ICIMOD Working Paper 2018/6

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FOR MOUNTAINS AND PEOPLE

A Multi-Dimensional Assessment of Ecosystems and Ecosystem Services in Taplejung, Nepal

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The International Centre for Integrated Mountain Development (ICIMOD), is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalaya – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

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ICIMOD gratefully acknowledges the support of its core donors: the Governments of Afghanistan, Australia, Austria, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Norway, Pakistan, Sweden, and Switzerland.

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International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, June 2018

Published by
International Centre for Integrated Mountain Development (ICIMOD)
GPO Box 3226, Kathmandu, Nepal

ISBN 978 92 9115 610 8 (electronic)

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This publication is available in electronic form at www.icimod.org/himaldoc

Citation: Thapa, S., Poudel, S., Aryal, K., Kandel, P., Uddin, K., Karki, S., Sharma, B. & Chettri, N. (2018). *A multi-dimensional assessment of ecosystems and ecosystem services in Taplejung, Nepal*. ICIMOD Working Paper 2018/6. Kathmandu: ICIMOD.

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Acknowledgements

We express our gratitude to David Molden, Director General of ICIMOD, for his encouragement and support. This Ecosystem Service Assessment component of the Himalica pilot project would not have progressed smoothly without the support of the District Development Committee, Taplejung; District Forest Office, Taplejung; District Agriculture Development office, Taplejung, and District Livestock Service Office, Taplejung. We are thankful to Amar Kunwar and Manisha Awasthi for their support in field survey and data compilation, social mobilisers, and local community, respondents, key informants who participated in the Ecosystem Service Assessment for their supportive attitude during participatory rural appraisal and household surveys. We owe special thanks to the staff of the Environment Conservation and Development Forum (ECDF) for their co-ordination and support in the field. We would like to thank SERVIR Himalaya for the land cover data support for this study.

We are very thankful to local community members of the three study areas for providing their time and invaluable information during the review process. Without their support this study would not have been possible. This document is prepared under the Support to Rural Livelihoods and Climate Change Adaptation in the Himalaya (Himalica) Programme (ASIE/2012/292-464) funded by the European Union. We are also indebted to Dhrupad Choudhury and Surendra Raj Joshi for their guidance and encouragement.

We would also like to thank Wu Ning for his valuable review and suggestions for strengthening the publication. Warm appreciation goes to the editorial team of Rachana Chettri and Dharma Maharjan for bringing the working paper to its present form. We are also grateful to Elaine Monaghan for the editorial support. The findings, interpretations and conclusions expressed in this work are those of the authors only and do not necessarily reflect the views of ICIMOD.

Acronyms and Abbreviations

CBD	Convention on Biological Diversity
CFUG	Community Forest User Groups
DADO	District Agriculture Development Office, Taplejung
DFO	District Forest Office
DPMAS	District Poverty Monitoring and Analysis System
ECDF	Environment Conservation and Development Forum
EDR	Eastern Development Region
ESA	Ecosystem Service Assessment
EU	European Union
ESA	Ecosystem Services Assessment
GIS	Geographic Information System
HKH	Hindu Kush Himalaya
ICIMOD	International Centre for Integrated Mountain Development
KCAMC	Kangchenjunga Conservation Area Management Council
KLCDI	Kangchenjunga Landscape Conservation and Development Initiative
MEA	Millennium Ecosystem Assessment
NGO	Non-Governmental Organization
NTFPs	Non-Timber Forest Products
PRA	Participatory Rural Appraisal
RS	Remote Sensing
SDG	Sustainable Development Goals
TEEB	The Economics of Ecosystem and Biodiversity
USGS	United States Geological Survey
VDC	Village Development Committee
°	Degree
‘	Minute
“	Second
%	percentage
E	East
ha	hectare
km	kilometre
m	metre
mm	millimetre
MT	Metric Tonne
masl	metre above sea level
N	North
sq.km.	Square kilometre
USD	United States Dollar [1 USD=NPR 100]

Executive Summary

Excessive demand for ecosystem services arising from rapidly growing human population and several anthropogenic activities have led to the extensive modification of vital ecosystems of the world. This has generated global concerns as this undermines ecosystem functioning and resilience and thus threatens the ability of ecosystems to continuously supply services. The United Nations' Sustainable Development Goals can only be met when ecosystem degradation is halted and further loss of ecosystem services is controlled, and only if the natural capital and assets can be utilized in a sustainable way. Therefore, regional, national and local assessments of ecosystem and their services are needed to identify and develop an effective policy in response to ecosystem degradation. Despite the multi-dimensional (ecological, socio-cultural and economic) importance of ecosystems to human society, there have been no serious efforts to assess the ecosystem services of the Hindu Kush Himalaya (HKH). The benefits provided by ecosystems are inadequately recognized and resource users do not take into account the cost of ecosystem degradation in their resource management decisions, since there is very limited understanding of ecosystem dynamics and the values that are being lost through degradation.

'Rural Livelihoods and Climate Change Adaptation in the Himalayas' aims to enable and promote equitable and sustainable well-being of people in the HKH. Specifically, the programme aims to work to reduce poverty, increase the resilience of local communities, and ensure equitable and sustainable wellbeing by building the capacity of local institutions, promoting new livelihood options, and encouraging regional cooperation in the promotion of equitable approaches to sustainable mountain development.

The main objective of this study is to understand the state and dynamics of ecosystems and their linkages to human wellbeing in the project site and mainstream the knowledge into planning and development strategies. Specific objectives are to identify and assess ecosystems in the study areas and prepare technical reports and develop, share and mainstream the knowledge products for effective planning and management of ecosystems.

The study covered pocket areas of large cardamom in two wards of Sikecha and five wards of Phurumbu Village Development Committees and three wards of Taplejung municipality, where Himalica Pilot Project is being carried out in Taplejung District. A research framework supported by an agreed-upon questionnaire for ecosystem assessment developed by ICIMOD was used to identify the current status of integrated ecosystem services (e.g., provisioning, regulating, supporting, and cultural services) in areas where communities depend heavily on natural resources for their subsistence livelihoods. Household survey in 250 purposively sampled households along with Land Use and Land Cover change analysis using Geographical Information System (GIS) and Remote Sensing (RS) were conducted to achieve the objectives of this study. Based on this assessment a technical report has been produced; the report contains the following findings:

Socioeconomic Profile

Among 250 respondents interviewed 57% were male and 43% were female. In terms of ethnicity, majority of respondents were Janajati (60% of the total survey population); and Brahmin, Chhetri and Dalit constituted 40%. The highest frequency of age group of respondents was 40-49 years. On an average, annual income of the households in the area was NPR 150,000. Large cardamom cultivation is a major source of income.

Status of Ecosystems and Dependencies on them

This assessment identified three major ecosystems in Taplejung District: forest, agricultural, and fresh water ecosystems. Direct and indirect use of resources from these ecosystems has largely been contributing to local livelihood. The cardamom farmers and entrepreneurs (94% of the total households) reported increase in the forest cover over the past 10 years. In contrast, agricultural lands (terraces) utilized for crop cultivation in the past 10 years have extensively been converted into agro-forestry systems (large cardamom cultivation), as reported by 98% of the total households. Surprisingly, 85% of the total households has witnessed decrease in the flow of streams, rivulets and river despite the expansion of forest cover in the area and most of them identified climate change as a cause.

As expected, among the three ecosystems, the cardamom farming communities in the study area heavily depend on agro-ecosystem (77% of the total households). Respondents reported being 'moderately dependent' on forest ecosystem. Although water is an essential part of daily life, the respondents accorded less priority to freshwater ecosystem.

In terms of ranking the importance of ecosystems, agro-ecosystem was ranked most important (52%), followed by freshwater (49%) and forest ecosystem (42%). Freshwater ecosystem was considered important because agro-forestry on which people are highly dependent needs water for irrigation. Altogether 46 services are rendered by three ecosystems in the area, which can be classified into four broad ecosystem services – provisioning services (n=27), regulating services (n=9), supporting services (n=5), cultural services (n=5). Agro-ecosystem provides the highest number of provisioning services. Except for freshwater ecosystem, all ecosystems provide an equal number of regulating services. However, all ecosystems bestow an equal number of supporting and cultural services.

Geospatial analysis reveals conspicuous changes in three major types of land cover in the study area – forest, agriculture and freshwater. Overall, over the period 1996 to 2015 (20 years), forest ecosystem, which includes government-managed forests and community-managed forests, (CFUGs) has slightly decreased. Agro-ecosystem, which includes agro-forest enterprises such as large cardamom plantation and crop farming terraces, is significantly increasing. Freshwater ecosystem is also decreasing.

In Phurumbu VDC during the year 1996, the forest covered more than 90% (2,593 ha) of the total land (2,838.69 ha), and just 8.64% (245.25 ha) of the total land was utilized for agro-forest enterprise and crop farming. Freshwater and settlements covered an insignificant portion of the land. By 2005, agricultural land had increased by about 4% due to conversion of forest land. Between 2005 and 2015, about 3% of the forest was further occupied for agricultural practices. In Sikecha VDC in 1996, forest cover was less than that of Phurumbu VDC, more than 81% (2,744 ha) of the total land (3,361 ha), and agricultural land was more than 18% (617 ha). Here, too, freshwater and settlements covered an insignificant portion of the land. By 2005, agricultural land had expanded to 30% because of the community's attraction towards large cardamom enterprise and heavy encroachment in the forest. Between 2005 and 2015, about 13% of the forest was resumed and agricultural land had shrunk. In the case of Taplejung Municipality, in 1996, forest cover was more than 80% (3,385 ha) of the total land (4,194 ha) and agricultural land was more than 17% (734 ha). Other land use types such as freshwater and settlements covered a minimal area of 24 ha (0.5%) and 50 ha (1%), respectively. By 2005, agricultural land expanded by 5% due to the large cardamom enterprise using the forest land. Settlement and other areas increased to 2% while freshwater decreased to 0.1%. Between 2005 and 2015, about 2% of the forest was resumed and agricultural land decreased.

