Climate change and its perceived impacts on the provisional ecosystem services vis-à-vis the community wellbeing of two highland communities of Merak and Sakteng in Bhutan

Kinley Dorji

Lecturer, School of Environment Management, Royal Thimphu College, Bhutan.

kdorji4499@gmail.com

Abstract

Biodiversity is increasingly affected by the global climate change, challenging ecosystems to perform its basic functions. The impacts of the climate changes on the mountain ecosystems are becoming visible at the rate faster than other ecosystems. The disruption in the functioning of mountain ecosystems, therefore, affects agro-ecosystem based livelihood of the highlanders. While the impacts are highly felt by the mountain communities, they have the least capacity to adapt and cope up with the changes.

This participatory research conducted using mixed methods i) identifies and priority-ranks the provisional ecosystem services, ii) estimates the economic value of these services, iii) assesses the agro-ecosystem based livelihood of the people, and (4) investigates people's perception towards climate change and it impacts.

The water has the highest utility with the average consolidated scoring for priority ranking of 10.77 in Merak and Sakteng. It has the total economic value (TEV) of US$22,201.4, which is 14% of overall TEV. Pasture, despite ranking second, with the average consolidated scoring for priority ranking of 9.23 is one of the most important resources, economically accounting for 30% of the total TEV; the importance directly transpiring these two communities' substantial/primary dependence on the pasture for fodder for their livestock. Nearly 90% of the community people depends on the livestock for their primary income. The average annual income of these two communities have increased over last few decades attributed to the availability of improved facilities/infrastructures and diversification of vocation.

The impacts of climate change were visibly felt in Merak and Sakteng. Despite nonexistent empirical records to indicate change, people's memory and experience postulated the changes were vivid, rapidly, and the impacts becoming visibly prominent. It increasingly exposed them to uncertainties and stresses beyond their adaptive capacity. However, surprisingly, 91% of the total interviewed people had a positive outlook towards climate change.

Keywords: *Provisioning ecosystem services, economic value, climate change, livelihood, climate change impact, vulnerability, adaptive capacity.*

1. Introduction

The Himalayan region, otherwise called the 'third pole' (Schild, 2008) and the 'water tower of Asia' (Xu et al., 2009) has the largest ice cover outside the Polar Regions. The ecosystem services of the Himalayan Region, a direct as well as indirect contribution of ecosystems to human well-being, are vital for rural livelihoods of over 300 million people (Schild, 2008). These mountain ecosystems host many communities in it providing various services including, inter alia, agricultural commodities, resources for income generation and other provisional and regulatory services. It also harbors and protects biodiversity, water and landscape amenities. However, the environmental changes coupled with concomitant stresses are affecting the ability of mountain ecosystems to continue to provide the ecosystem services required for sustainable rural livelihood. Rapid population growth characterized by unsustainable use of resources is compromising the regenerative bio-capacity of various ecosystems. It is exacerbated by the global climate change. The climate change scenarios suggest that there will be considerable impacts on ecosystems and their associated ecosystem services with serious consequences for the livelihood of communities, particularly in the most economically challenged parts of the world (IPCC, 2001).

Economic development is a key issue in the Himalayan Region and the impacts of climate change on the regional economy remains highly uncertain given the heavy dependence on the provisioning services (Gautam, Timilsina, & Acharya, 2013). The economically disadvantaged communities in the Himalayas heavily rely on the ecosystem services for their subsistence livelihood and often have limited capacity to adapt to change, which makes them more vulnerable to climate change and other forms of changes (ICIMOD, 2010). As the Millennium Ecosystem Assessment (2005) recognized climate change as one of the major drivers of ecosystem change, in these fragile landscapes, highly susceptible to natural hazards (Cruz et al., 2007), the impact on the rural population is inevitable. The surface temperature of our planet has increased by more than 0.8°C over the past 100 years with much rise taking place over last 35 years (National Research Council, 2012). The projected increase in the mean global temperature of 2°C (Solomon et al., 2007) by the end of this century and its impacts will be highly felt by Bhutan. Bhutan's vulnerability to the climate change and its impacts, determined by its resilience and adaptability to change, is aggravated by very volatile, agriculture and natural resource-based, economy.

The highland communities of Bhutan, ordinarily referred as the communities of 'Bjobs' and '*Brokpas*' ("men of pastures"), are predominately nomadic depending on the livestock – like yak, cattle and sheep – and other natural resources. However, the livelihood of these highlanders have been scarcely studied and their dependence on the natural resources, which is changing rapidly in response to many environmental issues, hardly documented, let alone the impacts of the climate change on their livelihood. Given the importance of understanding, scientifically, the impacts of climate change on the livelihood to appraise the social vulnerabilities to prescribe correct and timely adaptation measures, this research conducted in Merak and Sakteng, two of the remotest highland communities in the eastern Bhutan, 1) identifies provisional ecosystem services and priority-ranks the services based on its utility for the local community, 2) estimates economic value of these provisional ecosystem services, (3) assesses the agro-ecosystem based livelihood of the people, and (4) investigates people's perception towards climate change and it perceived impacts on their livelihood.

2. Review of the literatures

2.1. Ecosystem services

Ecosystem is a dynamic complex made up of various components, both living and non-living, working together as a functional unit. It ranges from natural forests landscapes with mixed patterns of human use to the ecosystems intensively managed and modified like agriculture and urban areas. The benefits humans derive from these ecosystems are termed ecosystem services (MA, 2005). Although vast array of services are derived from time immemorial, the concept of ecosystem services is relatively recent, proposed to appraise the utilitarian framing of beneficial ecosystem functions in order to increase public interest in biodiversity conservation (Baggethun et al., 2010). Since the global initiative was set up in 1999 by Millennium Ecosystem Assessment (MA) to assess how ecosystem change would affect human

well-being (MA, 2005), ecosystem services as a field of environmental and economic studies as well political pursuance has rapidly grown; to help decision-makers recognize the economic benefits and the growing cost of ecosystem degradation (TEEB, 2010; Maes et al., 2014). Despite conceptual and technical contentions over classification and evaluation of ecosystem services, Millennium Ecosystem Assessment's four categories of services – functional lines, of provisioning, regulating, supporting services, and cultural services – is well recognized and accepted (Young and Potschin, 2014; Mc Michael et al., 2005).

2.2. Himalayan Mountain Ecosystem

Himalayan Region has been a sanctuary to a vast collection of fauna and flora. It is also a paradise of traditional ecological knowledge as well as the centers of cultural diversity (IUCN, 2017). Among the global mountain systems, the Himalaya is the most complex and diversified. The region is the source of 10 major rivers and forms a formidable global ecological buffer and is endowed with rich natural resources (Singh, 2006). The mountain resources are the basis for livelihoods to 210 million people living in the region and indirectly benefits 1.3 billion people, one-fifth of the worlds' population, living downstream. More than 3 billion people benefit from the food and energy produced in these river basins that have their origin in the mountains (ICIMOD, 2009; ICIMOD, 2017). Although mountain ecosystem provides immense value, the communities in mountain regions face unique sustainable development challenges (IUCN, 2017). A large number of the people in these areas live in poverty and solely depends on the biological resources for their subsistence (ICIMOD, 2009). Production agriculture and extractive forestry are the mainstays of food security and subsistence livelihoods in mountain regions, which is built around indigenous knowledge and traditional practices of ecological sustainability in natural resources management. However, recent environmental changes coupled with other stressors are affecting the mountain agroecosystems' ability to sustainably provide the ecosystem services required for rural livelihood (Gentle and Maraseni, 2012).

2.3. Bhutan and ecosystem services

Forests constitute the dominant ecosystem in Bhutan, with total coverage of 71 percent of the country under forest cover (DoFPS, 2017). Half of the country's total land mass is under protected areas; National Parks, Sanctuaries, Strict Nature Reserve, and Biological Corridors. The Protection Area System of Bhutan is regarded as one of the most comprehensive in the world (Gurung et al., 2013; National Biodiversity Centre, 2014). It encapsulates wide range of forest types and vegetation zones corresponding to the variance in the altitudinal range and concomitant variation in climatic conditions. It also safeguards large areas of glaciers (677 glaciers), glacial lakes (app. 2,674 glacial-fed lakes), and naturally endowed inland renewable surface water resources (Dorji, 2013), which with the high level of precipitation Bhutan receives, makes it an excellent watershed (WWF and UWICE, 2011; FAO, 2012). The six major agro-ecological zones, defined by characteristic features of growing season, lodge more than 80 species of agricultural crops with more than 451 varieties (Bhutan Biodiversity Portal, 2017).

The value of ecosystem services has always been recognized, appreciated and reverently used in Bhutan. In this very vein, the Royal Government of Bhutan developed, and maintains, Gross National Happiness Accounts, encompassing proponents of ecological capital, cultural capital, human capital, social capital, and economic capital (GNHC, 2013). The preliminary study to determine the overall value of ecosystem services and its provision to the human well-being estimated USD 15.5 billion worth of services per year (Kubiszewski et al., 2013). The study also estimates 53% of the total benefits accrue to people outside Bhutan and only 47% of the benefits accrue to people inside the country: 15% at the national level and 32% at the local level. A per capita annual benefit at $15,400/capita/year was also calculated for both GDP and intangible ecosystem services (Kubiszewski et al., 2013).

2.4. Human wellbeing and provisioning ecosystem services

Human well-being is a broad concept (Alkire, 2002) but it boils down to reflect the basic material needs for a good life, the experience of freedom, health, personal security, and good social relations (MA, 2003) encompassing economic, social, cultural, and ecological aspects of our lives (McGillivray and

Clarke, 2006). Well-being and the poverty, the pronounced deprivation of well-being (World Bank, 2001), are the two extremes of a multidimensional continuum. Although it cannot be directly observed or accurately measured (Hagerty et al., 2001), human well-being is frequently considered analogous to income and as a direct function of consumption (McKenzie, 1983; Stiglitz et al., 2009), and using it as quintessential well-being indicator (Dasgupta, 2001; McGillivray and Clarke, 2006). Rojas (2006) argued that the very weak correlation existed between the subjective well-being and socio-economic well-being and indicated the involvement of a multidimensional evaluation of life (Diener and Larsen, 1993; Eid and Diener, 2003). To comprehensively assess the livelihood, composite indicators, such as the physical quality of life index (Morris, 1979) and the human development index (HDI) (UNDP, 1990) are used to challenge the hegemony of income indicating the level of wellbeing.

