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Bhutan's Forests through the Framework of Ecosystem Services: Rapid Assessment in Three Forest Types

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Abstract: Forests in mountain ecosystems provide a diversity of services and goods in mountain landscapes, and the immediate utility of the forest to upstream residents must be balanced with the insurance forests provide for downstream residents in the form of, especially, the services of water regulation and soil stabilization. Little empirical data exist for Bhutan that confirm a causal link between upstream forest use and downstream security. To help to fill this gap, we summarize the results of two literature reviews related to forest ecosystem services and human well-being, using the framework of Bhutan's Gross National Happiness (GNH). We report preliminary findings of three field-based assessments of forest ecosystem services on hillsides. We conducted an assessment of the perceptions of local residents about the forest ecosystem services in three distinct forest areas of Bhutan. The studies were carried out in high-altitude oak forests, forest management units (FMUs) in government reserve forests, and community plantations. We engaged villagers in focus group discussions and conducted key informant interviews. The strongest evidence in the literature for linkages between forests and GNH was found for the role forests play in socio-economic development and good governance, particularly through the community forestry program. Regulating services of forests were cited as crucial to several aspects of human well-being, but little empirical evidence was provided. To local residents in the three study locations, the provisioning services of forests were highly ranked, as were water regulating services. At the plantation sites, residents felt that the new forests did improve soil stability and water provisioning services. Cultural services were identified but not highly prioritized. Awareness of forest ecosystem services was high among participants in the study, but understanding of the causal links between forest use and human well-being was mixed. Lack of direct evidence about causal pathways between upstream forest condition and downstream security leaves gaps in our knowledge and even perpetuates myths and misconceptions about the role that forests play. We encourage further research at multiple scales and using mixed methods to test hypotheses on the linkages between forests and human well-being in mountain landscapes.

Keywords: mountain ecosystem; forest ecosystem services; Himalaya; ecosystem service assessment; Gross National Happiness

1. Introduction

Forests and trees provide vital goods and services from the local to global scales, from medicine to water regulation to sacred spaces [1,2]. Forest management in sloping landscapes must take into consideration the immediate utility of the forests to upstream residents, such as fuelwood and timber, and the structural insurance they provide for downstream residents by increasing the soil infiltration capacity [3] and reducing soil erosion [4].

Modernization, population growth and new wealth increase demands on forest goods and services. At the same time, climate change in the Himalaya is creating a more uncertain context for the design of natural resource and environmental management systems for the provision of those goods and services [5]. Mountain nations with glacial cover and monsoon climate especially experience multiple environmental problems, including glacial lake outburst floods, river flooding, soil erosion and landslips, which are likely to be exacerbated by climate change [6]. These problems are of grave concern, threatening public safety, investments in development infrastructure, and livelihoods of forest-dependent people [7]. Governments and residents alike recognize the critical importance of protection and restoration of forests in sloping landscapes to mitigate these and other threats.

Mountain ecosystem management must take into account the role of multiple components of the landscape and land cover types while considering the needs and actions of stakeholders upstream and downstream. In recent decades, governments in mountain regions have been reorienting their forest policies from a singular focus on timber production toward an integrated strategy for forest conservation, restoration and production [8–10], including planning and carrying out integrated watershed management. The small land-locked Kingdom of Bhutan, situated in the eastern Himalaya, is one such country. Bhutan enjoys high forest cover—71 percent of the land area [11]—and the economy and culture are inextricably linked to natural ecosystems, and especially forests. The economy is largely driven by natural resources, including arable land, water, forest products, minerals, and biodiversity, with hydroelectric power accounting for the largest portion of the country's gross domestic product [12]. Intact natural ecosystems also provide the milieu for cultural practices and festivals, tourism and recreation [13]. As an example of the links between forests and economy, the productivity of a hydropower plant is affected by the sediment load of the river feeding it, and that sediment load depends on upstream land cover and land use systems to retain soil [14]. In many ways, thus, the natural forested ecosystems are at the center of Bhutan's well-being.