Large cardamom is the most beneficial among the five most important provisioning services supporting local livelihood in the area. Timber (from Black Nepal Cedar), though consumed by fewer households last year, has a higher value than any other provisioning services. Estimated monetary value of fuelwood and fodder obtained from forest and agro-ecosystems on a daily basis is substantial, though people take it for granted. Medicinal herbs (especially '*Chiraito*') are commercially traded by a few households in the area; they have good sale value. Almost all important provisioning services are collected with the participation of both male and female members of the households in the area.

Drivers of Change, Community Perception, and Impacts

Vulnerability assessment reveals the area is vulnerable from the perspective of food security. The data shows high dependency on market for food supply due to shifting of agricultural practice from crop production to more profitable cardamom cultivation as well as poor production of crops in the agricultural land.

In the last ten years, local people in the area have witnessed several changes (improved or worsened) in the socio-economic sector. They are hopeful about increasing possibilities of income generation at the local level as several construction works are undergoing, possibilities of trade through the nearby Chinese border, investments from the remittances and establishment of rural cottage and small industries, and construction of hydropower projects including micro-hydro projects. Access to credit has enabled people to cope with vulnerabilities. Development scenario has been felt in the case of water availability for the communities. People's participation in decision making has been increasing.

The most viable options for value chain promotion in the Kangchenjunga landscape include further understanding and investing in the combined sectors of ecotourism and religious tourism including cardamom farm tourism, other livelihood improvement options such as developing green enterprise for the value chain promotion of resources (argeli, kiwi fruit, wild himalayan pear, hog plum, chestnuts, Indian butter fruit, Nepali pepper, several medicinal herbs, lichens [*Everniastrum nepalense*]) and even improving the value chain of large cardamom. This can help promote conservation of ecosystems while also providing benefits to local communities and can increase the awareness of decision-makers, leading to appropriate conservation-related outcomes. Based on the findings of the study, five key actions are recommended:

Action 1. Massive awareness campaign for local communities on the importance of and need for sustainable use of ecosystem services

Action 2. Develop integrated strategies and create synergies to mitigate food insecurity.

Action 3. Improve the value chain of large cardamom for better income and poverty alleviation.

Action 4. Promote green enterprises including tourism to contribute to social-ecological resilience.

Action 5. Focus on institutional development and mainstream the strategies in new set of federal administration.

Introduction

Ecosystem services, as defined by the Millennium Ecosystem Assessment, are 'the benefits people obtain from ecosystems' (MA, 2005). The services that ecosystems provide are generally classified into four types: provisioning services (food and water), regulating services (regulation of flood, drought, diseases), cultural services (recreational, spiritual/religious) and supporting services (soil formation and nutrient cycling). The health of ecosystems and the services provided by them play a crucial role in human survival and wellbeing (Diaz et al., 2018). However, excessive demand for ecosystem services arising from rapidly growing human population and several anthropogenic activities have led to the extensive modification of vital ecosystems of the world (Burkhad et al., 2010). Ongoing development in the Asia Pacific region has resulted in loss of natural capital, which is replaced with built capital (Kubiszewski et al., 2013), destroying ecosystem services in the long run. Recently, the value of ecosystem services for terrestrial ecosystems in 47 countries in the Asia Pacific region was estimated to be USD 14 trillion/yr including non-marketed resources that are excluded in GDP. Kubiszewski et al. (2016) applied the four Great Transition Initiative archetypes scenarios: (1) market forces (MF); (2) fortress world (FW); (3) policy reform (PR); and (4) great transition (GT), to estimate the changes in the value of terrestrial ecosystem services for the period up to the year 2050. According to the study, it is projected that there is a continuous decline of the ecosystem services value in the region from USD 14 trillion/yr in 2011 to USD 11 trillion/yr in 2050 under the MF scenario and USD 9 trillion/yr in 2050 under the FW scenario. However, the value remains the same in 2050 under the PR scenario while the value is expected to significantly restore to USD 17 Trillion/yr under the GT scenario (Kubiszewski et al., 2016). This has generated global concerns as this undermines ecosystem functioning and resilience and thus threatens the ability of ecosystems to continuously supply a flow of services. Furthermore, the United Nations' Sustainable Development Goals can only be met when ecosystem degradation is halted and further loss of ecosystem services is controlled, and only if the natural capital and assets can be utilized in a sustainable way. Therefore, regional, national and local assessments of ecosystem and their services are needed to identify and develop an effective policy in response to ecosystem service degradation.

The concept of ecosystem services dates back to the mid-1960s and early 1970s. However, the concept gained prominence in scientific and global communities after the publication of the Millennium Ecosystem Assessment (MA) and evolved substantially in the recent decades (Chaudhary et al., 2015). The MA highlighted the importance of ecosystem services to human wellbeing and showed that anthropogenic activities have affected the natural processes and diminished the capacity to provide services for future in many parts of the world. With the release of the MA, the number of publications on the subject has progressively increased (DeGroot et al., 2012; Chaudhary et al., 2015). Continuous efforts are being made to integrate the concept into everyday planning, policies and decision making (Chaudhary et al., 2016, 2017). Globally and regionally, mountains are most fragile, yet they are rich repositories and providers of ecosystem goods and services on which downstream communities rely (Chettri et al., 2010). However, integrating the concept into everyday practice remains a challenge because of the limitations of the methodologies available for understanding ecosystem services .

Ecosystem Services Perspective in the Hindu Kush Himalaya

The HKH, spanning over 4.3 million sq. km. includes the whole of Nepal and Bhutan and some parts of Afghanistan, Bangladesh, China, India, Myanmar, and Pakistan. The region has been identified as one of the most important conservation priority regions of the world (Brooks et al., 2006). The region is endowed with rich natural resources; it not only houses magnificent flora and fauna but also provides valuable ecosystem services to people in Asia and beyond (Schild, 2008; Murali et al., 2017; Kandel et al., 2018). Approximately 39% of the area of the HKH is managed as protected areas (Chettri et al., 2008) and most recent estimates show that throughout the HKH the land cover is as follows: 14% forest, 26% agriculture (including areas with a mixture of natural vegetation), 54% rangeland and scrubland, 1% water bodies, and 5% permanent snow cover (Singh et al., 2011). The Himalaya – the water tower of Asia – is the source of 10 major river systems that support water supply, food production, biodiversity, and energy generation in the region and beyond. The welfare of around 2 billion people in the uplands and downstream lowlands is thus inextricably linked with natural resources found in the HKH. However, these

ecosystems, like any other ecosystems in the world, are not exempted from the impacts of anthropogenic activities like over-exploitation and unsustainable use of natural resources due to rapidly growing human population and haphazard infrastructure development. Enhancement of economic development together with the change in the population dynamics and gradual land use/cover change are influencing the health of ecosystems and consequently the quality of services they provide. The challenge is compounded by the impact of global climate variability and change, which has not only affected the provision of valuable ecosystem services but also increased the vulnerability of mountain communities to natural disasters.

It was observed that about 85% of the households in Barshong *gewog* in Bhutan are directly dependent on forest, agriculture and freshwater ecosystems for provisioning services for their livelihoods and income (Kandel et al., 2018). This provides an indication of the level of pressures faced by these ecosystems in the eastern Himalayas. Furthermore, threats from various drivers of change, including climate change, pose additional risk. It is plausible that local warming can have a varying degree of impacts on different ecosystems of the Himalayas and possibly affecting the human wellbeing. Monitoring the state and dynamics of ecosystems that have varying degrees of vulnerability can help ensure the growth of biodiversity for the future generation (Chettri et al., 2010). A case study from the Mai Pokhari area in eastern Nepal reveals that benefit sharing related to ecosystem services can be uneven in terms of caste, income and gender in spite of social equity provisions built into policy and institutional structures (Chaudhary et al., 2018).

Nevertheless, despite the multi-dimensional (ecological, socio-cultural and economic) importance of ecosystems to human society, there have been no serious efforts to assess the ecosystem services of the HKH (Rasul et al., 2011). Benefits provided by ecosystems are inadequately recognized and resource users do not take into account the cost of degradation of these services in their resource management decisions. Also, there is very limited understanding of ecosystem dynamics and the values that are being lost through degradation.

In this regard, 'Rural Livelihoods and Climate Change Adaptation in the Himalayas' financed by the European Union (EU) and coordinated by ICIMOD aims to enable and promote equitable and sustainable wellbeing of the people in the HKH. The specific objective is to support the development of mountain rural livelihoods in the context of socio-economic and climate change, and the conservation of HKH ecosystem assets and services, through active regional cooperation. Specifically, the programme aims to work to reduce poverty, increase the resilience of local communities, and ensure equitable and sustainable wellbeing of men and women in the HKH by building the capacity of local institutions, promoting new livelihood options, and encouraging regional cooperation in the promotion of equitable approaches to sustainable mountain development. The programme has been implemented through five main areas: building the capacity to formulate adapted policy; expanding knowledge management; strengthening collaborative action research; piloting activities for climate change adaptation; and capacity building. As mentioned in the Himalica project document, one of the objectives of its policy component is 'Enhancing the knowledge base on Himalayan ecosystem services allowing an improved capacity to demonstrate its value and to monitor their evolution and support the use of ecosystems services such as landscape and biodiversity for recreational activities with direct community involvement and benefits'.

The main objective of this study is to understand the state and dynamics of ecosystems and their linkages to human wellbeing in the project site and ensure mainstreaming of the knowledge into planning and development strategies. Specific objectives are:

- Identify and assess ecosystems from the study areas and prepare technical reports.
- Develop, share and mainstream the knowledge products for effective planning and management of ecosystems.