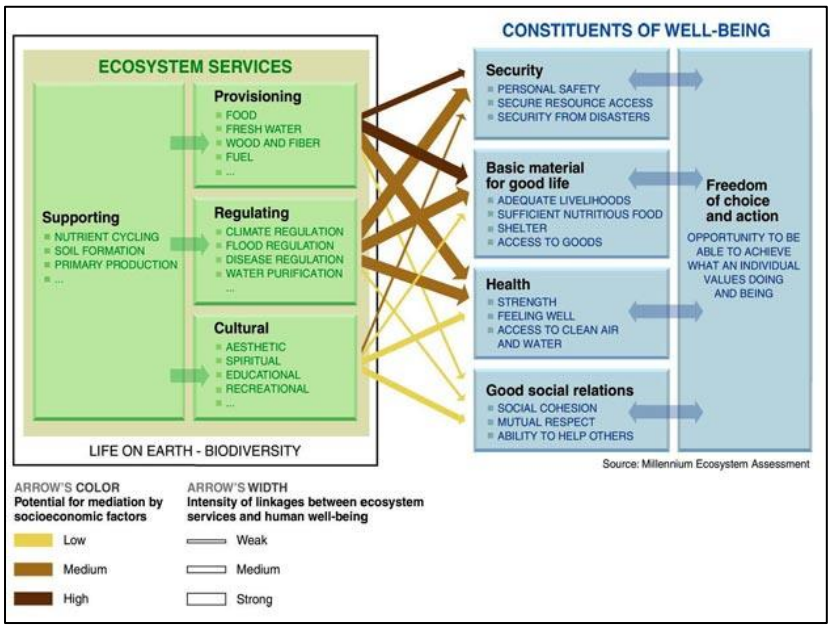

Figure 1: Relationship between ecosystem services and wellbeing (Source: MA, 2005)

Biodiversity underpins ecosystem functioning (Elmqvist and Maltby, 2016) and healthy ecosystem provides services for human well-being (SCBD, 2008). Its potential influence on well-being is overlooked (Sangha et al., 2011). Figure 1 outlines the benefits people derive from ecosystem for their wellbeing.

The Millennium Ecosystem Assessment (2005) highlights that the changes in ecosystem services influence well-being. Although the relationship is between ecosystem services and human well-being is mediated by access to manufactured, human, and social capital making it non-linear (MA, 2005) and often ambiguous (Sangha et al., 2011), Freitas et al. (2007) found that 41% of all Brazilian municipalities reported environmental changes, which was noted harmful to the landscape, the most damaging environmental problems in the degradation of the region's living conditions. Similarly, Costanza et al. (2014) estimates that the global land-use changes between 1997 and 2011 have resulted in a loss of ecosystem services of between $4.3 and $20.2 trillion/year.

The degradation of the ecosystem tends to harm rural populations more directly and has a more direct and severe impact on poor people as the degradation of ecosystem services represents a loss of a capital asset (Bhatta et al., 2015). Their limited capacity to adapt to change makes them more vulnerable to associated repercussions. Climate change is one of the most pressing drivers of environmental changes MA has outlined (Nelson et al., 2005).

2.5. Climate change and provisioning ecosystem services

Climate change has become one of the most pressing environmental issues. The earth's climate system has demonstrably changed on both global and regional scales since the preindustrial era (Sathaye et al., 2006). Intergovernmental Panel on Climate Change (IPCC) (2007) pronounced impacts of climate

change unequivocal. In 2017, the human-induced warming, the rise in the surface temperature, reached approximately 1°C above pre-industrial levels, in average increasing 0.2°C per decade, with much rise taking place over the last 35 years (National Research Council, 2012; IPCC, 2021) as shown in figure 2. Climate and natural ecosystems are tightly coupled, and the stability of this relationship underpins the provision of sustainable ecosystem services. Both by qualitative (interpretation of the storylines) and quantitative (modeling analysis) estimates of the change in ecosystem services shows the land use change as, and will be, the major driver of changes up to 2050 (Alcamo et al., 2005). In 2012, with the 29 billion acres of bio-productive and 97 billion acres of low-productive land and sea and an estimated population of 6.4 billion, the total bio-productive area available per person was 4.5 acres. An average bio-productive area needed to support a person was about 5.8 acres, with the overshoot earth's bio-capacity by 20% (Global Living Project, 2012). With increasing population, the degradation of natural resources, and human interference with the climate system, improving human well-being becomes increasingly imperative (IPCC, 2014).

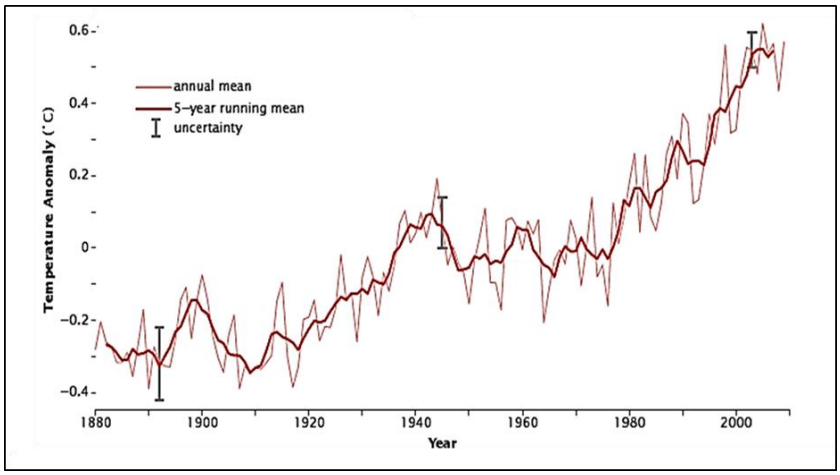

Figure 2: Earth's global surface temperature rise relative to average surface temperature of 1951–1980 over the past one and half century (Source: NASA's Goddard Institute for Space Studies, 2020)

Evidence of climate-change impacts is strongest and most comprehensive for natural systems. The loss of biodiversity, by species, today is estimated to be between 1,000 and 10,000 time higher than the natural extinction rate (WWF, 2017), which will be exacerbated by the changing climate. Martens and Rotmans (2005) have noted that the loss of biodiversity is one of the most significant aspects of global environmental change, given the extent to which it underpins the global economy and human welfare.

Agricultural production as a provisioning ecosystem service has grown overtime (FAO, 2008). Despite the agriculture representing humankind's largest engineered ecosystem, it also provides services like regulation of soil structure and fertility, natural control of plant pests, crop pollination, water provision and purification, genetic diversity, and climate regulation (Zhang et al., 2007). The growth in agriculture production is also on average at least twice as effective in reducing poverty as growth outside agriculture (The World Bank, 2008). On the contrary the increase in production have often been achieved at the cost of other critical services. (Garbach et al., 2014; Power, 2010).

IPCC (2007) reported that the global warming is expected to continue with an increase of 5.8°C by 2100. This is expected to increase the sea level, make the fresh water resources acutely scarce, cause erratic weather pattern, acidify the ocean, and affect the ecosystems – terrestrial and marine – indiscriminately. (Doney, 2007). This will completely change the rates and patterns of ecosystem productivity. The urgency for adaptation is highlighted by projections from the three reports produced by the IPCC in 2007. Over the course of this century, millions of people living in the catchment areas of the Himalayas will face an increased risk of floods as glaciers retreat followed by drought and water scarcity with increasing severity and possibly increasing frequency with all associated risks to life and livelihoods. So developing countries are the most vulnerable to these impacts because they have fewer resources to adapt: socially, technologically, and financially (IPCC, 2007).

3. Material and Methods

3.1. Study area

Merak and Sakteng are two remotest Gewogs (blocks) in Trashigang District. Merak is located at longitude 91°55'28" East and latitude 27°24'13" North, and Sakteng at longitude 91°51'28" East and latitude 27°18'06" North, both in eastern Bhutan. These two villages lying at an altitude above 3000 meters from sea level, are the most prominent semi-nomadic, *Brokpas* in the local dialect otherwise called the "men of pastures", highland communities. *Brokpas* have a unique lifestyle and culture. Merak Gewog (administrative block) has a total area of 867.7 km^2. There are four villages with a total number of households of 231 with the total population of 1957. Sakteng gewog stretches over the area of 910.0 km^2 with eight villages, 336 households, and 2251 people. Figure 3A and 3B depict the location of Sakteng and Merak on the map of Bhutan, respectively.