An ongoing concern for the government in Bhutan is to protect the fragile mountain ecosystem while providing a continuous supply of forest resources to residents and businesses [15]. The National Forest Policy and the National Environment Strategy prioritize an integrated landscape approach to forest management, balancing forest conservation with sustainable use of forest resources. They recognize that landscape stewardship by on-site land and natural resource users is critical to the well-being of off-site, downstream residents and water users. The government prioritizes restoration and the reclamation of degraded lands with reforestation and watershed development programs [16], including through the establishment of plantations (timber and tree crops), enrichment planting, and support for community and private forestry. These programs and approaches necessarily involve rural residents and farmers and have implications for their land-use practices.

While forest and land policy in Bhutan already reflect an integrated approach to watershed management, little is known about the actual impacts of upstream forest use on downstream ecosystems. To effectively implement these policies, it is critical to understand the dependencies people and society have on forests, the conditions of those forests, the plausible causal connections between the status of the forests and the livelihoods and security of people, and, finally, strategies and practices for the production and protection of forest ecosystem goods and services. To help fill this gap, in this paper we summarize the results of two literature reviews on linking forests to well-being and report preliminary findings of three qualitative field-based assessments of forest ecosystem services on hillsides.

2. Forest Ecosystem Services in Mountain Ecosystems

In a review of literature on forests and Bhutan, we explored the role that forests play in culture and society, economy, and conservation in Bhutan and specifically through the lens of the kingdom's development framework of Gross National Happiness (GNH) [17]. Current development priorities, which are linked to the GNH framework, were, in turn, examined through the lens of forest ecosystem services and human well-being. Because Bhutan is a mountainous country, it is of particular interest to understand the linkages between upstream forest status and forest-based activities and downstream stakeholders. For example, does selective harvest in the forest increase the sediment load in local streams; does reforestation reduce the quantity of water from nearby springs or improve local access to timber?

Prior to conducting the literature review, we posed a hypothetical framework for identifying specific causal pathways linking forests and GNH, broadly considering the four pillars of GNH: environmental conservation, cultural preservation, equitable socio-economic development, and good governance (Figure 1). Our framework suggested that environmental conservation results in the sustained provision of forest ecosystem services, which supports socio-economic development both directly through the provision of forest goods and river water (which drives the energy sector), and indirectly through providing regulating services for soil and slope stability, water regulation, and carbon sequestration. We suggest that cultural preservation underpins good governance, which in turn drives environmental conservation through well-informed and enforced policies and customary social norms.

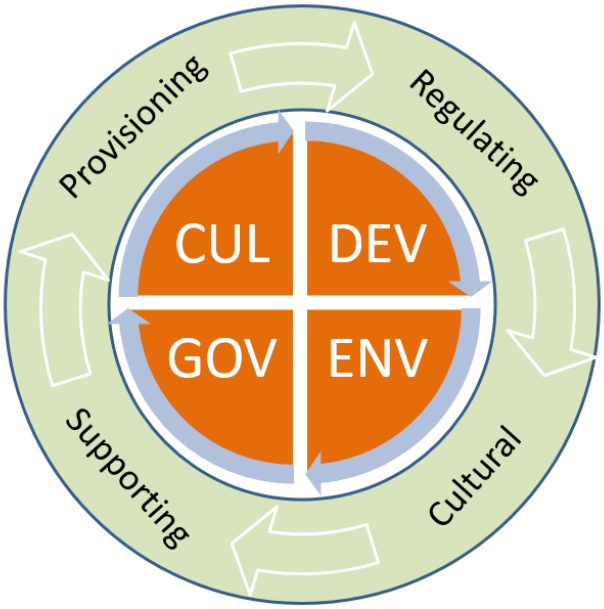

Figure 1. The relationships among the four pillars of Bhutan's development framework of Gross National Happiness and categories of ecosystem services. The four pillars are: equitable and sustainable socioeconomic development (DEV), cultural preservation and promotion (CUL), environmental conservation (ENV) and good governance (GOV). The four categories of forest ecosystem services are regulating, provisioning, cultural and supporting.

The review [17] revealed conceptual support for linkages between forests and each of the GNH pillars, but evidential support for cases in Bhutan was limited. No studies were found that specifically identified causal relationships between upstream forests and downstream human well-being. The strongest evidence for linkages between forests and GNH was found for the role of forests in socio-economic development and good governance, particularly through the community forestry program (for example [18,19]). Communities gain authority and responsibility over local

forests as well as directly benefit from forest resources. Improved access to forest resources contributes to food security and rural income. On the other hand, forests harbor wildlife that raid crops and kill livestock [20], thus threatening livelihood security.