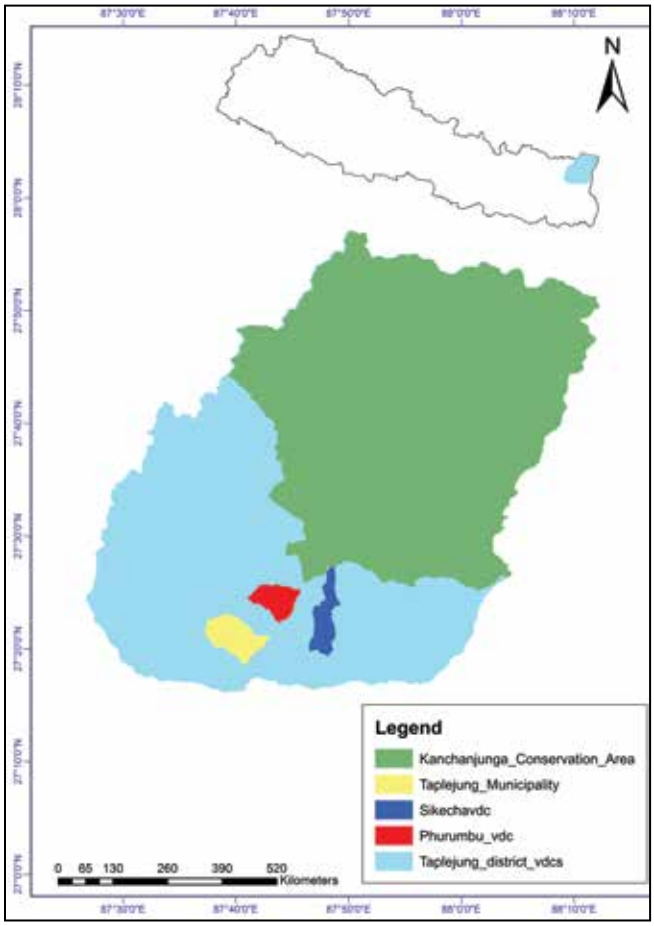
This study is expected to contribute significantly to ICIMOD's Transboundary Landscape programme, mainly Kangchenjunga Landscape Conservation and Development Initiative (KLCDI), by building the capacity of KLCDI key stakeholders such as the District Forest Office (DFO), Kangchenjunga Conservation Area Management Council (KCAMC), local NGOs and many other relevant institutions. The findings of the assessments were shared with relevant stakeholders mentioned earlier; it is expected that they will use the findings to assess and monitor the ecosystems of the area. Furthermore, the findings are expected to inform their annual action plan for ecosystem management related activities and help fulfill Himalica's aim to ensure uptake and out-scaling of project interventions at the transboundary level. Therefore, to attain the aforementioned 'Ecosystem Services' element, ICIMOD conducted the Ecosystem Service Assessment in Himalica pilot sites in Taplejung District.

2. Study Area

Taplejung district in the province number one covers an area of 363,700 hectares. It borders India on the east and China on the north; Terathum and Panchthar districts lie to the south and Sankhuwasabha district to the west. According to National Census 2011 the total population of the district is 127,461; and the population is spread across 1 municipality (also called Taplejung) and 48 VDCs. A total of 27,551 ha is available for agriculture in the district, of which around 82% or 22,500 ha is currently being used[1]. The district has 10,955 ha of irrigated land of which 5,255 ha is irrigated all year round and 5,700 ha is irrigated seasonally. About 190,403 ha of the total land is covered by forest and pasture.

According to DPMAS (2007), 45 VDCs in the district fall under the 'poor' category and 5 under 'very poor'. The district does not have any 'less poor' or 'well-off' VDC. Statistics on spices cultivation in the district shows an area of 4,500 ha under cardamom of which the productive area is 4,150 with an annual production of 2,490 MT. The productivity worked out 0.6 MT per ha. The productivity of Taplejung is very high compared to the national figure of 0.45 MT/ha (agriculture statistics). (Source: Statistical year Book 2013/14, Ministry of Agriculture Development).

Figure 1: **Map of Taplejung District with Sikecha and Phurumbu VDCs and Taplejung Municipality**



Pocket areas for large cardamom cultivation in the district are Taplejung Municipality, Niguradin and Sawa, Dhungesanghu, Phurumbu, Sikecha, Tiringe, Lelep, Tellok, Tapethok, Libang, Ikhabu and Surungkhim VDCs. Among these Himalica Project covers Taplejung Municipality, Phurumbu VDC and Sikecha VDC (Figure 1). The population, number of households and population in the project area is summarized in Table 1.

The District Agriculture Development Office (DADO) is the major government service provider. It renders various services in the form of extension services and grants for infrastructure development under its regular programmes. There are four agriculture service centres in the entire district. While DADO itself provides services to Taplejung Municipality and Phurumbu VDC, the Thechambu Agriculture Service Centre provides services to farmers of Sikecha VDC. Apart from government service centres, agro vets located at the district headquarters and other development projects also offer extension services to the farmers at specified locations.

Table 1: **Household demography of Himalica Project working area**

VDC/Municipality	Working area of Himalica Project	Total HH	Population	Women	Men
Taplejung Municipality (former Phungling and Dokhu VDCs)	Ward # 3, 4 & 6	4,480	19,085	10,037	9,048
Phurumbu VDC	Ward # 2, 4, 5, 7& 9	493	2,413	1,268	1,145
Sikecha VDC	Ward # 6 & 8	417	2,250	1,184	1,066
Source: HURDEC, 2016					

[1] For Nepal Total Cultivable Area 2,641,000 ha; Irrigable Area 1,766,000 ha and Total Irrigated Area 1,331,521 ha (Source: Statistical Information On Nepalese Agriculture, 2013/2014)

3. Methodology

The ICIMOD team prepared a multi-structured draft questionnaire deploying sets and subsets of indicators and values after vigorous consultations. The questionnaire was designed in accordance with the goals and objectives of the ESA component of the study. Experts and community members were directly involved in the assessment through household surveys (Chettri et al., 2014). Enumerators for the household survey were oriented on the final questionnaire and trained on their primary and secondary roles during the survey. An enumerators' training on PRA tools (mobility mapping, focus group discussion, key informant survey, pair-wise ranking) following Karki et al. (2014) and on the household questionnaire was organized at Machhapokhari, Phungling Municipality ward # 4 prior to the household survey. The household survey draft questionnaire was pre-tested in the field and further revised.

Following the orientation of enumerators, two rounds of VDC-level PRA were organized at Sikecha, ward # 6 and Bajhogara, Phungling, ward # 6. Data and information on major ecosystems, major crops cultivated, provisioning services, socio-culturally and ecologically valuable plant and animal species were collected. Three wards (administrative units of a VDC), ward # 3, 4 and 6 of Taplejung Municipality, five wards (ward # 2, 4, 5,7 and 9) of Phurumbu VDC and two wards (ward # 6 and 8) of Sikecha VDC – which is a large cardamom treatment area for Himalica Pilot Project – were selected as the study area. Altogether 250 households (92%) out of the total 271 involved in community-level commercial production of large cardamom (Himalica Pilot Project treatment group) were sampled. The Nepali language was used while conducting individual household interviews and administering the questionnaires, which required an hour per household. Completed questionnaires were collected and cross checks for discrepancies were carried out through close consultation among enumerators. Social mobilizers (staffs and local people coordinated by the staffs from ECDF) assisted the enumerators to reach each household and arranged face-to-face interviews with household members.

The data collected through the household questionnaire survey were entered into a data entry format designed with the SPSS Statistics software package. The data was processed for plausibility checks to control entry errors and inconsistencies in order to guarantee data quality. The survey data was analysed deploying the SPSS version 20.0 software package. The frequencies procedure was conducted for obtaining summaries of individual variables. Overall, two basic methods, numerical and graphical, were followed. The numerical approach statistics computation, such as the mean and standard deviation, was obtained, which conveys information on the average degree of shyness and the degree to which people differ in shyness.

3.1 Ecosystems and Ecosystem Services Assessment

Three major ecosystems – forest, agricultural, and freshwater – were identified through the PRA. An extensive list of ecosystem goods and services obtained and derived from these ecosystems was prepared based on the literature review and PRA outputs. These ecosystem services were categorized into provisioning, regulating, supporting, and cultural services, following the Millennium Ecosystem Assessment (MA, 2005) framework. Provisioning services included fuelwood, fodder, grazing, timber/poles, leaf litter, medicinal plants, ornamental plants, wild edible fruits and vegetables, mushrooms, fibre, thatch, bush meat, dyes, paddy, cereals, vegetables, fish, drinking water, bathing water, irrigation water, boulders, and sand. The regulating services were classified as carbon sequestration, climate regulation, flood control, groundwater recharge, nutrient enrichment, pest regulation, pollination, seed dispersal, soil fertility, soil formation, soil stability, waste treatment, and water purification and retention. The supporting services were identified as ecosystem resilience, habitat for species, hydrologic cycle, and soil formation. Cultural services included aesthetic beauty, ecotourism, education and research, recreation, nature worship, and spiritual enrichment.

Based on the community's perception of the degree of importance and level of dependency, these goods and services were ranked as high, medium, and low. Goods and services that were widely used and essential for local subsistence were ranked high; those preferred by the community were ranked medium; and those considered optional by the community were ranked low. Similarly, some socially, ecologically, and culturally important plants, animals, and sacred places (sites) were also identified through the PRA. The community's perceived significance of those plants, animals, and sacred places, including the three important ecosystems, was ranked very important, important, moderately important, less important, and not important.

3.2 Geospatial Analyses

For the land use and land cover change analysis, efforts were made to map the study area using three different time series images from 1992, 2002, and 2010. The idea was to detect the change in, and status of, land use cover and the changes that have taken place, particularly in forested and agricultural land, over the period, using both GIS and RS data. Subsequently, an attempt was made to project the use of the identified ecosystem services in the area over the same period. Medium spatial resolution satellite images from Landsat were used from 1992, 2002, and 2010 and further rectified using Google eye images from 2014 to generate the land cover maps. The land use categorization was defined using the standard land cover protocol. The land cover information derived consisted of pre-processing and classification using object-based algorithms.