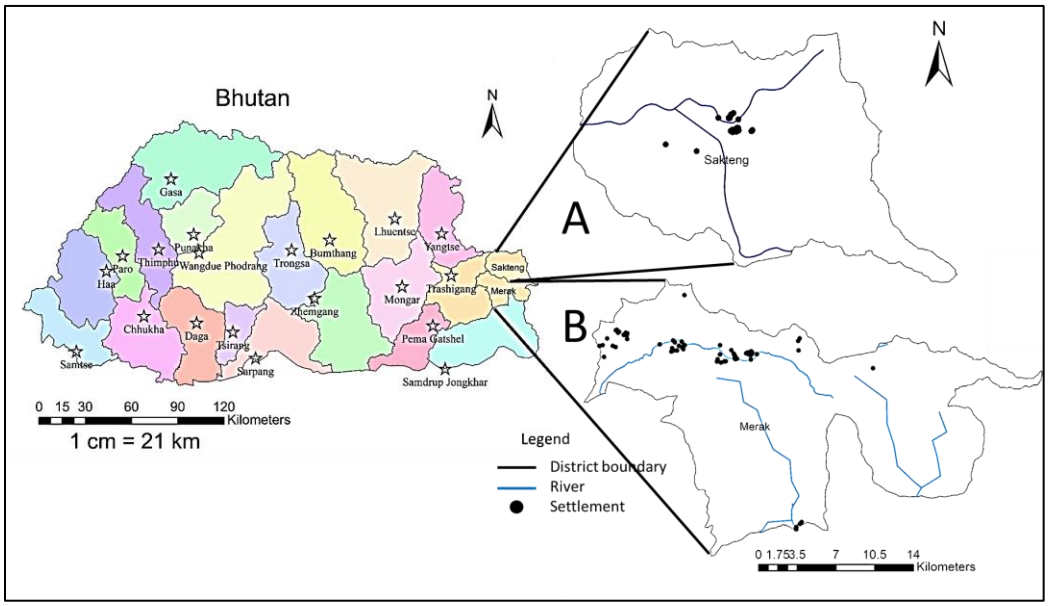

Figure 3: A – Sakteng District, and B – Merak District

These two gewogs fall under the Sakteng Wildlife Sanctuary, which was established in 2003. It has an area of 937.62 km^2 area sharing a border with the Indian State of Arunachal Pradesh in the East and North (DoFPS, 2017). The sanctuary harbors eight different forest types ascending from warm broadleaved to temperate zone to alpine meadow. Sanctuary outlets three major rivers of Gamri chuu, Nyera ama chuu and Jomo chuu. With the rich biodiversity of 857 plants (including 130 orchids and 41 Rhododendrons), 280 birds, 37 mammals, 63 butterflies, 5 reptiles, 3 amphibians, and 2 fishes species (BS 2015), the sanctuary is propounded as the "Paradise of Rhododendrons" (DoFPS, 2017). Besides, the legend has it that the *Yeti* otherwise known as *Abominable Snowman* roams free at pristine mountains of Sakteng Wildlife Sanctuary (SWS). With an assemblage of rich ecosystem diversity and spectacular landscape engraved with a rich, unique culture and tradition of *Brokpas* (Wangchuk, 2008), the climate change will not only impact the livelihood because of the change in ecosystem but also transcended bearings on the very living culture,

3.2. Socio-economic profile

The initial socio-economic survey carried out in 2004 and the subsequent surveys carried by different sectors concluded that Merak and Sakteng are two of the poorest gewogs (blocks) in Trashigang district, with the poverty rate as low as 57.86% and 40.33%, respectively, compared to the Dzongkhag's average of 29.3% (Tashigang Dzongkhag, 2011). Wangchuk (2008) reported that about 90% of the residents of Merak and Sakteng are pastoralists. Livestock is the main source of livelihood, contributing to about 85% of total household income (Bhutan Foundation, 2017).

These approximately 5000 semi-nomad inhabitants *Brokpa* with their livestock spread across the mountain pastures at altitudes over 3000 meters remain year-round with their livestock shifting according to season and availability of the fodder grasses. This group of people migrates twice annually from mountains to lower areas in winter and vice versa in summer with their livestock.

3.3. Methods

3.3.1. Sample size and sampling

Two villages have a total number of 567 households with a total population of 4208. The sample size, which is approximately 23%, was determined by using Cochran's (1977) formula to calculated sample size for infinite population (i) and adjusted sample size (ii) as shown below in table 1.

Table 1: Cochran's formula to calculate sample size for infinite population and adjusted sample size

$$(S_\propto) = \frac{z^2 \hat{p}(1-\hat{p})}{m^2} \quad \text{----------} \quad \textbf{(i)}$$

$S_\propto$ - *Sample size for infinity population*
z – *z score*
$\hat{p}$ – *Sample proportion*

$$(S) = \frac{S_\propto}{1+(\frac{S_\propto - 1}{P})} \quad \text{----------} \quad \textbf{(ii)}$$

S - *Adjusted sample size*
P – *Total population*
m – *Margin of error*

The total of 567 households were taken to calculate the sample size with the sample proportion of 50%. Owing to 95% Confidence Interval (CI), z score of 1.96 was taken with the margin of error 7.5%, which gave the sample size of 131. Since Merak has 231 households, which is 40% of the total household, and Sakteng has 336 households, which is 60% of the total household, the sample of 52 and 79 households were selected from Merak and Sakteng for the study, respectively.

After determining the sample size, count of total households in each village, in both the study areas, was done to allocate the samples equally for survey, in terms of percentage proportion, based on the total number of household in each village. Determining the total samples to be taken from each village, a random selection of household was done, on the map containing numbered houses obtained from the Google Earth, using random numbers generated from Microsoft Excel. The head of the house (or if in case he/she was absent, the next person in charge) was called upon for the survey. When the house selected for survey was empty or dwellers weren't available, next household was taken.

3.3.2. Data collection

This research used both primary and secondary data. The primary data was collected from the field using questionnaire survey, focus group discussion, and participatory discussion (participatory rural appraisal) conducted for three months in the fall of 2019. The secondary data was mainly collected from reports published by different government institutes and from peer reviewed academic papers.

a. Questionnaire survey

A comprehensive questionnaire survey framework containing both the structured and non-structured questions was designed to collect the qualitative and quantitative data. The questions were grouped into four categories to collect the data 1) to assess the economic wellbeing, 2) to assess the use of provisioning ecosystem services, 3) to appraise the economic value the provisioning ecosystem services, and 4) study the people's perception of climate change and its perceived impacts to the provisioning ecosystem services and wellbeing.

b. Participatory discussion (participatory rural appraisal)

To directly study the lived environment of the rural people by making them participate in analyzing the management of the resources (Chambers and Conway, 1992), participatory discussion (participatory rural appraisal), which limns their creative capability to investigate, analyze, and plan towards improving their own situation (Cavestro, 2003), was conducted. Four groups, consisting of 10 people each, from Merak and Sakteng, were engaged for a participatory discussion to extract data, structurally, for resource mapping, to develop seasonal calendar, and assess stresses and shocks (Conway, 1987) (Conway & Barbier, 1990). The discussion also focused on practical adaptation measures to cope with these stresses, shocks, and other vulnerabilities.

c. Focus Group Discussion (FGD)

FGD permits richness and flexibility in the collection of data that are not usually achieved when applying an instrument individually; at the same time permitting spontaneity of interaction among the participants (Freitas, et al., 1998). For this research five focus groups 1) timber user group, 2) non-timber forest product (NTFP) user group, 3) pasture land user group, 4) water user group, and 5) women's group, were identified and a series of meetings were conducted to generate qualitative data with respect to rapid assessment of forest ecosystems, to document the provisional ecosystem services, and assess its use to enhance the livelihood.

3.4. Valuation of provisioning ecosystem services

3.4.1. Ecosystem services

The inventory was conducted to note all the provisioning ecosystem services derived from the natural environment through survey, participatory discussion and FGD. Individual household was asked if they obtained the services, and were asked to priority rank the services based on factors such as i) degree of importance for their livelihood, ii) household benefit, iii) availability, iv) regenerative potential, v) time consumed to harvest, and vi) market demand (DoFPS, 2013).

3.4.2. Economic valuation

The Total Economic Value (TEV), instrumental or use-values and intrinsic or non-use value (Adjaye, 2000), of the provisional ecosystem services obtained by the household from the natural environment was calculated by i) accounting the current or most recently-quoted price (market value) for market-traded security, and ii) using the contingent valuation method (CVM), where individuals were asked to place value on environmental goods or services based on their willingness to pay (WTP) for the use of ecosystem services, willingness to pay for conservation, willingness to accept (WTA) in compensation to forgo the environmental goods and services. The values of NTFPs were directly equated to the market prices it fetched in their last trade, and the resources like pastureland, water resources, and other non-marketed services were evaluated using CVM.

3.5. Wellbeing assessment

Sustainable livelihood framework (SLF), a tool to improve our understanding of livelihood, particularly the livelihood of the people living in rural areas (Scoones, 1998), was used to prepare a checklist of facilities, and important issues to sketches out the link, draws attention to core influences and processes, and emphasizes the multiple interactions which affect livelihoods. Firstly the inventory of community facilities was conducted to understand community welfare within which people's wellbeing can be groomed. Secondly, the selected household's family profile like total family members, gender, their availability and capability for economic contribution, and their literacy status was sketched. Thirdly, the documentation of the economic profile of the selected households, their assets, liabilities, total income per annum, and the sources of income was done. Fourthly, a simple economic welfare analysis was done based on household consumption expenditure or household income with further analysis to study household vulnerability to poverty. And finally an assessment of the food security of the household based on availability, access, utilization, and stability of food to understand how sufficiently, safely and nutritiously they eat to lead an active and healthy life was conducted.

4. Result

4.1. Infrastructure and facilities

Merak and Sakteng are two of the remotest villages under Tashigang District. Although it was two walking days away from the road point, Merak and Sakteng recently got its feeder road connection. However, it mostly remains closed in summer due to bad road conditions resulting from heavy rain. In winter, heavy snowfall causes similar inconveniences.

Sakteng is a Dungkhag center, a sub-district administration center, for two gewogs (blocks) of Merak and Sakteng. The government facilities like Basic Health Unit, Agriculture Extension Facility, Livestock Extension Facility, a Middle secondary School, Legal Court, Park office, Police Station, Community Information Center, Farmer's Shop, Financial Institute (bank) and Monastic Body are availed to people.

The research showed that in Sakteng 92% of the total people are satisfied with Education Facilities, 58% with Basic Health Facilities, 93% with Agriculture Extension Facilities, 91% with Livestock Extension Facility, 78% with Park Office, 30% with Farmer's Shop and 68% with Financial Institutions. Whereas in Merak, 89% of the total interviewed households were satisfied with the Education Facilities, 47% with Basic Health Facilities, 67% with Agriculture Extension Facilities, 93% with Livestock Extension Facility, 73% with Park Office, and 89% with Farmer's Shop as shown in the figure 4. Generally approximately 70% of the people in Merak and Sakteng were happy with the different government facilities.