Regulating services of forests are crucial to several aspects of human well-being, but, again, there was weak empirical evidence on the causal connections. The strongest evidence found in the literature on Bhutan is about the soil stabilizing property of forest above hydroelectric installations. A watershed-scale study on the sediment load to a proposed dam site in Bhutan [21] indicated that shrubland, grassland and, to a lesser degree, dryland agriculture together account for 90 percent of the total annual sediment export. The scenario model suggested that transitioning 10,886 ha of shrub and grassland to forest could reduce the sediment export in the river by 85 percent.

Cultural services of forests include recreation and maintenance of physical and mental health [11], aesthetic value for tourism and mental health [13], and spiritual value of sacred groves, trees and other sites [22]. Supporting services include the role of forests in the water cycle [23] and their provision of habitat for native fauna and flora.

A key approach to finding direct evidence for these linkages is through conducting an ecosystem services assessment. Drawing upon methodologies used elsewhere for assessing forest ecosystem services [24,25], and including three case studies from other mountain countries, Baral et al. [26] present guidelines to identify and assess the status and trends of forest ecosystem services specifically in mountain ecosystems. Their approaches integrate assessment tools for the biophysical and social components of the system and in a stepwise fashion [24]. In a first phase, researchers might strive to understand the social perception of forest ecosystem services among stakeholders and their dependencies on them. For the forest ecosystem assessment to be locally relevant, it is critical to define and classify ecosystem services according to local knowledge and needs, and this requires in-depth understanding of local livelihoods and people's perceptions of services. This information then can help to prioritize efforts to quantify certain services through direct measurement. The quantification of specific services can help help to establish causal pathways from ecosystem to people and society and can inform land use planning and guide resource managers. In a final phase of an ecosystem services assessment, valuation processes can further help to define priorities for management decisions and action.

The lack of empirical data on specific services, uncertainties associated with climate change, and complex relationships among ecosystem services hinders taking action to achieve discrete outcomes. Empirical data, coupled with ethnographic understanding, of the bio-physical and social dimensions of the forest ecosystem dynamics can help to raise awareness among policy makers, local communities and environmental groups about the importance of maintaining the delivery of those services. The assessment tool can also inform processes of building successful payments for ecosystem services and other incentives for ecosystem management.

The two literature reviews summarized above, one on approaches and tools for assessing mountain ecosystem services, the other on linkages between forests and measures of Gross National Happiness in Bhutan, provide direction for the design of field research to explore the causal links between the status and use of upstream forest ecosystems and the well-being of downstream ecosystems, people and built infrastructure.

The ultimate goal of this research on forest ecosystem services in sloping landscapes is to generate information and analysis for decision-makers and institutions involved in the management of these critical ecosystems to ensure the continuity in provision of key ecosystem services. In this first phase, our goal was to understand the importance of forests to local communities and identify their perceptions on the past and future trends in the ecosystem's delivery of services.

3. Perceptions of the Ecosystem Services of Three Forests

A series of social surveys conducted in 2017 with local residents on their perceptions of forest ecosystem services in three distinct forest areas of Bhutan comprises the first phase of this research.

The studies were carried out in relation to high-altitude oak forests, forest management units in government reserve forests, and community plantations (Figure 2). At each site, we emphasized a specific topic of interest that had been defined *a priori* through previous field work and discussion with forest users and authorities. We employed focus group discussions as a primary method, supplemented with key informant interviews. Research teams used a common bilingual guide in all villages for both the focus group discussions and interviews, with some modification appropriate to each site. In the three studies, all subjects gave their informed consent for inclusion before they participated in the study. The protocol presented minimal risk to participants. The results of each of these studies are summarized in the following sub-sections.