In this study, Landsat 30 m spatial resolution (185 x 185 km swath), ortho-rectified and cloud-free thematic mapper (TM), enhanced thematic mapper plus (ETM+), and Landsat 8 images were used for land cover mapping and change detection between 1992, 2002, and 2010. All images were downloaded from the United States Geological Survey (USGS) archived data portal. The whole study area lies within 13 fully or partially covered Landsat images (each scene 185 x 185 km). The shuttle radar topography mission (SRTM), one arc second (30 m) digital elevation model (DEM), with add-on products such as slope and aspect, was used for the topographic information as well as identification and mapping difference in land cover classes. Base layers with district, physiographic, and settlement points in geographic information system (GIS) format were used both as baseline information for the maps and land cover extraction and analysis.

Land cover maps for 1992, 2002, and 2010 were prepared from analysis of the Landsat TM, ETM+, and Landsat 8 images using geographic object-based image analysis (GEOBIA). The detailed methodology used to prepare the land cover maps is described in Uddin et al. (2015). Briefly, eCognition Developer software was used to divide the

image into segments. A multi-resolution segmentation algorithm was applied, in which homogeneous areas resulted in larger objects and heterogeneous areas in smaller ones. Information on the spectral values of image layers, vegetation indices, Normalized Difference Vegetation Index (NDVI), and a land water mask was used in the analysis. Six land cover classes were mapped for the comparison and further analysis on ecosystem services.

Following Chaudhary et al. (2016) in ArcGIS environment, the land cover was analysed and interconnected based on the sum scores for provisioning, regulating, supporting, and cultural services. Values were obtained from the SPSS data generated after the completion of the household survey, in which the respondents shared their routine resource dependency on, and usage of, the various services drawn from the different ecosystems. Projection to land use and land cover maps for 2030 was mapped setting up modelling.

3.3 Livelihood Vulnerability Assessment

To assess livelihood vulnerability, information was collected on inaccessibility, fragility, marginality, biological niches, and human adaptation mechanisms. A focus was placed on thematic areas like food security; productivity; long-term changes in basic facilities of health; education; communication; and electricity; accessibility to ecosystem services and goods; crisis/shocks; and the community's coping strategies to overcome those crises.

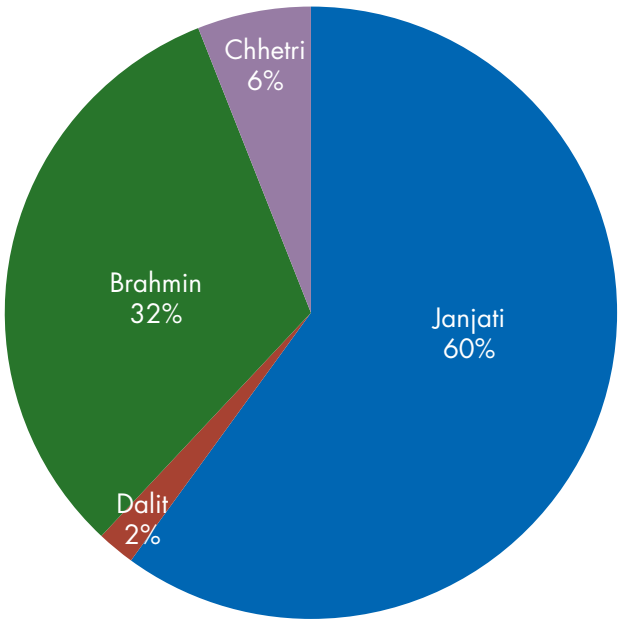
4. Results

4.1 Socio-economic Profile

In the sampled 250 households, 57% of the respondents were male and 43% were female. In terms of ethnicity the respondents were predominantly Janajati (60% of the total survey population). Among the Janajati, the majority belonged to the Limbu ethnic group, with surnames such as Sauden, Lechharbo, Maden, Yanbago, Laxamba, Phurumbu, Yanden, Yawagu etc. Among other communities, Dalits made up the smallest proportion (2%). The Tamang, Sunuwar, Gurung and Sherpa communities were also found to be residing in the study area (Figure 2). Basic service available are provided in Box 1.

In terms of age, most of the respondents were young, which indicates that the socio-economic condition of the area is satisfactory. The highest frequency of age groups was 40-49 years (Figure 3).

Figure 2: **Ethnicity of respondents**



Box 1: Basic services available in the study area

Health: When local people in the area fall ill, they do not immediately go to hospital. They first turn to priests and shamans and/or use medicinal plants and other products based on their traditional knowledge. Only if this does not work do they visit the hospital, generally the government hospital in Taplejung bazaar, Phungling Municipality. Depending on the patient's condition, the hospital refers them to hospitals in Jhapa, Dharan, Biratnagar and even to Siliguri, a city at the Nepal-India border in the state of West Bengal, India. If the patient is serious and the disease cannot be diagnosed, they are taken to hospitals in Kathmandu or other cities in India.

Employment: There are plenty of local employment opportunities in the area. A male agricultural labourer is paid NPR 250-500 per day and a female labourer is paid NPR 150-250 per day for household and construction works. In addition, they get food from the employing households on the working day(s). However, local people temporarily or permanently migrate to India to join the Indian Army and to find other work. They also go to Malaysia and Middle East as migrant labourers. Some have served in the British Army and are based in the UK.

Technical support (agriculture): Local people visit Agrovets at Phungling Municipality for seeds, fertilizers and pesticides. Although the District Agriculture Development Office (DADO), Taplejung is the main service provider for local farmers, it seems the farmers in the area have either not received support from the DADO, or they are reluctant to visit and seek support from the DADO.

Education: Most children in the village attend the local government school (Bhanu Secondary School) and Navajyoti English Boarding School. After finishing school, they pursue higher studies in Phungling Municipality or move to Biratnagar, Dharan, or Kathmandu within Nepal or to India for higher studies.

Market: Veterinary Chowk in Taplejung Bazaar is the central hub where locals buy and sell goods. They sell local agricultural products including husbandry products and buy rice, utensils, electronics, clothes and apparels, etc.

The average annual income of the households in the area is about NPR 150,000. However, a few households earn more than NPR 350,000 annually (Figure 4). Agricultural produce and livestock are the major sources of income for the majority of households (Tables 2, 3; Figure 5). Large cardamom cultivation has been supporting rural livelihood, as it has the highest annual production value (Table 2). Most households cultivate cardamom in large areas (0.7 ha and more, Table 4). In addition, livestock rearing is aiding the local economy. This indicates cardamom cultivation has also been extended to agricultural terraces that were previously under crop cultivation (Table 5; Box 2). However, negative impacts are also perceived.

Figure 3: **The age group of respondents**

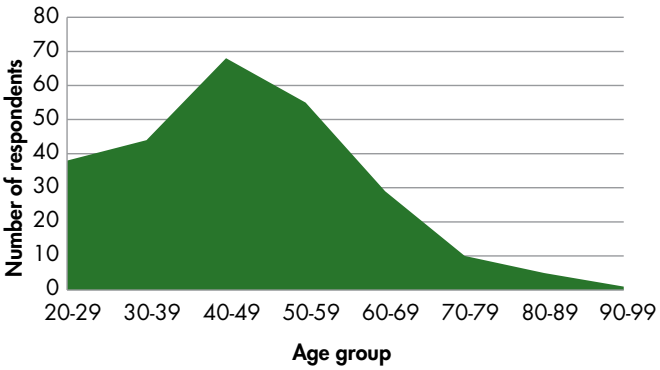
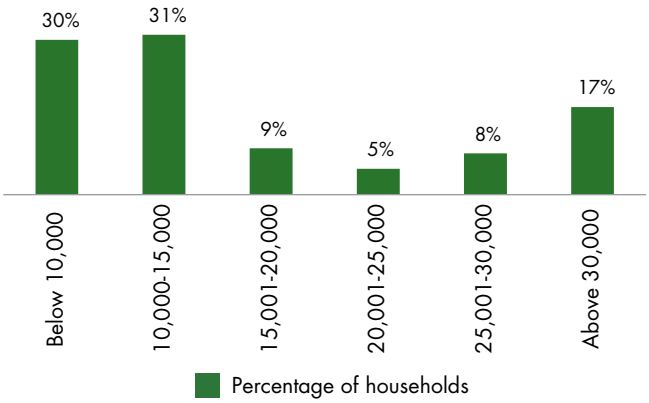
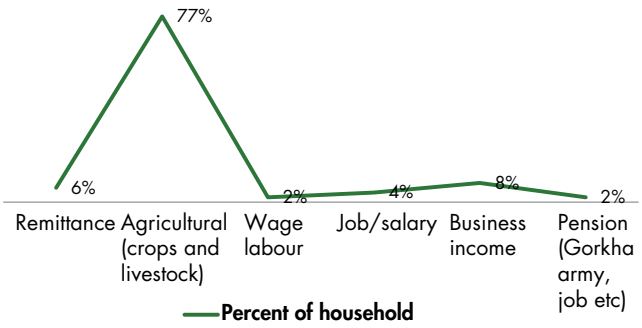


Figure 4: **Average monthly HH income**



Source: HURDEC, 2016

Figure 5: **Major source of HH income**



Source: HURDEC, 2016

Table 2: **Annual production value of agricultural produce**

Agricultural produce	# of HH	Total value	Percentage value	Mean
Cardamom	259	49,579,256	80	191,426
Intercrop products, for example, beans	8	96,100	0	12,013
Livestock and livestock products	205	6,255,499	10	30,515
Other agricultural crops	223	6,180,699	10	27,716

Source: HURDEC, 2016

Table 3: **Annual sales value of agricultural produce**

Agricultural produce	% of HH	Total value	Percentage value	Minimum value
Cardamom	259	46,526,864	92	2,000
Intercrop products, for example, beans	1	1,000	0	1,000
Livestock and livestock produces	126	2,900,000	6	1,000
Other agricultural crops	32	1,301,002	3	2
Total		**50,728,865**		

Source: HURDEC, 2016

Table 4: **Size of cardamom farm**

Cardamom farm size	# of HH	Percentage of HH
Below 0.2 ha	50	18.50
0.2 ha to below 0.45 ha	45	16.60
0.45 ha to below 0.7 ha	51	18.80
0.7 ha or more	125	46.10