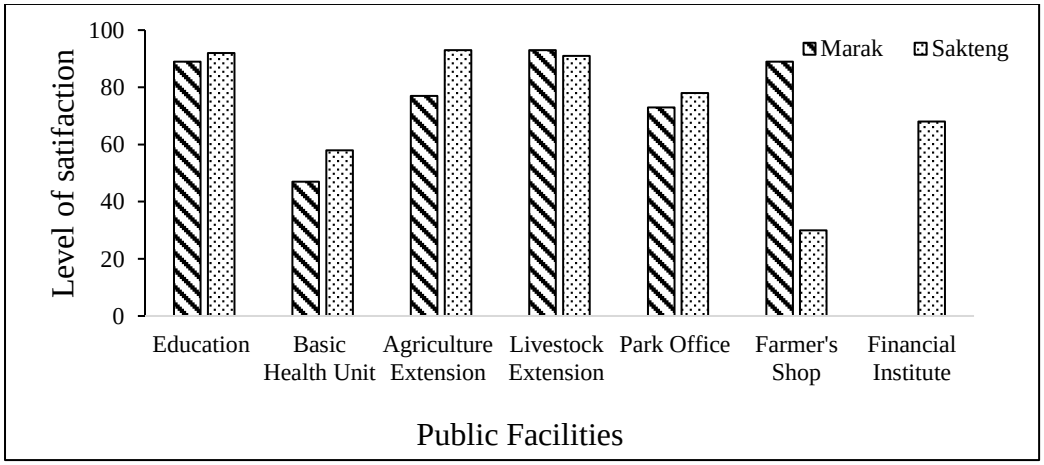

Figure 4: Level of satisfaction with the government facilities in Merak and Sakteng

4.2. Livelihood

4.2.1. Household income

The overall livelihood of the people has improved, taking it analogous to the household income, by approximately 3.1% over a decade. Based on earlier year's (2018) annual household income, the mean annual income for each household was Ngultrum (Nu.) 141,485 (US$2,194.25) for Sakteng and Nu. 237,914 (US$3,689.74) for Merak (US$1= 73.57 dated 02/09/2021). There are households with annual income as high as Nu. 550,000 (US$8529.78) and there are households whose annual income is as low as Nu. 13,000 (US$ 201.6). Figure 5 shows the numbers of household in percentage in different group of annual income. The income disparity amongst the households interviewed within the village was seen as high. It is bigger in Sakteng, with a Gini coefficient of 0.304 than Merak, which has a Gini coefficient of 0.236 as shown by the Lorenz curve in figure 6A and 6B. Although Merak has a higher mean annual household income, there are 22.85% of the households actually living in poverty. In Sakteng, 19% of the households live with a monthly income less than Nu. 2,195.947 (US$29.85). The calculation is based on the poverty analysis framework *small-area estimation method* developed by

Elbers, Lanjouw, and Lanjouw (2003), which is used by the Bhutan's National Statistics Bureau and the World Bank (2019).

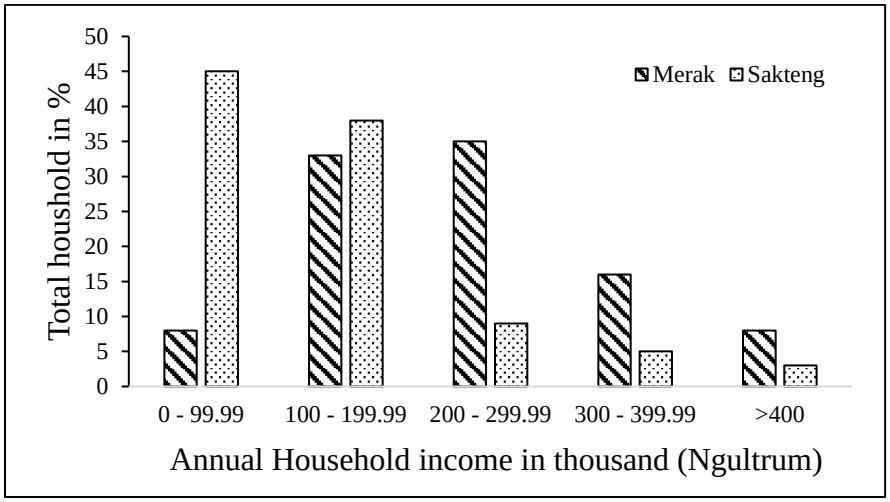

Figure 5: Total household within given frequency of annual income (Nu.)

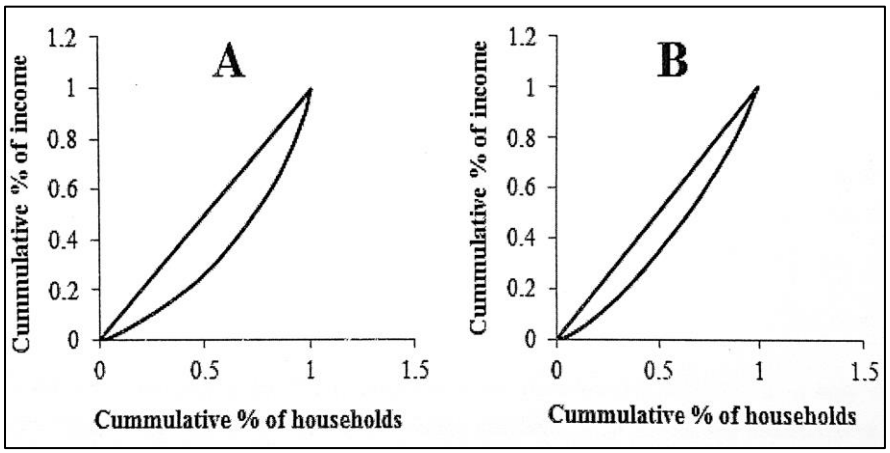

Figure 6: Lorenz curves showing the income inequalities in (A) Sakteng and (B) Merak

The primary source of household income in both the places is livestock. In Sakteng and Merak, a total of 88% and 91% households depend on livestock for income. The main livestock they depend upon is yaks, cattle, sheep, and horse. Yaks make up to 51% of the total domestic animal reared followed by 32% of cattle, as shown in figure 7.

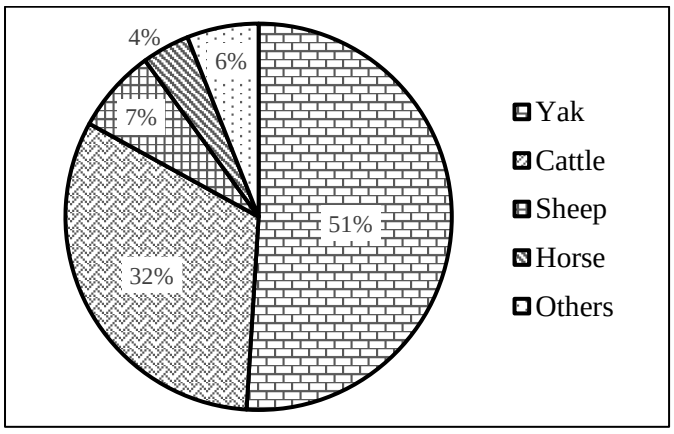

Figure 7: Livestock reared in Merak and Sakteng

Although the majority of the people still consider livestock as the main income generator, 37% of the total households interviewed also have other sources of income. In 2018, selling non-timber forest products like *Paris polyphylla* and Burl made up 11.3% (Nu. 1,730,150) and 7.8% (Nu. 1,182,200) of total annual income in Sakteng and Merak, respectively. Other activities like agriculture, tourism, business, contract, carpentry, and wage work made up approximately 27% and 36% of total annual income for Sakteng and Merak, respectively.

4.2.2. Literacy level

The illiteracy rate, among the family members in the interviewed households, is 57.1%. This means only 42.9% of the total family members in the interviewed households are able to either read or write Dzongkha (National Language) or English or both. The numeracy rate, with the knowledge of basic mathematical functions, is even lesser at 33%. From the total literate population, 23% have studied or are in the primary schools, 22% have or are attending the Middle Secondary School, 20% of them have are in the Higher Secondary School, 13% have graduated or are in the Graduate Schools, and 3% have or are doing their Post-Graduation as shown in figure 8A. The trend clearly shows how enrollment into the school has grown over time in these two villages as shown in figure 8B.

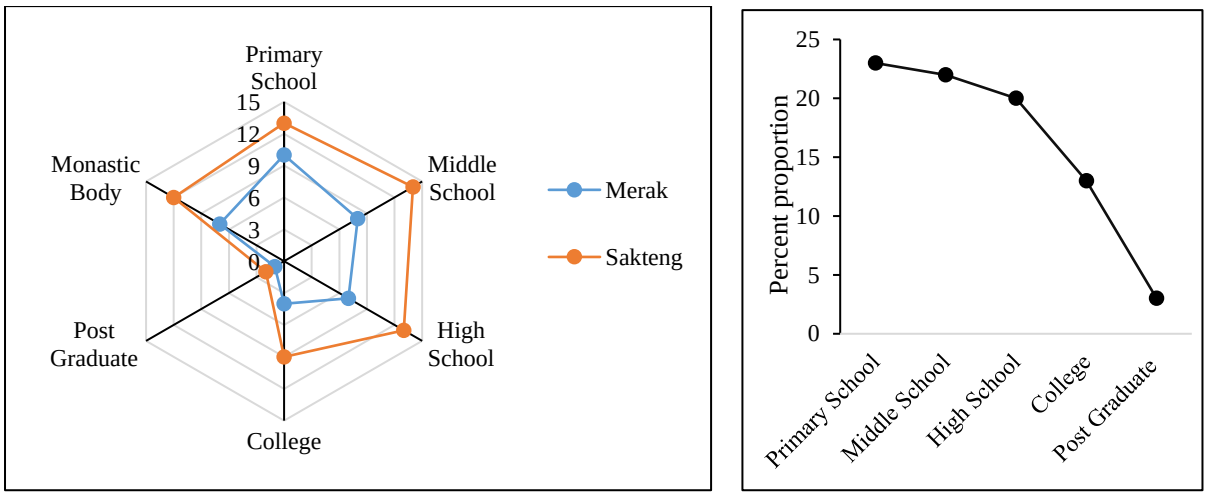

Figure 8A: Literacy rate and enrollment into different level of education attainment, 8B: Trend in the enrollment.

Monastic Institutions have always played a crucial role in teaching people how to read and write in Bhutan, and so has it is in these two villages. A fifth of the literate population has monastic education, Vajrayana Buddhism.

4.2.3. Food Security

The Food Security of a household exists when all the people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2003). The assessment of Food Security was done based on the Global Food Security Index (GFSI), the index has dynamic quantitative and qualitative benchmarking model constructed from 59 unique indicators (Economist Intelligence Unit, 2017), which considers the issues of i) food affordability, ii) availability, and iii) quality and safety using parameters like, inter alia, nutritional standards, food consumption as a share of household expenditure, volatility of agricultural production, access to financing for farmers, sufficiency of supply, food safety, and so on. The research found out that the Merak is more secure with the overall Food Security Index score of 68.6 compared to Sakteng whose overall score was 59.5 as shown in figure 9.