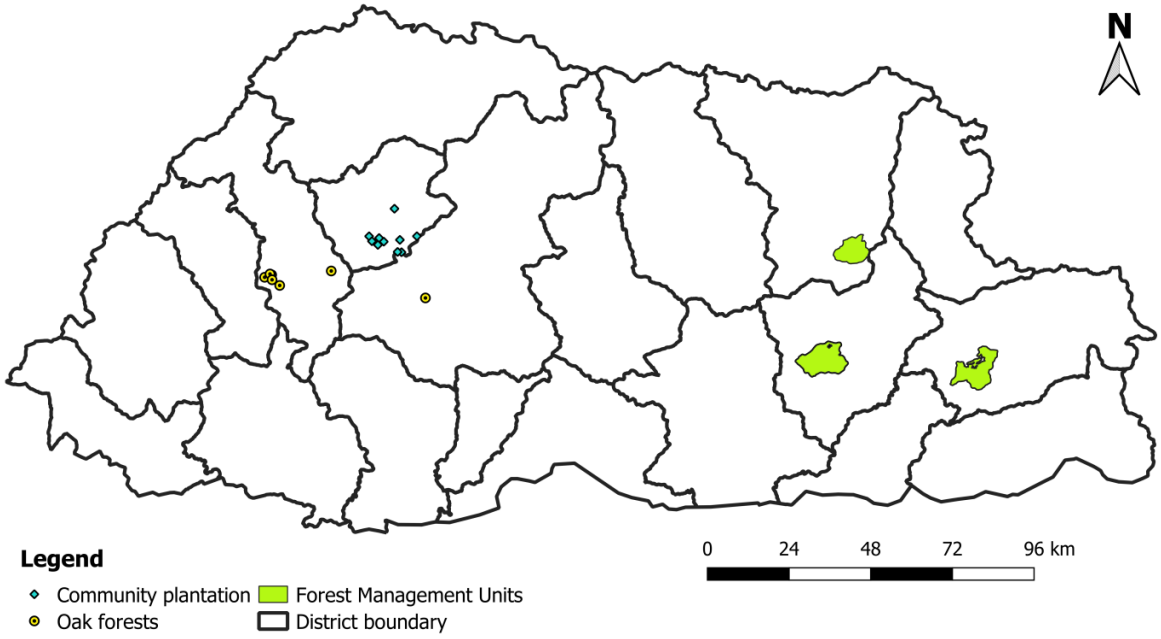

Figure 2. Map of Bhutan and district boundaries with the three study areas indicated.

3.1. High–Altitude Oak Forests

The high–altitude oak forests, dominated by *Quercus semecarpifolia* Sm. (Fagaceae), are distributed in the eastern Himalaya as a belt at 2400–3200 m.a.s.l. elevation. These forests are significant for their diverse ecosystem services and strong connection with the farming systems [27]. Oak forests on hillsides are indispensable for the protection of watersheds as these forests are correlated with the production of quantity and quality mountain springs [27–29]. Furthermore, they are situated close to the alpine meadows and, thus, act as water towers, storing snow and rain water and releasing it gradually and continuously in the lean season. Rapid population growth and economic development in Himalayan countries have put severe pressures on high-altitude forest ecosystems, particularly the oak forests [29].

The objective in this first phase of research was to understand local people's perceptions and values of ecosystem services provided by high-altitude oak forests and to identify trends in the provision of key services. We held focus group discussions with village residents (84; 61 percent female) and key informant interviews (9, all male) in seven villages located adjacent to oak forest in Western Bhutan. Village elevation ranged between 2400 and 3000 m.a.s.l.

Results revealed that the communities have high regard for their oak forests and pay special respect for the continued provision of forest ecosystem services. These forests are seen as a source of rural livelihood and support a rich biodiversity (Table 1). Provisioning services from these forests include fuel wood, timber, fodder, and non-wood forest products. They also serve as an important grazing ground for cattle and yak of local herders and farmers. All groups highlighted the provision

of fresh water as the most important service. Provisioning services were important, such as valuable non-wood forest products, fodder, and fuel wood.

Table 1. Priority ecosystem services derived from forests indicated by villagers in focus group discussions in the three study sites in Bhutan. Ranking is according to the prioritization within focus groups and the frequency of mention by focus groups (*high* indicates mention by all or a marjority of groups; *low* is one or two).