Source: HURDEC, 2016

Table 5: **Impact dynamics of large cardamom enterprise in the study area**

Impacts upon	Positive Impact	Negative Impact
1. Socio-economic sector		
1.1 Livelihoods	High economic benefit Purchasing power increased	High expenses Migration (education, health, other opportunities) to town, cities from rural areas
1.2 Development	Education and health facilities within people's reach Road and track construction with community's investment Micro-hydro projects Well-managed drinking water supply Travel facilities Commodities easily supplied	Road damaged due to excessive water flow (unmanaged irrigation) from cardamom farms Less water flow on head streams and springs dry out Tour and trekking shortened and disturbed
2. Biodiversity		
2.1 Forest	Private forest and wood land increased Pressure on national forest for fuelwood, fodder, timber decreased	Logs of Nepal Black Cedar Cedar timber is transported to towns and cities Forest encroachment (community forest) Monoculture (private forest)
2.2 Natural hazards	Soil erosion, landslides decreased due to crown and ground cover extension Forest fire reduced	Prone to landslides due to unmanaged irrigation
2.3 Agriculture		Crop production decreased substantially Risk of food security increased; Dependency on market for food sources increased Feeding habits shifted from millet and corn to rice (staple food) Honey production is not satisfactory. Pasture land decreased (sheep, high altitude animal husbandry affected)
2.4 Wildlife	Less disturbance faced by natural habitat Co-existence of wild animals in private forest Habitat development for wild animals	Human-wildlife conflict increased due to depredation of cardamom Habitat loss for some species such as jackal, fox and hare Himalayan cliff bee disappeared from the area due to decrease in flowering plant diversity and monoculture and increased pesticide use
3. Agriculture land use change		
3.1 Crop farming	High income generation	Traditional subsistence crop farming reduced Agricultural land encroachment (converted to cardamom farm) High risk and vulnerability of crop damage
3.2 Livestock rearing	Change in stall feeding practice; Grazing pressure reduced in the forests and rangelands (natural hazards reduced)	Animal husbandry (livestock production) declining

Box 2: **Impact of large cardamom cultivation on agriculture and food security in Taplejung**

For a year and two, large cardamom price hiked, which enticed local farmers to shift from traditional agricultural practices of crop cultivation to agro-forest (cash crop). In 2016, annual production value of cardamom is eight times greater than agricultural crops and livestock products. Whereas the annual sales value of large cardamom constitutes 92% of the total sales value of agricultural produce, annual sales value of other agricultural crops and livestock products cover 3% and 6% respectively. Therefore, large cardamom enterprise has been a major primary source of family income in the area.

Nearly half of the households in the Himalica Pilot project intervention area has large cardamom farm covering an area of 14 ropanis or more. This indicates that most of the households have converted their crop-farming land into large cardamom cultivation. Although some of the households are still continuing crop production for subsistence, shade from the adjoining large cardamom farm and poor production is hampering their efforts. There are several hurdles in the area for crop farming. Labour cost for farming has increased due to the large cardamom enterprise. As crop farming is labour intensive and labour cost has increased, investment in crop farming has become unprofitable. In terms of labour investment and cost-benefit scenario, large cardamom cultivation requires less effort and has higher value than other crops. Local farmers are hence interested in expanding large cardamom cultivation in their agricultural lands.

Until a few years ago, agricultural land was used to grow permanent cereal crops such as paddy and wheat (in irrigated land), and maize, millet, soybean and buckwheat (in un-irrigated land). These lands are now mostly covered by large cardamom. Most of the households used to sustain their livelihoods through traditional farming in their own land (irrigated and un-irrigated). Some of the households used to sell their surplus crop and earn an income to meet other expenses.

The worst impact of the cardamom cultivation enterprise in Taplejung is that most of households are dependent on rice transported from different parts of Nepal and India. These households borrow rice from merchants in the villages and municipality and give cardamom in return. Food habits of the local people are also changing. In the past, staple diet consisted of maize and millet; now it has changed to rice and other packaged food.

Cardamom cultivation has also had an impact on livestock rearing. Farmers do not use organic manure for cardamom cultivation As a result livestock rearing is declining. However, some households still rear livestock for the production of milk and meat, which they consume themselves and also sell to make extra income. Apart from the mid-hills, which are largely covered by large cardamom farms, cardamom cultivation has encroached on pastureland in higher elevations too, and this has direct impact on sheep and cattle grazing and rearing.

In case of bee-hive farming, due to the use of pesticides in the cardamom farms, attacks by the wasp to honey bees in the cardamom farm and not many varieties of flowering plants in the cardamom farms as in the forests, honey bee has been leaving their hives and honey production is not satisfactory.

4.2 Status of Ecosystems and Dependencies

Three major ecosystems were identified in Taplejung District: forest, agricultural, and fresh water ecosystems. These ecosystems provide several goods and services that contribute in sustaining local livelihoods. Many people (94% of the total households) reported that forest cover has increased over the past ten years, as shown in Tables 6 & 7. Land use change due to the expansion of large cardamom cultivation can be a plausible reason for increase in forest cover. However, the forest regenerated in this cultivation is monoculture agro-forest dominated by Nepal Black Cedar (*Alnus nepalensis*) and Chilaune (*Schima wallichii*). Meanwhile, the primary forests or government forests have decreased.

In contrast, 98% of the total households reported that extensive conversion of agricultural lands (terraces) into agro-forestry systems (large cardamom cultivation) has led to the decline of agricultural lands, which were previously used for crop cultivation (Tables 6 & 7).

In the case of fresh water ecosystem, local people (85% of the total households) perceive decrease in the flow of streams, rivulets and river (the Tamor and Kabeli). Despite the expansion of forest cover in the area, drying of head stream source "*mool*" and ponds has directly influenced the flow of water. In addition diversion of water from its course for household utility, irrigation and micro-hydro projects has affected water flow. Even the water channels dry out during the dry and winter season. Communities in the study area believe that earthquakes and road construction have led to the drying of more water sources compared to the past. Communities have been witnessing heavy rainfall within a narrow span of time and with longer drier days than before (Box 3). Some of them reported that snowfall has shifted to higher elevations. It means their nearby surroundings are not getting snowfall anymore; however, snowfall occurs in upper elevations. Climate change may be a plausible cause behind this. A few people say they have not observed any changes in the ecosystems over the last ten years (Tables 6 & 7).

Table 6: **Status of ecosystems in the study area (based on public perception and enumerators' observations)**

Type of Ecosystem	Driver and Pressure	Indicator	Overall condition
Forest	Pressure reduced on national and community forests for fuelwood, fodder, timber and grazing	Greenery enhancement in the area; crown cover and ground cover increased	National forests and community forests degraded; private forests increased
	Encroachment for large cardamom farming	Mixed forest is restricted to distant and inaccessible area from the households	
	Change in livestock rearing practice from open grazing to stall feeding	Natural hazards (forest fire, soil erosion, landslide) reduced	
Agricultural	Land use change from cropland to large cardamom farm	Land cover expanded (before, the area used to be open and houses could be clearly seen from a distance, but now houses are not seen even from a close distance as the canopy and ground cover has increased due to large cardamom farm in the surroundings); distance travelled and time required for fodder, fuelwood and timber collection reduced	cropland decreased; agro-forest, especially cardamom farms, increased; dependency on fodder, fuelwood and timber shifted from national and community forests to agro-forest
	Encroachment on cropland	Dependency of the local community on local market for the food, vulnerability of food security	
	Change in livestock rearing practice from open grazing to stall feeding	Greenery enhancement in the area; crown cover and ground cover increased; Natural Hazards (forest fire, soil erosion, landslide) reduced	
Freshwater	Demand for irrigation; supply for household utility	Head streams dry out; water flow reduced in springs and streams	Decreased
	Climate change	Erratic precipitation; snowfall occurs at much higher elevations, and areas that had been receiving snow for the past 20 years no longer get snowfall	

Among the three ecosystems the communities residing in the study area are heavily dependent on agro-ecosystem (77% of the total households), as depicted in Figure 6. In this report, agro-ecosystem includes agro-forestry practices of large cardamom cultivation with interspersed trees that provide day-to-day basic needs such as fuelwood, timber, fodder, cash crops, cereals, vegetables and fruits. However, these cash crops, cereals, vegetables and fruits are depredated by wildlife. Agro-ecosystem also

Table 7: **Perceived change in ecosystems as reported by respondents**

Ecosystems	Increasing	Decreasing	No change
Forest	94%	4%	2%
Agricultural	0	98%	2%
Freshwater	7%	85%	8%

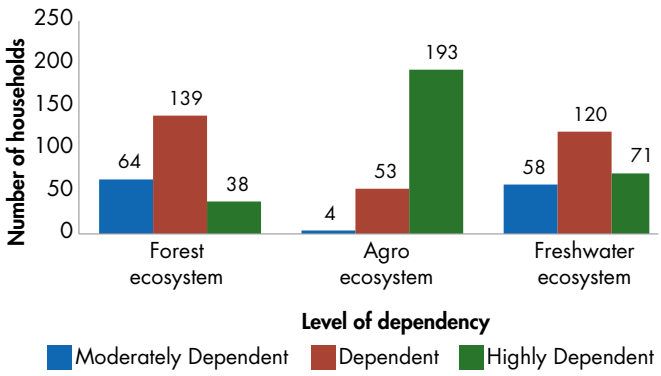
Box 3: **Climate change can affect large cardamom cultivation**

Erratic precipitation (higher in wet seasons and lower in dry season) will directly impact the ultimate harvest of large cardamom. Too much irrigation in cardamom farms during the wet season will result in tangible effect (landslides) and intangible effect (nutrients deficiency), whereas insufficient water for irrigation during the dry season will suppress the growth of cardamom saplings and plants. Precipitation (especially hailstone) has been damaging the crop, right from flowering to harvest.

Large cardamom farm at Ose village that was damaged by hailstones

includes livestock rearing, which is also depredated by wildlife (Table 8). Since the local people are sustaining their livelihood through crop cultivation in agricultural land and in the agro-forestry system, crop depredation is quite obvious. However, respondents ranked forest ecosystem under 'moderately dependent'. Local people collect timber, wild edible fruits (ainselu, kafal, katus, okhar, mayal, chiuri, etc.), wild vegetables (fern, nettle, mushroom, young bamboo shoot, yam and lichen) and medicinal herbs (*satuwa*, *chiraito*, *budo okhati*, etc.) from the forest.