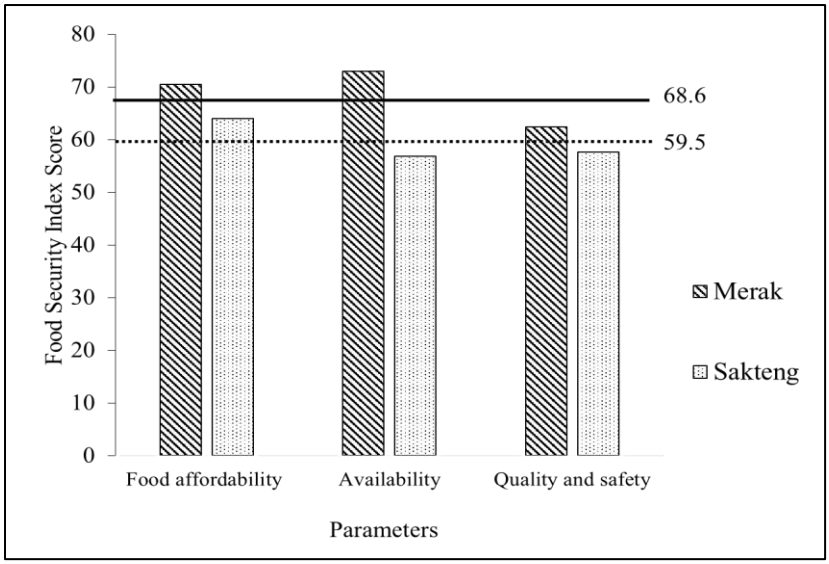

Figure 9: Food Security Index Score for Merak and Sakteng

Food security, as per the survey, has increased. All the interviewed households agreed that they have better food on the table compared to the past. Nutritional intake has also improved in both the villages. This will improve further in coming years when they will have better access to food resources from outside, as transportation is becoming easier in both places.

4.2.4. Gender participation

Gender inequality remains a major barrier to human development. Women have made major strides since 1990, but they have not yet gained gender equity. The disadvantages facing women are a major source of inequality. Often, women are discriminated against in health, political representation, education, labor market, and so on, bringing negative consequences for the development of their capabilities and their freedom of choice. Gender participation in household activities is hugely skewed. In 89% of the households, the economic activities are all done by male, whereas 80% of female are stuck inside the house doing household chores. Even resource control and decision-making inside the house are male-oriented as shown in Figure 10.

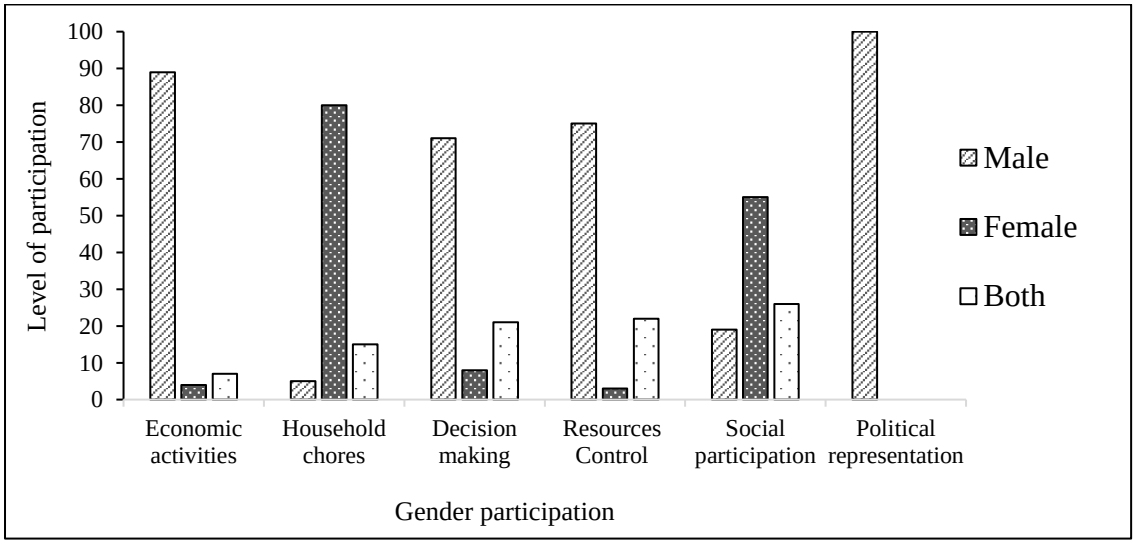

Figure 10: Gender participation in different activities

In terms of literacy, of 42.9% of literate population only 37% of the total members are female. Similarly, the political representation of females in the local government is nonexistent. All the seven seats of

local government (as a people's representative) in Sakteng and another seven seats in Merak are occupied by male representatives.

4.3. Ecosystem Services

4.3.1. The Sakteng Wildlife Sanctuary (SWS)

The SWS covers the total area of 750.60 km^2 with 19.73% of the total area designated as the core zones' and 80.27% of the total area as 'multiple-use zone'. However, the park also controls over another 206.37 km^2 of land outside the park boundaries as a buffer zone (Gyeltshen, Tshering, & Wangdi, 2011). Forestry legislation provides ample rights and privileges to Bhutanese citizens with respect to umber and other natural resources, including access to and subsidies for forest products, such as house building timber, fuel-wood, NWFPs, grazing, etc. However after establishment of SWS in 2003, both development and individual household activities related to forestry and forest production had to be carried out in good terms with legal provisions of SWS regulations. The SWS is categorized into four participatory zones. i) core zones (19.73%), where except for research, habitat management, and best control, any human activities remain strictly illegal, ii) multiple-use zone, where sustainable use of resources like timber, firewood, and bamboo and livestock grazing, is allowed, iii) buffer zone, demarcated around the park boundary includes portions of Merak and Sakteng, where the development activities and individual household activities concerning forestry and production are allowed with stringent scrutiny and management practices, and iv) resource use areas designated for extraction of timber, bamboo, fodder, and pasturelands in keeping up with identifying traditional areas used.

4.3.2. Ecosystem Services

The resource mapping listed some of the main provisioning ecosystem services used by the people of Merak and Sakteng. The people used water for various purpose, pasture land as the primary source of fodder for their livestock, timber for construction, fuel wood as the source of energy, Bamboo for fencing and construction, *Paris polyphylla* is collected, illegally, and sold for cash, burl for wood turning and then selling it as a finished product like traditional cup, which can fetch a huge amount of cash, and other NTFPs like wild edibles. The people also practice agriculture cropping in small scale. Since the winter is severely cold, the seasonal calendar for the agriculture and other activities is busy in from late spring till late autumn, as shown in the figure 11.

After listing all the available provisional ecosystem services, it was ranked to weigh on its importance for the wellbeing based on five parameters of marketing demand, household benefit, availability, regeneration potential, and time-consuming for harvesting (Department of Forest and Park services, 2013). The ranking based on consolidated scoring of priority legend of (i) very high priority, (ii) high priority, (iii) medium priority, (iv) low priority, (v) lower priority, and (vi) lowest priority along with their weightage of 12, 10, 8, 6, 4, and 2 respectively was obtained for 7 different types of ecosystem services.

The most important and prioritized provisioning ecosystem service is water resource, with 71.8% and 69.1% of respondents prioritizing it with the total consolidated scoring of 10.75 out of 60 and 10.79 out of 64 in Satkeng and Merak, respectively. Although water as a resource does not have a market, many respondents ranked it very high on parameters like the household benefit, availability, regeneration potential, and the time consumed to collect it. Mr. Sang Norbu (personal communication, September 15, 2019), a respondent Merak village explains,

“water doesn’t need to be priced to understand its value. We have to just imagine what we cannot do without it. We can do nothing without water. I cannot rear livestock! I cannot grow food! There will be no life without it.”

Collection of *Paris polyphylla* and the burl from the forest has the highest market demand, which yet is ranked lowest. It postulates that these provisioning services doesn't have much household use, it is scarce in the forest, and has the lowest regeneration potential. On the contrary, the fodder collection/pastureland has an average scoring in all the parameters suggesting its importance for