Service/Site	Oak Forest	FMU Forest	Plantation Forest
Provisioning	Fresh water (*Highest*) Timber (*High*) Fuel wood (*High*) NWFP (*Medium*) Fodder (*Low*) Leaf litter (*Low*)	Fresh water (*High*) Timber (*High*) Boulder (*Medium*)	Leaf litter (*High*) Fodder collection (*High*) Flag pole (*Low*)
Regulating	Soil erosion protection (*Low*) Fresh air (*Low*) Groundwater recharge (*Low*) Wind break (*Low*)	Land productivity (*Highest*) Fresh air (*Medium*) Carbon sequestration (*Low*) Local weather regulation (*Low*)	Soil erosion protection (*High*) Improved vegetation cover (*Low*) Reduced forest fire incidence (*Low*)
Supporting	Wildlife habitat (*Low*) Biodiversity (*Low*)	Pollination (*Low*)	Wildlife habitat (*Low*)
Cultural	Spiritual sites (*High*) Recreation (*Low*) Aesthetic (*Low*)	Spiritual sites (*Low*)	Aesthetic (*Low*)

Cultural services identified by participants varied across villages and included several religious sites, such as meditation caves, religious rocks and monasteries, where people go frequently to offer prayers. They also identified important places for aesthetic and scenic beauty that have high potential for ecotourism and recreation. Regulating services indicated by the participants included fresh air regulation, ground water recharge, soil protection, disease regulation, habitat for pollinators, and carbon sequestration.

How each village ranked services depended on their current livelihood challenges? For example, two villages that ranked ground water recharge highly have been recently suffering water shortage, which they attribute to forest disturbance (logging activities) upstream from their water sources. A causal connection between the logging and water provision has yet to be explored empirically, however.

Participants overall suggested that the provisioning services from their local forests are decreasing. Household dependence on the collection of wild food (fruits, vegetables and root tubers) has decreased recently with economic development and availability of other food options. This comment about fuelwood access from one participant summarizes the situation:

"In the past, when we were about 17 years old, we could fetch our timber requirement for house construction and renovation from the nearby forests about 10–15 min walking distance from the house. Now we have to travel more than 5–6 h by truck looking for firewood and timber."—Gyem Tshering, 62 years, Shari, Tsaluna.

High-altitude oak forests are vital for the well-being of communities living adjacent to and downstream from them. It is clear that the forests serve multiple purposes and should be managed as such. Concern was expressed by villagers about the levels of extraction of leaf litter and some non-wood forest products. Both villagers and scientists are concerned about the future of these forests, not so much from over-extraction of resources, but from the low rate of regeneration of the oak species [30,31]. Conservation of these forests is of paramount importance for the continuity of life of all beings.

3.2. Community Plantations

While there are conflicting notions of the value of planted forests according to conservation and production priorities [32,33], plantation forestry has become an important strategy in some countries to overcome the shortage of timber from natural forests [34]. Planting forests for the purposes of afforestation and reforestation of degraded lands is also a practice that has gained traction of late in the face of continual agricultural and pasture expansion [35]. It is further suggested that the success of reforestation initiatives depends largely on the involvement of local stakeholders [36].

The Bhutan government has long presented reforestation as an approach to maintain the integrity of mountain ecosystems. Plantation programs were initiated by civil authorities in the 1940s, even before the establishment of the Department of Forests in 1952 [37]. From 1947 to 2015, the Department established over 17,400 ha of plantations [38]. In the 1990s, responding to a general call for community-based forest management, the government shifted from project-based reforestation to community-based reforestation. In this way, authority and responsibility for forest management were shifted from central government to local populations.

During that shift, a government-driven initiative established forest plantations to restore degraded hillsides around the country as an approach to this community-based paradigm. The community plantation was initiated essentially to address forest degradation problems while also meeting the basic forest resource needs of communities such as fuelwood, timber, and fodder for livestock in the long run. Community members were enlisted to contribute labor to these activities. Some of the areas were eventually formally integrated as community forest after the legalization of community forestry in 1995.

We set out to assess the long-term benefits of the community plantation as a restoration effort, from biophysical and social standpoints, specifically looking to assess the status of these planted forests and their contributions to the livelihoods of community forest management group (CFMG) members. We approached with three main questions about the planted forest areas: What was the burden on CFMG members to plant and manage these forests, and what has been the payoff? What types of ecosystem services are being provided by them? How do CFMG members perceive the value of their planted forest area?