Figure 6: **Dependency on different ecosystems**



Although, water is an essential part of day-to-day life, the respondents reported that they are just dependent on freshwater ecosystem. Communities are dependent on fresh water ecosystem for the household utility (drinking, washing and bathing) as well as for irrigation.

Provisioning services in acknowledged by 59% of household followed by 19% on regulating services. It is widely bestowed and consumed services amongst four ecosystem services delivered by three ecosystems in the area (Figure 7).

4.3 State of land use land cover

Remote sensing maps depict conspicuous changes in three major types of land cover in Taplejung District: forest, agricultural, and freshwater (Figure 8; Table 9). Overall, within the time period of 1996 to 2015 (20 years), forest ecosystems, which includes government-managed forests and community managed forests (CFUGs), have decreased slightly. Agro-ecosystem, which includes agro-forest enterprises such as large cardamom plantation and crop farming terraces, has been increasing significantly. Freshwater ecosystem is also decreasing for the most part. Settlement and 'other' land uses, which include settlements and barren lands, are decreasing, but to a lesser extent. While settlements have been increasing year after year, barren lands have been decreasing each year. These lands are either utilized for agro-forest enterprises or occupied by settlements.

In Phurumbu VDC during the year 1996, the forest covered more than 90% (2,593 ha) of the total land

Figure 7: **Composition of ecosystem services in the study area**

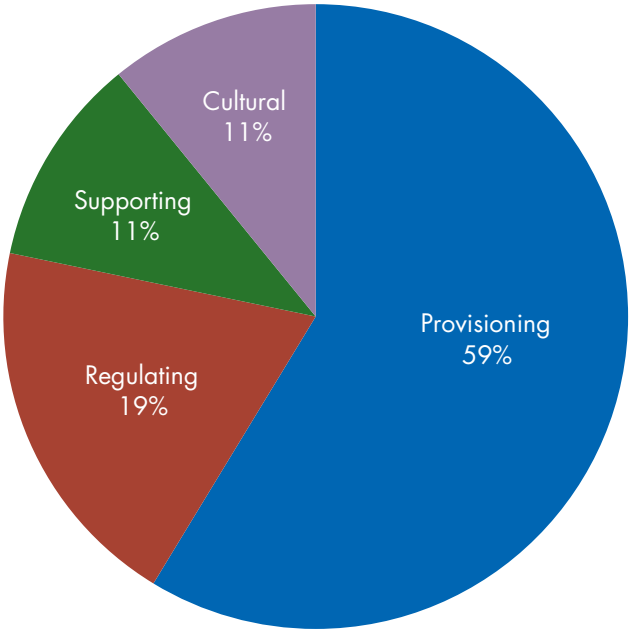
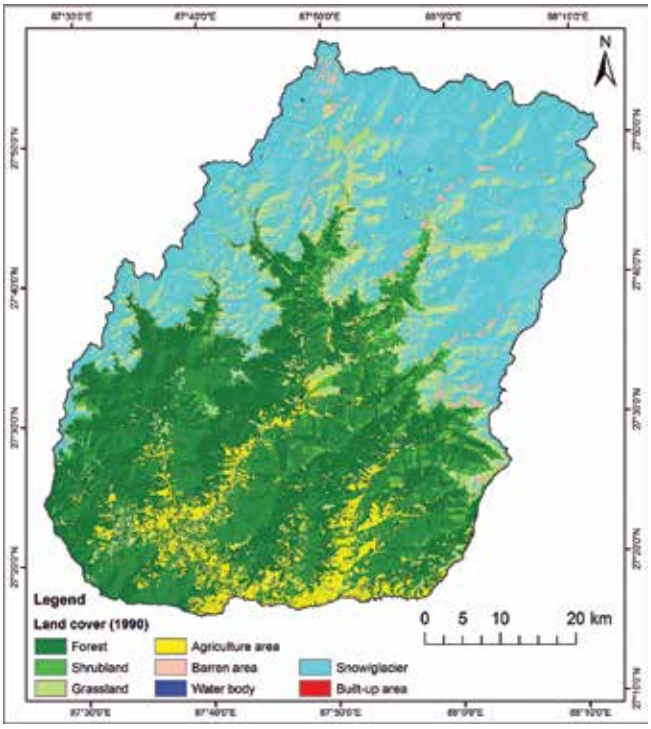
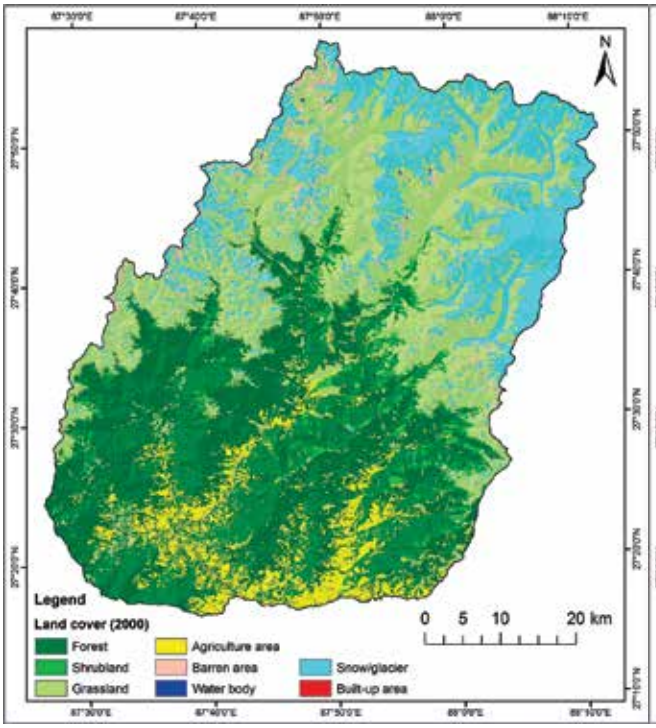


Figure 8: **Map showing land cover types in Taplejung District in 1990, 2000 and 2010**





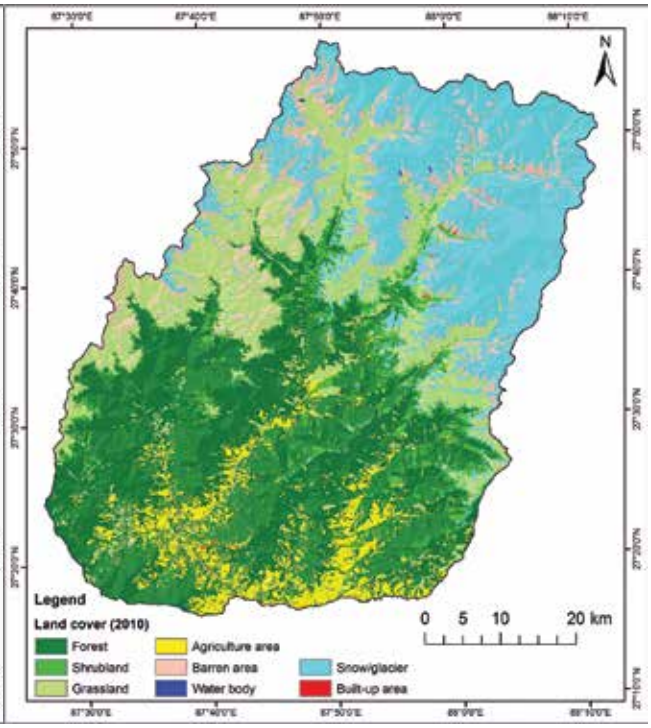


Table 8: **List of wildlife that damage cash crops, cereals, vegetables, fruits and livestock in the study area**

Species	Common Name	Damaged resources
Callosciurus pygerythrus (I. Geoffroy Saint Hilaire, 1832)	Hoary-bellied Squirrel	Fruits
Canis aureus (Linnaeus, 1758)	Golden Jackal	Livestock
Dremomys lokriah (Hodgson, 1836)	Orange-bellied Himalayan Squirrel	Fruits
Felis chaus (Schreber, 1777)	Jungle Cat	Livestock
Herpestes auropunctatus (Hodgson, 1836)	Small Indian Mongoose	Livestock
Herpestes edwardsii (È. GeoffroySaint-Hilaire, 1818)	Indian Grey Mongoose	Livestock
Hystrix brachyura (Linnaeus, 1758)	Malayan Porcupine	Cereals, cash crops, vegetables
Macaca assamensis (M'Clelland, 1840)	Assam Macaque	Cereals, cash crops, vegetables, fruits
Macaca mulatta (Zimmermann, 1780)	Rhesus Macaque	Cereals, cash crops, vegetables, fruits
Martes flavigula (Boddaert, 1758)	Yellow-throated Marten	Livestock
Muntiacus vaginalis (Zimmermann, 1780)	Barking deer	Cereals, cash crops, vegetables,
Paguma larvata (C.E.H. Smith, 1827)	Masked Palm Civet	Cash crops, vegetables, fruits
Petaurista magnificus (Hodgson, 1836)	Hodgson's Giant Flying Squirrel	Vegetables, fruits
Semnopithecus schistaceus Hodgson, 1840	Nepal Grey Langur	Cereals, cash crops, vegetables, fruits

Table 9: **Summary of Landsat classification area statistics for 1990, 2000, and 2010 for Taplejung District**

ID	Land cover	Year 1990		Year 2000		Year 2010		LC Change %
		Ha	%	Ha	%	Ha	%	(1990-2010)
1	Forest	151,584.4	36.85013	143,281.5	34.83171	144,566.2	35.14401	-1.706122995
4	Agriculture	23,444.28	5.6993	26,307.81	6.395423	25,182.36	6.121827	0.422526895
6	Freshwater	165.6	0.040257	196.38	0.04774	202.05	0.049118	0.008860988
	Total	**411,353.7**						

(2,838.69 ha), and just 8.64% (245.25 ha) of the total land was utilized for the agro-forest enterprise and crop farming. Freshwater and settlements covered an insignificant proportion of the land. By 2005, agricultural land had increased by about 4% due to the conversion of forest land. Between 2005 and 2015, about 3% of the forest was further occupied for agro-practices (Figure 8). Ostensibly, encroachment of forests for agro-forest practices, for example, large cardamom (*Amomum subulatum* Roxb.) plantation, has changed the land cover. There have been no significant changes in other land use types such as settlements and freshwater. However, there are visible signs of the expansion of settlement, though any expansion may be balanced out by the temporary and permanent migration of households from the VDC to other parts of the district and to other parts of the country as well.