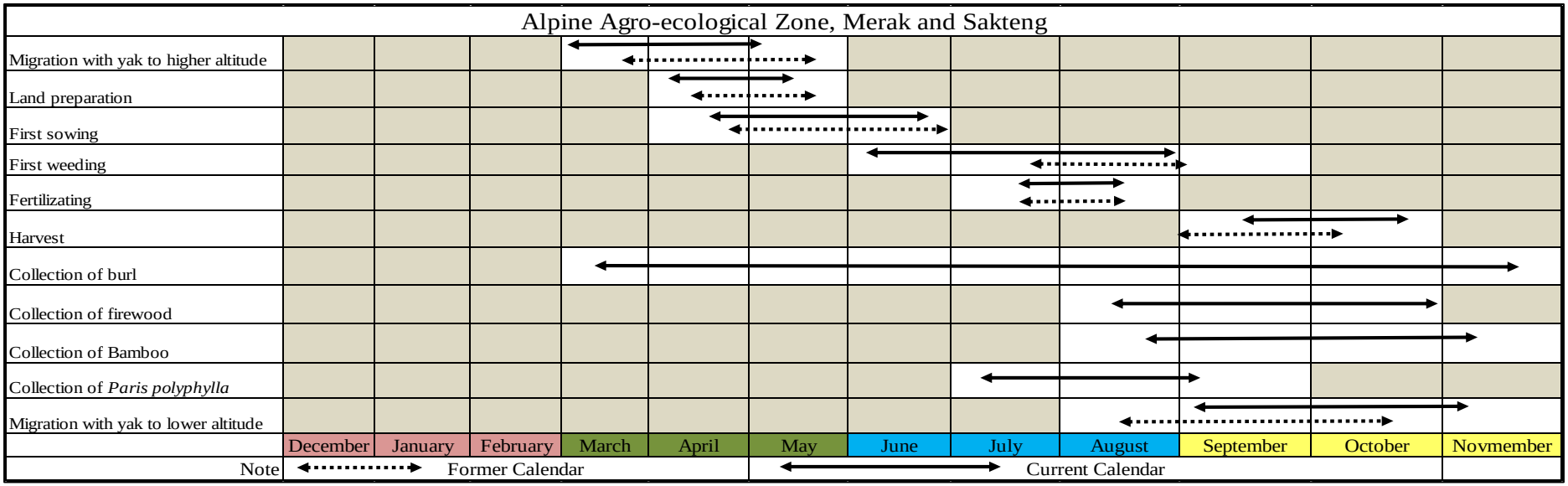

Figure 11: Seasonal calendar for Merak and Sakteng

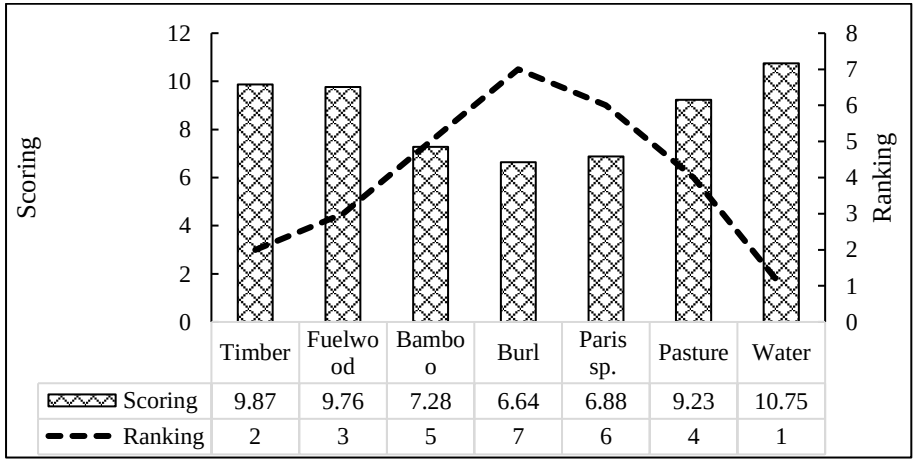

Figure 12A: Priority ranking based on the consolidated scoring for Sakteng

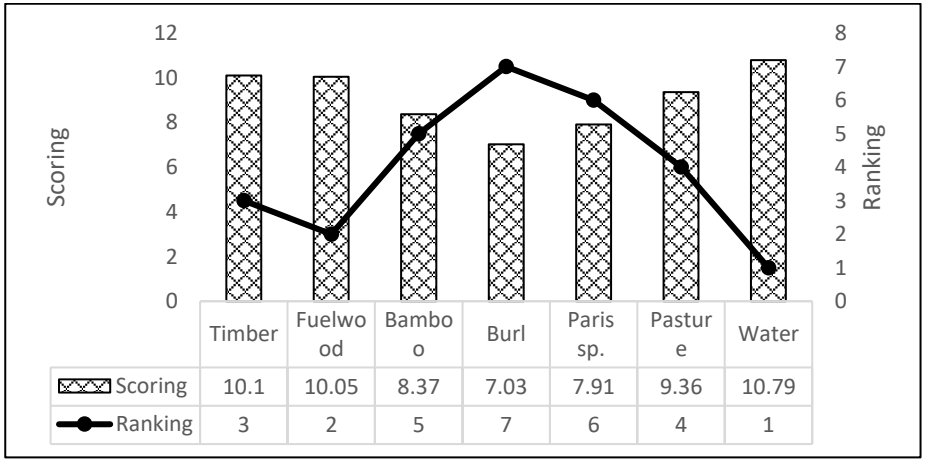

Figure 12B: Priority ranking based on the consolidated scoring for Merak

Table 2: Data sheet showing the consolidate scorings for priority ranking for Provisioning ES for Sakteng

	Timber	Fuelwood	Bamboo	Burl	*Paris sp.*	Pasture	Water
	1: 56.2%: 6.74	1: 56.2%: 6.74	1: 24.2%: 2.9	1: 23.6%: 2.83	1: 25%: 3	1: 48.6%: 5.83	1: 71.8%: 8.62
	2: 17.6%: 1.76	2: 16%: 1.6	2: 20.8%: 2.08	2: 7.2%: 0.72	2: 13.2%: 1.32	2: 21.2%: 2.12	2: 14.2%: 1.42
	3: 8.8%: 0.70	3: 7.2%: 0.58	3: 14.8%: 1.18	3: 8.6%: 0.69	3: 7.2%: 0.58	3: 7.2%: 0.58	3: 5%: 0.4
	4: 5.6%: 0.37	4: 8%: 0.48	4: 5.2%: 0.31	4: 19.8%: 1.19	4: 16.2%: 0.97	4: 2.8%: 0.17	4: 1.6%: 0.10
	5: 3.6%: 0.14	5: 5.4%: 0.22	5: 5.8%: 0.23	5: 19.8%: 0.79	5: 12%: 0.48	5: 6.2%: 0.25	5: 3%: 0.12
	6: 8.3%: 0.16	6: 7.2%: 0.14	6: 29.2%: 0.58	6: 21%: 0.42	6: 26.4%: 0.53	6: 14%: 0.28	6: 4.4%: 0.09
Scoring	**9.87**	**9.76**	**7.28**	**6.64**	**6.88**	**9.23**	**10.75**

Table 3: Data sheet showing the consolidate scorings for priority ranking for Provisioning ES for Merak

	Timber	Fuelwood	Bamboo	Burl	*Paris sp.*	Pasture	Water
	1: 55.7%: 6.69	1: 63.1%: 7.58	1: 35.4%: 4.25	1: 27.4%: 3.29	1: 32%: 3.84	1: 53.4%: 6.41	1: 69.1%: 8.30
	2: 22%: 2.2	2: 15.4%: 1.54	2: 18.3%: 1.83	2: 12.3%: 1.23	2: 19.4%: 1.94	2: 18.9%: 1.89	2: 18%: 1.8
	3: 9.43%: 0.75	3: 4.57%: 0.37	3: 12.3%: 0.98	3: 6%: 0.48	3: 10.9%: 0.87	3: 5.71: 0.46	3: 6.29%: 0.50
	4: 1.43%: 0.09	4: 3.43%: 0.21	4: 10.3%: 0.62	4: 18.3%: 1.10	4: 7.71%: 0.46	4: 2%: 0.12	4: 0.29%: 0.02
	5: 2.57%: 0.10	5: 4.29%: 0.17	5: 10.9%: 0.43	5: 10.9%: 0.43	5: 9.71%: 0.39	5: 4.29%: 0.17	5: 2%: 0.08
	6: 8.86%: 0.18	6: 9.14%: 0.18	6: 12.9%: 0.26	6: 25.1%: 0.50	6: 20.3%: 0.41	6: 15.7%: 0.31	6: 4.29%: 0.09
Scoring	**10.01**	**10.05**	**8.37**	**7.03**	**7.91**	**9.36**	**10.79**

Parameters: A = Marketing Demand, B = Household benefit, C = Availability, D = Regenerative Potential, E = Time consumed to harvest.
Priority legend: 1 = Very high priority, 2 = High priority, 3 = Medium priority, 4 = Low priority, 5 = Lower priority, 6 = Lowest priority.
Weightage: 1 = 12, 2 = 10, 3 = 8, 4 = 6, 5 = 4, 6 = 2.

economic gain as well as for domestic use. The importance of ecosystem services based on the scoring is ranked in Tables 4 and 5. Figures 12 and 13 depict the ranking and scores of these services in Sakteng and Merak, respectively, in the following order:

Sakteng: Water > Timber > Fuel-wood > Pasture > Bamboo > *Paris polyphylla* > Burl collection

Merak: Water > Fuel-wood > Timber > Pasture > Bamboo > *Paris polyphylla* > Burl collection

4.3.3 Economic value of water

The Economic evaluation for water, for drinking and other uses, calculated by taking mean willingness to pay (WTP), was Nu. 2,524.7 (US$ 39.2) for two places. The mean WTP for 79 interviewed households of Sakteng was Nu. 2531 (US$ 39.3). When extrapolated to the whole gewog (block) it is sums up to Nu. 850,416 (US$ 13,188.8). Although WTP and willingness to accept (WTA), considering that the people were to forgo their resources for other people's use, should be equal theoretically, WTA was found slightly higher with the mean WTA of Nu. 2555.25. Merak has the total economic value (TEV) of water at Nu. 581,130 (US$ 9012.6) with the mean WTP of Nu. 2515.7 (US$ 39.0). The WTA is slightly higher than WTP.

WTP for conservation of water resources, in both the villages was higher showing positing the responsibility and how anticipative people are to conserve the available resources. The mean WTP for the conservation of water resources for two villages is Nu. 2,919.7 (US$ 45.3). The TEV for water for both the villages is calculated at Nu. 1,431,508.2 (US$ 22,200.8).

The WTP and the annual household income are fairly correlated. There is a significant correlation between annual household income and their WTP at 0.01 level (2-tailed), r=0.272, p=0.006 for Sakteng and r=0.327, p=.006 for Merak as given in Table 2 and 3.

Table 4: Pearson's correlation for household income and WTP, Sakteng

	Household income in Nu.	WTP in Nu.
Household income in Nu.	1	0.272
WTP in Nu.	79	1

*significant at p<0.05

Table 5: Pearson's correlation for household income and WTP, Merak

	Household income in Nu.	WTP in Nu.
Household income in Nu.	1	0.272
WTP in Nu.	52	1

*significant at p<0.05

4.3.3. Economic Value for Pasture (rangeland)

As 88% of the total households in Sakteng and 91% in Merak depend on livestock for their livelihood, pasture becomes a very important resource. The TEV of rangeland calculated based on the people's willingness to pay for its services was Nu. 2,970,913.2 (US$ 46,075) for both the villages; with a mean WTP of Nu. 5,162.5 (US$ 80.1) for Sakteng and Nu. 5,350 (US$ 83) for Merak. The highest amount an individual is willing to pay is Nu. 15,000 (US$ 232.6). The total value based on the willingness to accept by the people to forgo the resource is higher than TEV based on WTP at Nu. 4,722,776.5 (US$ 73,244.1). In Both the villages the WPA and WTP for conservation were higher than WTP for their use.