Five plantations that were regularized as community forest in the Punakha *Dzongkhag* (District) in western Bhutan were assessed. These areas were planted in the early to mid-1990s with *tsenden*, or the Bhutan cypress (*Cupressus tortulosa* Griffith, Cupressaceae). (There is some disagreement on the accepted name for the *tsenden* tree. Names vary among *Cupressus corneyana*, *C. torulosa*, and *C. tortulosa*. Maerki [39] accepts *C. tortulosa* Griffith as the proper Latin name for the national tree of Bhutan.) Later, some of these same stands were enriched with plantings of species in the genera *Quercus* and *Cryptomeria*. These planted forests in Punakha, which is in the temperate zone of Bhutan, are located at mid-elevation level, between 1100 and 2500 m.a.s.l. and range from 0.9 to 15 ha in size. We administered a questionnaire and conducted open-ended interviews with 94 CFMG members to analyze benefits and costs of planting and managing the stands. We also reviewed existing records of plantations maintained by management groups or relevant offices.

Interviews and document review revealed that the two main objectives for establishing all five plantation areas were to meet future demand of timber and fuel wood, followed by soil protection and halting further land degradation. The local people easily recognized the provisioning services of these young planted forests, including flagpoles, leaf litter, fodder, incense, and mushrooms (see Table 1). Only one community plantation had yielded any timber resources, which were used as flag poles. Improved vegetative cover and soil protection were two prominent regulating services identified by residents in all five communities. Three of the five groups identified improved habitat for wild animals as a regulating service, and two attributed no or reduced forest fire incidences to the presence of the planted stands. Three groups mentioned cultural services of these forests, among those the improved aesthetic value and picnic spots.

As these were young stands (25 years old), the CFMG members expected them to provide more services in the future, especially timber and fuelwood. Trees in one plantation were still small, and thus present potential for income generation, particularly the cypress. It was noted that the presence of oak, either planted or naturally occurring, will provide a supply of raw materials for furniture production and fuel wood in the future.

Various issues and constraints to effective management of plantations were mentioned by the CFMG members. These included labor shortage for managing the plantations, poor original soil condition in the plantation area resulting in poor survival of trees, and wild animals damaging trees by debarking and uprooting. Other lesser issues were forest fire, poor relationship among CFMG members, and grazing hampering the survival and growth of planted trees. Some of these issues and constraints could be resolved with interventions and improvements, including fencing, community social development, construction of fire lines, and financial support for management.

In general, the community plantations present important ecosystem services to the communities, though they are currently minimal. Success in the community plantation program will require attention to the social dynamics of forest management, financial support, and adequate planning.

3.3. Forest Management Units

The main source of commercial timber in Bhutan is the forest management unit (FMU), which is a component of the government reserve forest designated primarily for timber production. The FMU system is based on principles of sustained yield of timber but tempered with attention to multiple-use forestry objectives that best reflect the needs of Bhutanese society. Besides timber production and the harvest of non-wood forest products, forests in the FMUs are appreciated for their aesthetic, recreational and spiritual values [40].

Rural and sometimes urban communities had been long settled prior to the allocation of public forest to FMU. These communities historically obtained most of the forest resources from forests adjacent to their land, and they expected to continue to do so even with the change in management status to FMU. Local villagers recognize that the ecosystem services provided by these forests are vital for rural livelihood. However, it is thought that alterations to the forest ecosystem within the FMU through the operation of heavy machinery and extraction of timber might have consequences on the delivery of those critical ecosystem services (Figure 3).

In some villages, residents have voiced concern over perceived or potential downstream impacts of timber harvest and land cover change (forest to plantation) in the FMU, in one case attributing timber harvest events with changes in the water quality and quantity in their streams. Others worry that tree loss leads to reduction in the quantity of water delivered by springs below the forest.

Understanding the ecosystem services that communities obtain from the forests in FMU areas is critical to evaluate the sustainability of the silvicultural systems employed and logging operations carried out. We initiated a study to advance this question, targeting three villages situated inside or close to an FMU area. These were located in eastern Bhutan in the Trashigang, Lhuntse, and Mongar districts. Water scarcity has been identified by residents as a problem in these villages [41], and, thus, we chose these villages in part because they all obtain drinking water from the FMU area. We held focus group discussions with representatives in each of the three villages. To encourage women to speak freely in the group setting, the discussions were conducted separately with women and men.

Figure 3. Forest after the extraction of timber at Khaling-Kharungla Forest Management Unit, Trashigang Dzongkhag Bhutan. (Photo credit: Jigme Wangchuk).