In 1996 Sikecha VDC had less forest cover than Phurumbu VDC, i.e., more than 81% (2,744 ha) of the total land (3,361 ha), and agricultural land was more than 18% (617 ha). Here, too, freshwater and settlements covered an insignificant portion of the land. By 2005, agricultural land had extensively expanded to 30% as the community became increasingly attracted to the large cardamom enterprise, resulting in heavy encroachment of the forest. Between 2005 and 2015, about 13% of the forest was resumed and agricuture land was shrunken (Figure 8). This change in land cover is interesting. Even though this period witnessed spread of disease in large cardamom in the area and discouraged large cardamom cultivation. There have been no significant changes in other land use types such as settlements and freshwater. There are visible signs of the expansion of settlement, though any expansion may be balanced out by the temporary and permanent migration of households from the VDC to other parts of the district and to other parts of the country as well.

In the case of Taplejung Municipality, during the year 1996, forest cover was more than 80% (3,385 ha) of the total land (4,194 ha) and agricultural land was more than 17% (734 ha). Other land use types such as freshwater and settlements and others covered a minimal area of 24 ha (0.5%) and 50 ha (1%), respectively. By 2005, agricultural land expanded by 5% due to the large cardamom enterprise utilizing the forest land. Settlement and other area increased to 2% while freshwater decreased to 0.1%. Between 2005 and 2015, about 2% of the forest was resumed

and agricultural land was decreased (Figure 8). There have been no significant changes in freshwater cover. However, settlement area is expanding, though there is temporary and permanent migration of households from the municipality to other parts of the country. But other areas such as barren lands have decreased as these lands are either utilized for the agro-forest enterprise or occupied by the settlements.

In terms of ranking the importance of ecosystems, agro-ecosystem is ranked as most important (52%), followed by freshwater (49%) and forest ecosystem (42%). Freshwater ecosystem was considered important as agro-forestry on which people are highly dependent needs irrigation (Figure 9).

Figure 9: **Importance of major ecosystems in the study area**

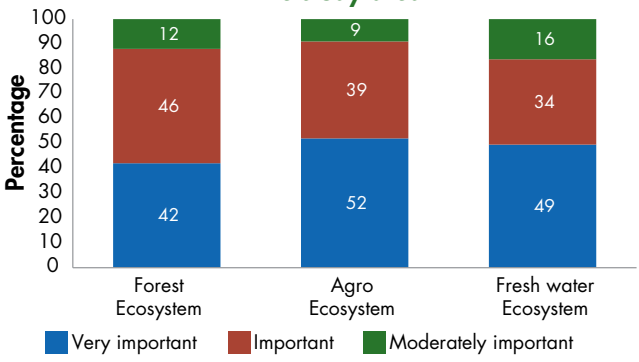
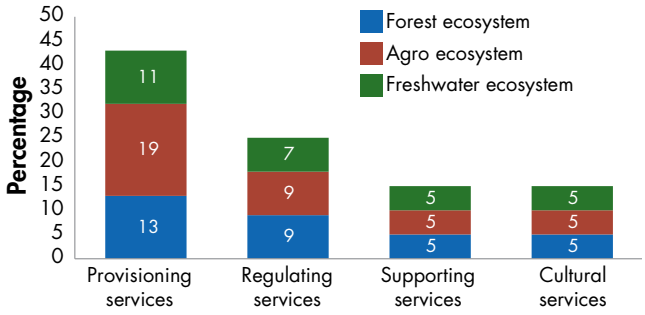


Figure 10: **Total number of ecosystem services rendered by different ecosystems in the study area**



Altogether 46 services are rendered by three ecosystems in the area, which can be classified into four broad ecosystem services: provisioning services (n=27), regulating services (n=9), supporting services (n=5), cultural services (n=5). Agro-ecosystem provides the highest number of provisioning services. Except freshwater ecosystem, all ecosystems provide equal number of regulating services. However, all ecosystems bestow an equal number of supporting and cultural services (Figure 10). Distribution of provisioning serivces in Taplejung district during 1990, 2000 and 2010 is depicted in Figure 11.

The community depends on ecosystems for several provisioning services (Figure 12) but more than half of the total households depend mainly on fuelwood, fodder, leaf litter and timber/poles from forest ecosystem. Most of the households fetch wild edible fruits 74% (186 HHs) and mushrooms 60% (149 HHs) from the forest (Figure 12).

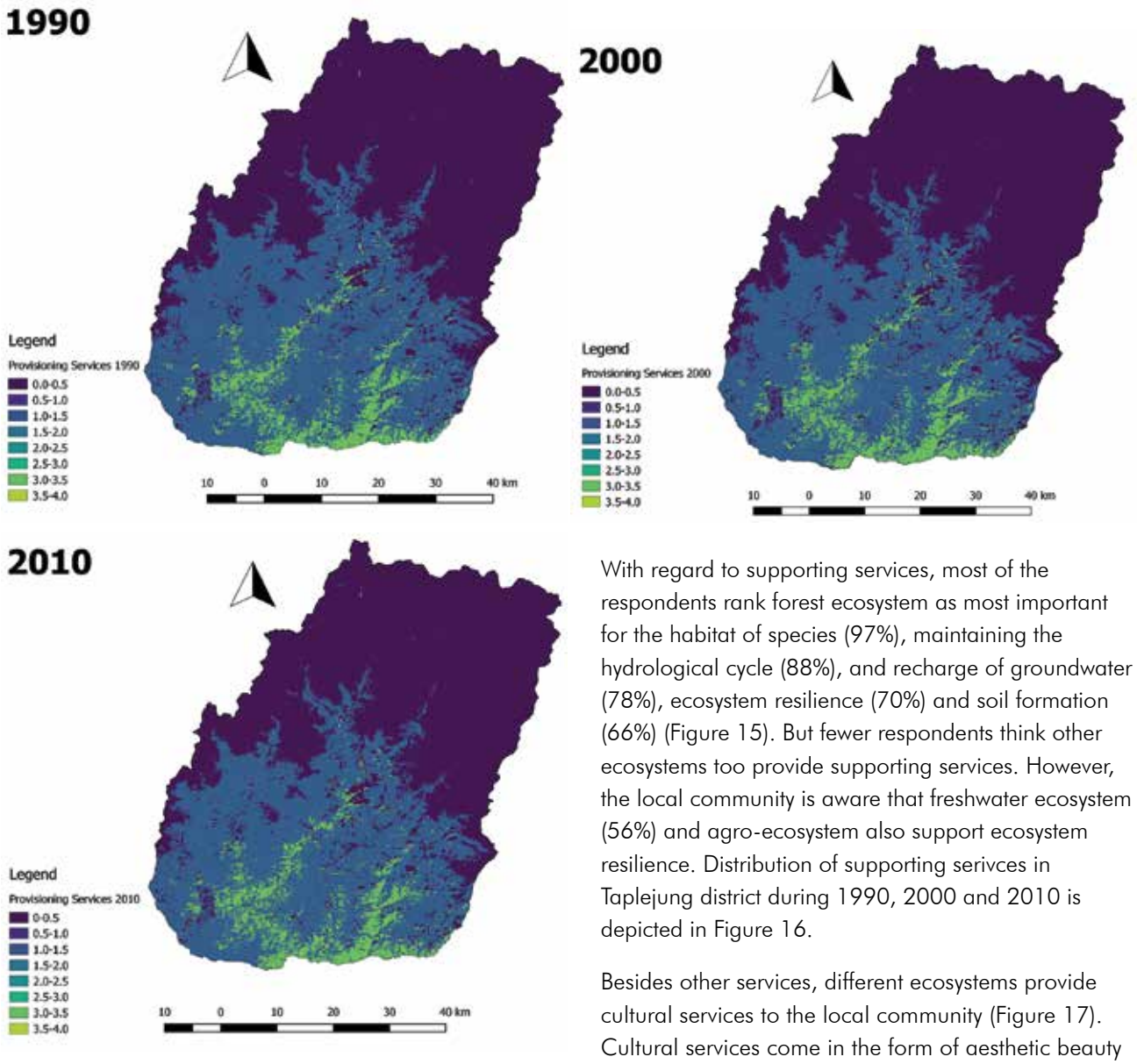
Agro-ecosystem is designated 'most important' in terms of providing provisioning services to the communities. More than 90% of the total HHs obtain fuelwood, fodder, food (cereals, vegetables, fruits) and soil/red mud in addition to cardamom. The soil or mud is mixed with water and cow dung and smeared on the walls and floors of the house. More than 80 % of the HHs obtain leaf litter and boulders for construction from the agro-ecosystem (Figure 12).

Freshwater ecosystem is equally important as it provides drinking water (93% of total HHs) and irrigation (89%) of agro-forest. About 36% of HHs consume fish (Figure 12), *paha* (mountain frogs) and crabs found in the freshwater ecosystem (rivers and streams). It can be surmised that households that do not obtain fish are either far from freshwater sources or there is not enough fish in the rivers and streams.

Respondents think forest ecosystem is highly significant in regulating climate (96.4% of HHs). They know that forest regulates climate and makes it cool and pleasant to live. Forests play an important role in controlling erosion (94.8% of HHs) and floods (83.2% of HHs), as well as protect soil and maintain the health of the environment. Forests also contribute significantly to carbon sequestration (75.6% of HHs) and purifying water resources. More than half of the respondents believe that forest ecosystem is vital for regulating services like seed dispersal (63.2% of HHs), pollination (60.4%) and water retention (55.2%).