It is observed that the TEV of the rangeland/pasture, calculated using the willingness to pay for the resource use, is determined by two factors i) the mean household annual income and ii) the number of animals reared by a household. The household income and the WTP for the use of pasture resources are significantly correlated at the 0.01 level (2-tailed), r=0.593, p=0.000, for both the Villages. Furthermore, the numbers of animals per household and the WTP are significantly correlated at the 0.01 level (2-tailed), r=870, p=0.000, for both the places as shown in tables 6 and 7.

Table 6: Pearson's correlation between the household income and WTP for the use of Pasture in Merak and Saktang

	Household income in Nu.	WTP in Nu.
Household income in Nu.	1	0.593
WTP in Nu.	131	1

*significant at p<0.05

Table 7: Pearson's correlation between the number of animals and WTP for the use of Pasture in Merak and Saktang

	Number of animals	WTP in Nu.
Number of animals	1	0.870
WTP in Nu.	131	1

*significant at p<0.05

4.3.4. Economic value of timber, fuel-wood, and bamboo

The entire households depend on wood for timber and fuel and bamboo for fencing. Although there are financial rates/cubic feet (Cft) for timber circulated from the government, people have no records of how many cubic feet of timbers they have used in the past years. So the TEV for fuel-wood, bamboo as well as timber had to be calculated by asking for the willingness to pay for it. The mean WTP for timber is Nu. 9,752 (SU$ 151.2) when extrapolated the TEV was at Nu. 1,657,840 (USS 25710.9). The TEV for fuel-wood was at Nu. 918,000 (US$ 14,237) with a mean WTP of Nu. 5,400 (US$ 83.7). Bamboo is a fifth-ranked resource, its TEV is at Nu. 164,900 (USS 2,557.4) with mean WTP Nu. 970 (US$ 15). So the total TEV for these three resources is Nu. 2,740,740 (US$ 4,2505.3)

4.4. Climate change

The data in terms of the historical record or spatial coverage for baseline assessment of climate is very limited in Bhutan. An analysis of observed data from 2000-2009 has shown an increase for both maximum and minimum temperatures. Based on the data from 1980 to 2009, the future trend has been modeled and it is projected that increase of 0.8°C to 1.0°C to happen by 2039 and another 2.0°C to 2.4°C by 2069 (National Environment Commission, 2011). A change in mean annual precipitation is projected to increase by 10% by 2039, and 20% by 2069, however, it is seen that the monsoon season would become wetter and the winter season slightly drier. These extreme precipitation changes between seasons conform to the findings of the IPCC (2007) report for the Himalayan region of Southeast Asia. The fifth assessment report of the IPCC, 2014 shows that warming is very likely in the 21st century and that assessment still holds for all land areas of Asia. The mean changes in mean annual temperature exceed 2°C above the late-20th-century baseline over most land areas in the mid-21" century under, and range from greater than 3°C over South and Southeast Asia.

Although it is difficult to prove that the climate is changing without the concrete data, this study showed that all the households experienced warmer summer. Everyone agreed that the precipitation (snowfall), both in terms of frequency and density, has been decreasing over years. The knowledge of climate change in rural Bhutan is based on the daily experience of the people. Their perceptions are more on

the basis of the changes observed in the weather patterns and the seasons. However, only 6% of the total people interviewed were aware of climate change. Despite the interviewees' agreement of winter having become shorter and the summer warmer, they had completely wrong perceptions about the cause of the change. Approximately 76% of the people accused the incoming of electricity as the major cause of warming. Another 3% thought the development activities like construction of roads, electricity, and phone network are causing it. Rest couldn't point to anything to have caused the change, as shown in figure 13.

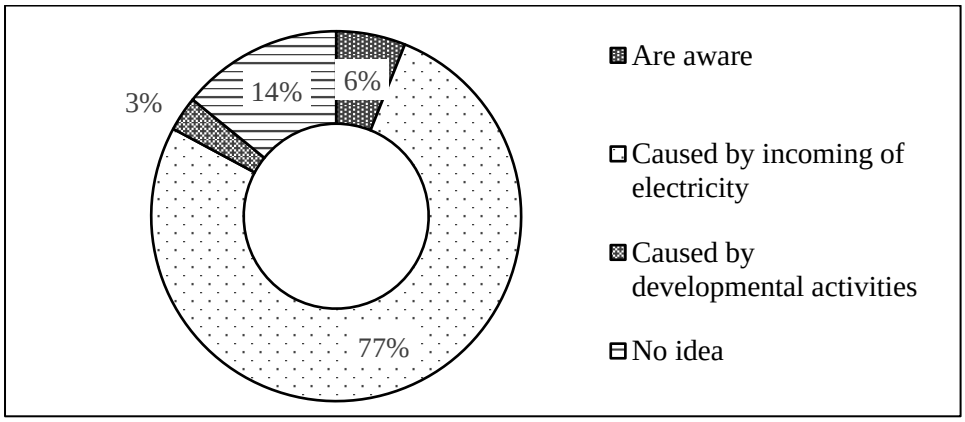

Figure 13: People perception about the cause of climate change

4.5. Perceived impacts of Climate Change

Global climate change has already brought about observable impacts on the environment. The consequences of climate change are becoming clearer with shrinking glaciers, changing weather patterns, shifting ranges of plants and animals, disturbing growing season and so on. In many places, people are bearing the brunt of climate change while, despite it is unsustainable for a colder places to become favorable with the rising temperature, in some places, the changing climate is observed as beneficial for the livelihood of people.

In Merak and Sakteng, climate change has and is, becoming severe, disrupting the trends of weather patterns. All the respondents agreed that there is less snow while 83% of people in Sakteng and 87% of people agreed that the rainfall has increased over the years. As posited by many scientific studies, the people believe that the windstorms and hail has become frequent phenomenon as depicted in figure 14. From the total sample, 37% of households in Sakteng and 44% of households of Merak believe the animals' diseases outbreak has become more prevalent. However, some also believe it has decreased due to improved livestock extension services.

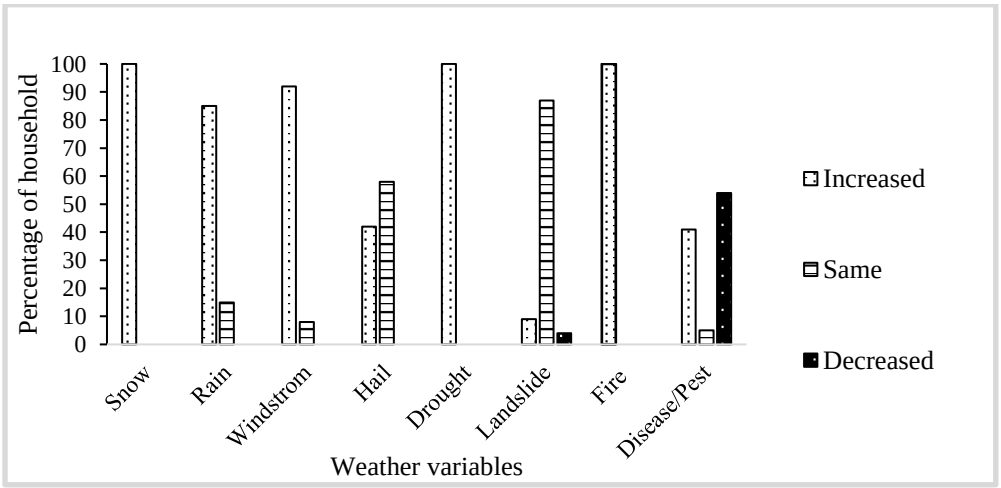

Figure 14: Perceived changes in the weather variables over late two decades

4.6. Livelihood Impact

The main issues, raised during the Focus Group Discussion, of climate change in the highland communities of Sakteng and Merak are an invasion of pasture lands by the invasive pests, human-wildlife conflict, and unsustainable harvesting of NTFP like *Paris polyphylla*. The shortage of labor has also become prominent in recent times. The four/fifth of the household interviewed mentioned that there is an increasing invasion of rangelands by plant-based pests making them unpalatable to their animals. It is difficult to calculate the financial loss incurred by pest invasion due to the absence of records tracking the change in productivity. The human-wildlife conflict was observed to have become 77% more prevalent in the last five years approximately incurring an average loss of Nu. 37,000 (US$ 573.8) for each household, summing up to Nu. 20,979,000 (US$ 325356.7). The labor shortage, an issue that has become adverse in recent times, has incurred financial implications for Nu. 23,814,000 (US$ 369,323.8). It was calculated by adding the total amount of money paid for jobs, usually done by the household members in the past, and the opportunity cost of labor shortage.

However, the study revealed that the people are contented with changing climate. Almost 91% of the people have a positive outlook towards changing climate. Everyone agreed it has become warmer and more comfortable to live in Merak and Saktang over the last few years. A slender majority of 77% of interviewed households mentioned that the growing season has become longer increasing their agriculture production. Although the rangelands are threatened by the pest invasion, they said pasture grasses grow better enhancing the productivities as the growing season starts earlier. The growth is ensured by less snow cover and more rainfall, which enriches the growth of feeds.

4.7. Adaptation

Just like the migratory animals avoiding harsh weather patterns and for better availability of pasture for the animals the highlanders take their animal herds to the lower valleys of Sakteng Wildlife Sanctuary for six whole months from mid-Autumn to the mid-spring. In the mid-Spring, as the snow cover melts and pasturelands start getting lush green with grasses, they come back to highlands.

In order to secure the properties like houses and cars, from the shocks of changing climate and other natural hazards, all the households have it insured. 97% of the households also have Bank accounts along with savings for sustainable financial use. However, none of the households have their animals insured, which makes these households bear all the loss in times of disease outbreak ad human-wildlife conflicts, making their fundamental source of livelihood highly vulnerable to unforeseen shocks.

Furthermore, in both places, awareness campaigns on climate change and disaster management have been hardly carried out by the government and related institutions.

About 95% of the people have no idea the disaster management, which makes them highly vulnerable to disasters. It constrains their ability to adapt to stresses brought about by climate change. On top of their unpreparedness to face the uncertainty, the survey also concluded that 43% of the total people do not have the financial capacity to cope with any kind of major disaster.