Results revealed that the ecosystem services most highly ranked were provisioning services: timber production, freshwater, and stone production (see Table 1). Land productivity was emphasized and conceived by these villagers as underlying all other forest ecosystem services. Reasons given by villages for the high ranking of freshwater were that it is essential for all living beings for drinking, health and hygiene, and for the growth of forests, animals, and production of agricultural crops. They associated freshwater provision very closely with forest cover. Stone was cited by villagers to play an important role in the local livelihoods as it forms the basis for soil formation and soil management and is used for construction and fencing for crops. The provision of fresh air and the forests' role in carbon sequestration were cited as the two most important regulating services.

There was high congruency of importance ranking between female and male focus groups, with some swapping of services in the middle. For example, the female group in one village prioritized freshwater in second position and timber in the third place, while the male group prioritized the other way around.

The forest ecosystem services in the local FMUs were generally perceived to have decreased in the past decade (2006–2016). Exceptions were that land productivity and stone were viewed to remain the same by both the female and male groups of one village. The perceived causes of declining forest ecosystem services from the FMUs were increases in human population, pollution, road construction, demand for timber resources, waste disposal, activity by timber harvest and road operation machinery and vehicles, deforestation and climate change.

While villagers recognize the importance of the FMU for the production of timber at the national scale, they were concerned about how the rules for FMU access might hinder their use of those forest resources. They were also concerned about how harvesting activities in these forests might affect the regulating services of the forests, and especially the provision of fresh water. There is yet no empirical evidence for this, and research on this topic should be continued.

4. Discussion

Using focus group discussions and key informant interviews in three forest ecosystems across Bhutan to elicit perceptions about the local forest ecosystem services, we have identified some of the local dependencies on and concerns about forest ecosystems. We identified priority forest ecosystem services in each forest type that merit attention from forest users, researchers and policy implementers alike.

In the oak forests and the eastern FMU forests, for example, the provision of freshwater was ranked at or near the top of the list. With actual and expected changes in precipitation patterns in the eastern Himalaya [42], more attention should be paid to the linkages between forests and water provisioning services and to the conditions for forest growth [6]. Across the board, the collection of timber, fuel wood and non-wood forest products was cited to be highly important to local villagers.

Awareness of provisioning services of forests on these sloping landscapes was high among participants in the study. Cultural services were also readily identified, such as spiritual and aesthetic value of forests. Less clear to villagers were the concepts of regulating and supporting services, but they did mention several of these, such as "fresh air" and soil protection. This suggests a need to generate awareness among the public of the full range of ecosystem services in order for people to appreciate the full value of forests. As a first step, the government might do well to introduce the ecosystem service conceptual framework [43] in its grade-school curriculums.

5. Conclusions

Our broad hypothesis was that environmental conservation results in the sustained provision of forest ecosystem services, and that those services undergird the well-being of the people of Bhutan and the nation as a whole. We suggested that forests support socio-economic development both directly through the provision of forest goods and services, and indirectly through providing regulating services for soil and slope stability, water regulation and carbon sequestration. We further suggested that the preservation of the cultural attitudes and use of forests inspires good governance, which in turn drives environmental conservation through well-informed and enforced policies and customary social norms.

The literature review provided conceptual support for our hypothesis, and some empirical evidence, particularly for the links between the forests' provisional services and rural livelihoods. Our field work results also supported this link. The second part of the hypothesis, linking forests and cultural preservation to good governance, was only weakly supported by the literature. Our social survey was not designed specifically to explore these links, so field work provided little evidence in either direction. This could be explored in more targeted studies in the future.

Given the perceived importance at the local level of ecosystem services from forests in these mountain landscapes, a next step is to quantify the services and monitor and promote their continued delivery. Lack of direct evidence about causal pathways between upstream forest condition and downstream security leaves gaps in our knowledge and even perpetuates myths and misconceptions about the role that forests play in Bhutan [44]. We encourage further research by students, scholars and professionals at multiple scales and using mixed methods [24,26] to test hypotheses with detailed research on the linkages between forests and human well-being. The evidence should inform public policy and forest management strategies and practices, contributing to the development of incentive programs for forest conservation and restoration, such as payment for ecosystem services and pay-for-performance donor funding.

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