, ecosystem services, conservation and tourism amounted to Nu. 33.92 million (Diaz et al., 2011). The value from timber products at Bumdeling Wildlife Sanctuary was less than what was found for Khaling *gewog*. This could be due to restriction of harvesting timber in the protective areas while in case of Khaling people have access to such resources with limited restrictions. The value of non-timber forest products accounted for Nu. 2.66 million that is almost half of what was being calculated for BWS. Such difference could be due to exclusion of the value of water resources in the current study, which was the most utilized ecosystem good.

Table 2. Valuation of ecosystem goods

Ecosystem goods	Average harvest per month	Unit	*Price per unit (Nu.)	Total economic Value (Nu.)
Fire wood	0.43	Truck load	180	0.19
Edible fern <sup>1</sup>	2.67	Bundle	10	0.07
Mushroom <sup>1</sup>	1.53	Kg	100	0.37
Bamboo <sup>2</sup>	1.26	Piece	1	0.003
Damru	1.16	Bundle	10	0.03
Timber <sup>3</sup>	3.66	Per tree	2200	18.94
Shinglep	17.54	Piece	0.90	0.04
Dry leaves <sup>4</sup>	20.22	Truck load	20	0.98
Flag poles <sup>5</sup>	11.25	Piece	4	0.12
Fencing poles <sup>6</sup>	30.26	Piece	12	0.89
Total value				21.6 M

\*Calculation based on royalty rate for rural timber and non-timber forest products for rural use (MoAF-Bhutan, 2006).

<sup>1</sup>Current costs in local market is used for edible fern and mushroom, <sup>2</sup>Cost for small bamboo *Fargesia* sp. was used, <sup>3</sup>Cost of timber class 'A' was used, <sup>4</sup>Cost for dry leaves of blue pine was used, <sup>5</sup>Cost for *Dangchung* (Girth below 1 inch) was used, <sup>6</sup>Cost of *Tsim* (Girth 1 to 2 inch) was used.

Such studies have been carried out worldwide and became very important tool for the decision makes to weigh pros and cons while planning for developmental activities. For instance Guo *et al.*, (2001) conducted county-level annual economic valuation of some ecosystem services by forest ecosystems in the Xingshan County of Hubei Province of China, using both simulation models and geographic information system. The study reported that direct economic value of timber and other forest products was 48.43 million RMB in 1997 (RMB: Chinese Currency, 8.3

RMB = US\$1). The value was much higher (528.73 million RMB) when other indirect benefits from services like water conservation, soil conservation and gas regulation were included.

**4. Change in natural resource base-respondent's perception:** Khaling communities believe that over the years, there has been change in quantity and quality of top three (water, firewood and leaf litter) ecosystem goods and services that they accessed (Table 3). There was significant reduction in quantity of available firewood stock  $X^2(56) = 168, p < 0.001$ . Local residents believe that there is reduction in available fuel wood nearby their villages. They could notice the reduction in quantity of natural resource base like fuel wood in the recent years. However there was no significant difference in change in quantity of water  $X^2(38) = 29.99, p > 0.05$  and dry leaves  $X^2(52) = 55.99, p > 0.05$ .

**Table 3.** Respondents perception about change in quantity of top three ecosystem services extracted by Khaling gewog

Response	Frequency (HHs)	%
Yes	169	81.6
No	16	7.7
Don't know	22	10.7

In order to understand people's willingness to conserve natural resource base the respondents were asked if they believe that the health of an ecosystem is related to human well-being or not. 96.7% of respondents agreed that health of an ecosystem is related to personal health, which was further evident from the fact that more than half respondents (56 %) were the member of community forest in their locality. Quite low percentage of respondents joining community forest could be because in some places such schemes are yet to be introduced as it requires undergoing tedious procedures before an area gets converted to community forest.

#### Conclusion

Besides water resources, firewood and collection of dry leaf litter was the most accessed forest ecosystem goods. Firewood is the main source of energy while leaf litter is very important for maintaining soil fertility. With simple valuation method of the forest ecosystem goods and services, the study area was worth more than Nu.22 million per year. However such results have to be cautiously interpreted. This kind of valuation studies are mainly done to create awareness among various stakeholders to show that ecosystem degradation is loss of the capital assets.

The local communities noticed that over the years there has been a change in their surrounding ecosystem. For instance they have noticed that, to collect firewood they have to travel longer distance than they did in the past. This shows that there was an impact on local ecosystem by the surrounding communities. Further the community's high dependence on rain-fed agriculture shows that they

can be very vulnerable to erratic rainfall and climate extremes.

**Acknowledgement:** we are grateful to joint research programme between Sherubtse College, Bhutan and CSEAS, Kyoto University, Japan for funding the study. We also owe our heartfelt gratitude to the gewog administration of Khaling, Dr. Kazuo Ando (CSEAS, Kyoto University) and the entire survey team for making necessary arrangements during the study period.

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