Sakteng Wildlife Sanctuary has provided all the households with a roofing facility of CGI sheet to curb down timber demand for sustainable and healthy natural resource use. SWS also has provided their help to build toilets for 37% of the interviewed households. Additionally, 4% of the interviewed household also has greenhouse facility, provided by SWS, where vegetables were grown. To overcome harsh climatic conditions in winter from doing agriculture work (basically a kitchen garden) and secure food resources, all the households plead for the government's help to acquire a greenhouse.

There are conflicts pertaining to the legal rights of pastureland, which people said affects their livelihood based on livestock farming. To combat these problems along with increasing competition for common resources and human-wildlife conflict, 69% of the households also look forward to bringing in other livestock like improved cows, poultry, and sheep.

5. Discussion

5.1. Economy

The country's economy is important to maintain the living standard of its people. Bhutan's Gross Domestic Product (GDP) for 2016 has been projected to grow at the rate of 8.4% (ADB, 2015: Tobgay, 2016). However the Gini coefficient of Bhutan was as high as 0.36 in 2012. The expenditure share of the richest quintile is 43.7% whereas the poorest quintile shares only 7.1% (ADB, 2014). The growth must be more inclusive. Even in remote places like Merak and Sakteng, the inequality is large. The mean annual income for each household was at Nu. 141,485 (US$2194.25) for Sakteng and Nu. 237,914 (US$3689.74) for Merak. However, as the inequality in the distribution of wealth, shown with the Gini coefficient, is 0.304 for Sakteng and 0.236 for Merak, the rich and the poor have huge gaps in income.

The poverty rate is drastically lowered in Bhutan from 31.7% in 2003 to 23.2% in 2007 and 12.0% in 2012. The South Asian Region had a poverty rate of 13.5% in 2015. The poverty rate of rural Bhutan is 16.7% and urban has 1.8% showing that 94.4% of the poor dwells in the rural areas. Merak and Sakteng are two of the poorest gewogs in Trashigang Dzongkhag. The poverty rate, in 2011, was 57.86% for Merak and 40.33% for Sakteng, compared to the Dzongkhag's average of 29.3%. Today, as the study revealed, 22.85% households in Merak, and 19% households in Sakteng live with a monthly income less than Nu. 2,195.947 (US$29.85) per month. Despite drastric reduction of poverty by about 35% in Merak and 21% in Sakteng over 6 years, the rate still remains high.

Unlike other villages of Bhutan, Merak and Sakteng has a very little contribution from the cultivation of agriculture crops. Livestock remains their main source of livelihood. The livestock does not just act as an asset for sustainable production of income but also liquidity available for the market at any time of need. However, as the pasture resources are becoming ultimate competition ground, and as the development comes into their villages, the income sources are diverting. Other activities like agriculture, tourism, business, contract, carpentry, and working for wage already make up to approximately 27% and 36% of total annual income for Sakteng and Merak, respectively. There is no mass cultivation of agriculture crops except for small kitchen gardens, which are also attenuated to just three to five months a year. They have bartered their livestock products to the lower valleys of Tashigang for rice and vegetable for ages. Yet Merak and sakteng are fairly food secure with the overall Food Security Index score of 68.6 and 59.5 respectively.

In 2016, Bhutan had gender inequality ranking 110 out of 160 countries with a GII of 0.477 as shown in the table 8.

Table 8: Gender inequality in Bhutan, Source: Human Development Report, 2016.

GII	Female seat in Parliament (%)	Population in sec. edu. (%)		Labout force (%)	
		female	male	female	male
0.477	8.3	5.8	13.4	58.7	72.8

In the same line, Merak and Sakteng, with economic activities, decision making, and resource control all male-driven, 80% of the women stay home doing household chores. There is not a single female leader revealing that the women of these places are politically inactive. The sustainable climate change adaptation measures need all the stakeholders to work together.

5.2. Economic valuation of provisional resources

The valuation of non-market environmental commodities has significant policy implications. In the past, such commodities have been assigned zero or of low value, which in turn has undermined their services leading to policies overlooking the fundamental functions of the environment. An economic valuation can also help people understand what can be the costs of an intervention that can alter the ecosystem through conservation investment, developing projects, framing regulations, and conferring incentives. This can make ecosystem goods and services comparable with other investments (Maître, 2005).

Evaluation of ecosystem services has never been an easy task. Even if the economic modules are available for valuation, Daily et al. (1997) argued that methodological limitations constrain the extent to which economic valuation methods can capture all benefits provided by the ecosystem. Further Adekola et al, (2010) points that the economic valuation of the ecosystem services is fraught with uncertainties, which often results in the estimation of value that is not precise.

Although we agree that a comprehensive, complete, and undisputed valuation of an ecosystem services is virtually impossible to achieve, we know that economic valuation is useful and "failure to quantify ecosystem values in commensurate terms with opportunity costs often results in an implicit value of zero being placed on ecosystem services" (Adekola et al., 2008). They also state that in practice, it may be better to reach an agreement based on imperfect value estimates rather than continuing theoretical disputes over the "real" value of environmental resources. In the measure of value for ecosystem services, the total economic value (TEV) for the services with consumptive uses can be done based on their price in the market. Intrinsic or non-use values, as the name suggests, are inherent in the goods. Since it is the satisfaction people derive from the goods and services, not related to consumption, it is difficult to assess.

The initial estimation of the value of ecosystem services in Bhutan done by Kubiszewski et al., (2012) using benefit transfer methodology shows a total estimated value of approximately US$15.5 billion per year, which was significantly greater that GDP of US$ 3.5 billion per year. The TEVPs for NTFPs like *Paris polyphylla* and collection of burl can be done based on its market value where the contingent methods have to be used for valuation of water resources, pasture, timber, fuel-wood, bamboo, and so on. The total economic value for the 7 provisional ecosystem services in Merak and Sakteng is Nu. 10,055,549.2 (US$ 155,948.3) as shown in Table 9.

Table 9: TEV for various provisioning ecosystem services

Provisional Ecosystem services	TEV in Nu.
Water	1,431,546
Pasture	2,970,913.2
Timber	1,657,840
Fuel-wood	918,000
Bamboo	164,900
Burl collection	1,730,150
Paris polyphylla	1,182,200
Sum	10,055,549.2

The priority rank of the provisional ecosystem services doesn't necessarily correlates to the rank of the resources calculated based on the TEV. The value of resources like water, which is very important to the livelihood, based on WTP can be very minimal owing to its abundance. The relationship is depicted below.

Priority rank	Sakteng: Water > Timber > Fuel-wood > Pasture > Bamboo > Paris p. > Burl collection Merak: Water > Fuel-wood > Timber > Pasture > Bamboo > Paris p. > Burl collection
TEV rank	TEV: Pasture > Burl collection > Timber > Water > Paris p. > Fuel-wood > Bamboo

5.3. Climate change and livelihood

According to the latest scientific report, the earth's climate system has demonstrably changed on both a global and regional scale since the preindustrial era (Sathaye et al., 2006). In the Eastern Himalaya, Dash et al, (2007) observed, during the last century the maximum temperature increased over North East India by 1°C during winter and 1.1°C during the post-monsoon months. To the southwest region,

over the observation period of 41 years, the mean annual air temperature increased at the rate of 0.01°C/yr to 0.04°C/yr. However, in Bhutan based on the data from 1980 to 2009, the future temperature projections have been made with an increase of 0.8°C to 1.0°C by 2039 and another 2.0°C to 2.4°C by 2069.

This is felt in the highland communities of Merak and Sakteng. With all the people agreeing that the temperature has raised, impacts like change in precipitation and wind pattern have become visible. These impacts are usually accompanied by stress and vulnerabilities. However, people are completely unaware of disasters and stresses brought about by climate change. This exacerbates the community's vulnerability. In these two highland livestock dependent communities, none of the animals are insured risking communal wellbeing against uncertainties associated with climate change. The recorded experience of increasing climate disasters, like human-wildlife conflict, and disease outbreaks, will certainly impact the household income and food security. While only 57% of the people have financial ability to withstand uncertainties, there is a need to improve the facilities like basic Health Unit, Veterinary extension facilities, Agriculture Extension Facilities, Road and so on to enhance the community resilience towards climate disasters.

Due to rising temperature, the study shows, the summer has become longer fetching early and better fodder for animals. It is positive impact for the livestock owners. Moreover, it enables more agriculture work. The shortened and weakened winter can also give the highlanders more time to invest in productive vocations like a contract, carpentry, working for wage. It is apparent that around 91% of the people had a positive outlook towards rising temperature, since the highlands are becoming warmer, due to overarching impacts of climate change, involving countless feedback-loop affecting overall environmental health, it cannot be sustainable.

6. Conclusion

The livelihoods of the highland communities are largely dependent on natural resources. So economic evaluation of the ecosystem services gives insight into how the environment influences and helps to improve the livelihood of these people. In turn, it also helps in sustainable utilization and management of important resources.

The total economic value of provisional ecosystem services in Merak and Sakteng is calculated at 10.055 549.2 (US$ 155,948.3) for the years 2014-2015. The value cannot be thoroughly representative of all the services limited by the methods of measurement.

The findings from this study related in relation to the livelihood, ecosystem services, its influence on the livelihood, and impacts of climate change on the overall livelihood would help decision-makers and policy planners to understand better about these two remote areas. The impact of climate change is exposing poor people to different stresses and uncertainties. These economically disadvantaged highlanders have very less adaptive capacity to adapt to all the uncertainties. More than 50% of the households are highly vulnerable. A practical climate change adaptation framework needs to be developed and implemented to enhance economic, social and environmental resilience in these highland communities.

The value of ecosystem services calculated in this study is purely based on the subjective disclosure of the people. The participants, in many cases, reluctantly disclosed their economic profile. The economic data from the households earning from the trade of NTFPs like *Paris polyphylla* and burl, which is very widespread, which is also usually done illegally, would be underrepresented. Although SWS has clear management plans for resource use and conservation, the people appeared unaware of the laws and policies governing resource use. Appropriate measures need to be taken to educate people about the sustainable livelihood based on the use of local resources.

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