Agro-ecosystem, on the other hand, is considered imperative for climate regulation (21.6% of HHs), pollination (18 % of HHs) and dispersal of seeds (17.2 % of HHs). Although to a smaller degree, freshwater ecosystem also regulates climatic conditions (35.2 % of HHs) and contributes to carbon sequestration (10 % of HHs), as shown in Figure 13. Distribution of regulating serivces in Taplejung district during 1990, 2000 and 2010 is depicted in Figure 14.

Figure 11: **Map showing distribution of provisioning services in Taplejung District during 1990, 2000, and 2010**



With regard to supporting services, most of the respondents rank forest ecosystem as most important for the habitat of species (97%), maintaining the hydrological cycle (88%), and recharge of groundwater (78%), ecosystem resilience (70%) and soil formation (66%) (Figure 15). But fewer respondents think other ecosystems too provide supporting services. However, the local community is aware that freshwater ecosystem (56%) and agro-ecosystem also support ecosystem resilience. Distribution of supporting serivces in Taplejung district during 1990, 2000 and 2010 is depicted in Figure 16.

Besides other services, different ecosystems provide cultural services to the local community (Figure 17). Cultural services come in the form of aesthetic beauty and nature worship, which involves the worship of various deities such as Sano Pathivara, Ban Devi, Sinha Devi in the forests. This helps ensure the protection of religious forests around these sacred places. Agro-ecosystem and freshwater ecosystem also deliver aesthetic beauty. Nature worship takes place within these ecosystems during festivals such as Chasok Tangnam as well as Udhauli and Ubhauli. Worshipping is also done before the harvest of cardamom; people pray for good harvest and the wellbeing of family members. Devotees on their way to Pathivara Temple also worship the rivers along the way; this cultural practice is mainly common within the Limbu community. Distribution of cultural serivces in Taplejung district during 1990, 2000 and 2010 is depicted in Figure 18.

4.4 Ecosystem services use and market values

Five most important provisioning services supporting local livelihood in the area are listed in Table 10. Large cardamom is the most beneficial among the five provisioning services. Timber (from Black Nepal Cedar), although obtained by fewer households last year, has a higher value than other provisioning services. Estimated monetary value of fuelwood and fodder obtained from the forest and agro-ecosystems on a daily basis is substantial though people take it for granted. Medicinal herbs (especially 'Chiraito'), which are traded by a few households in the area, have good sale value. Households also use or consume other provisioning services such as livestock, crops, vegetables, fruits, etc., but such services are either provided on a smaller scale or have less monetary value compared to the other five provisioning services. However, these goods are part of their traditional knowledge and religious belief (Box 4).

Figure 12: **Provisioning services provided by different ecosystems in the study area**

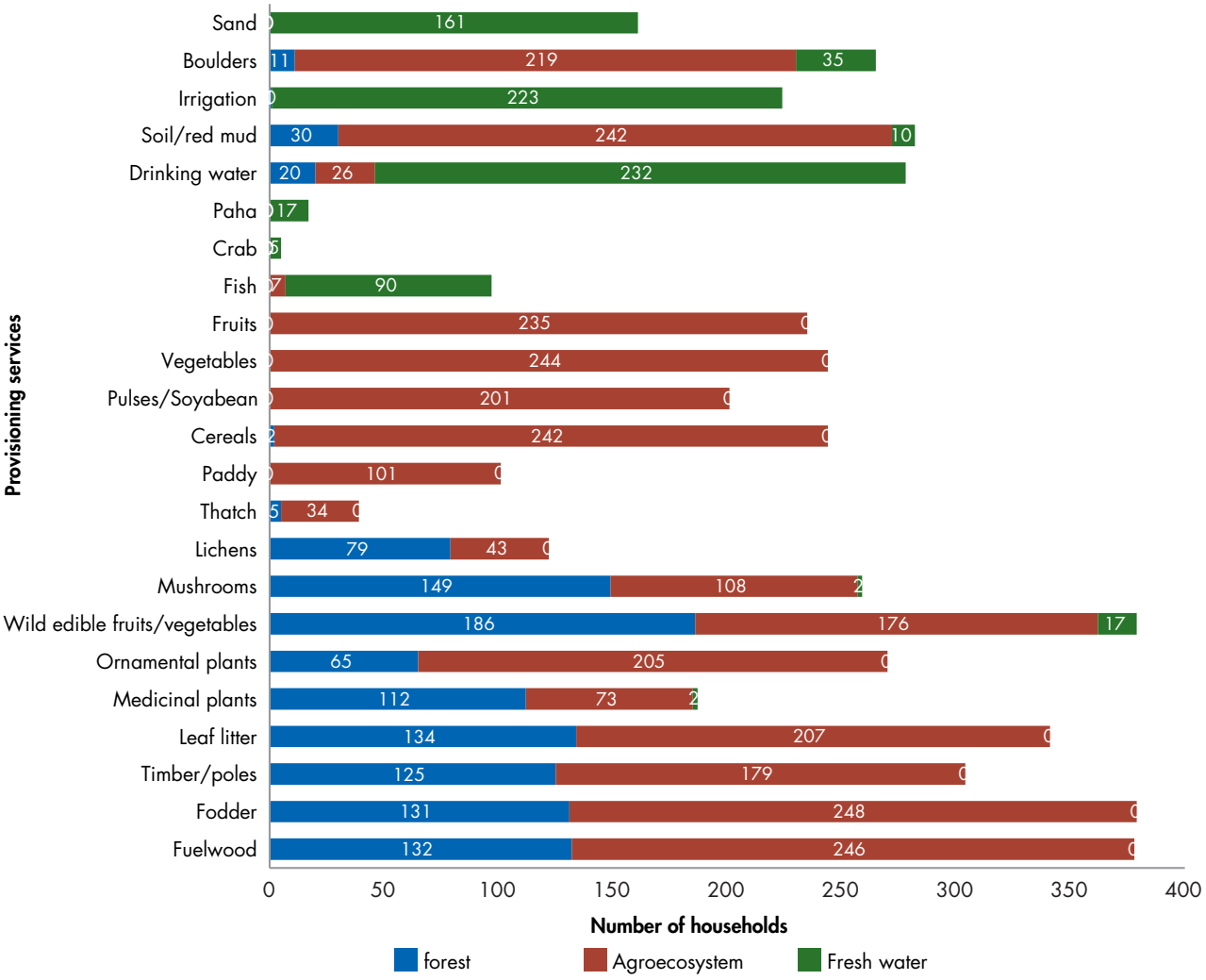


Figure 13: **Regulating services rendered by different ecosystems in the study area**

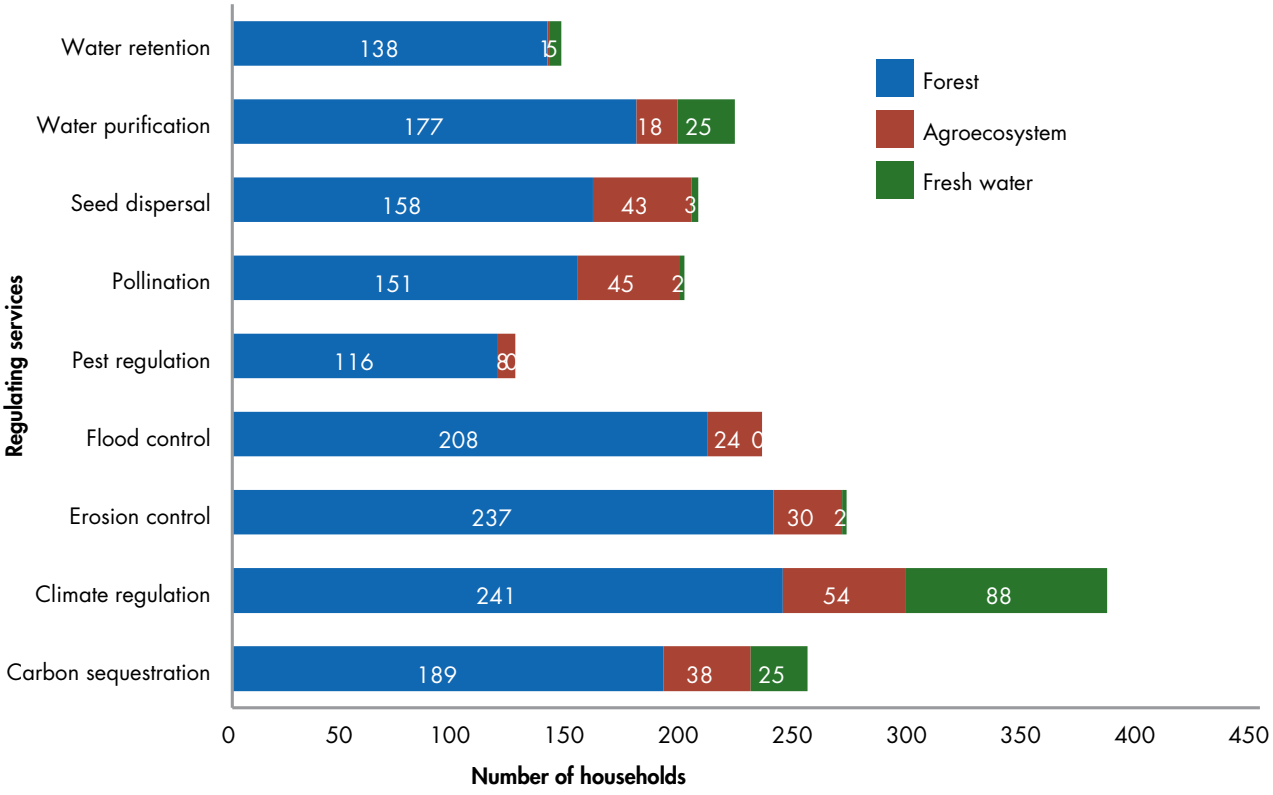


Figure 14: **Map showing distribution of regulating services in Taplejung District during 1990, 2000, and 2010**

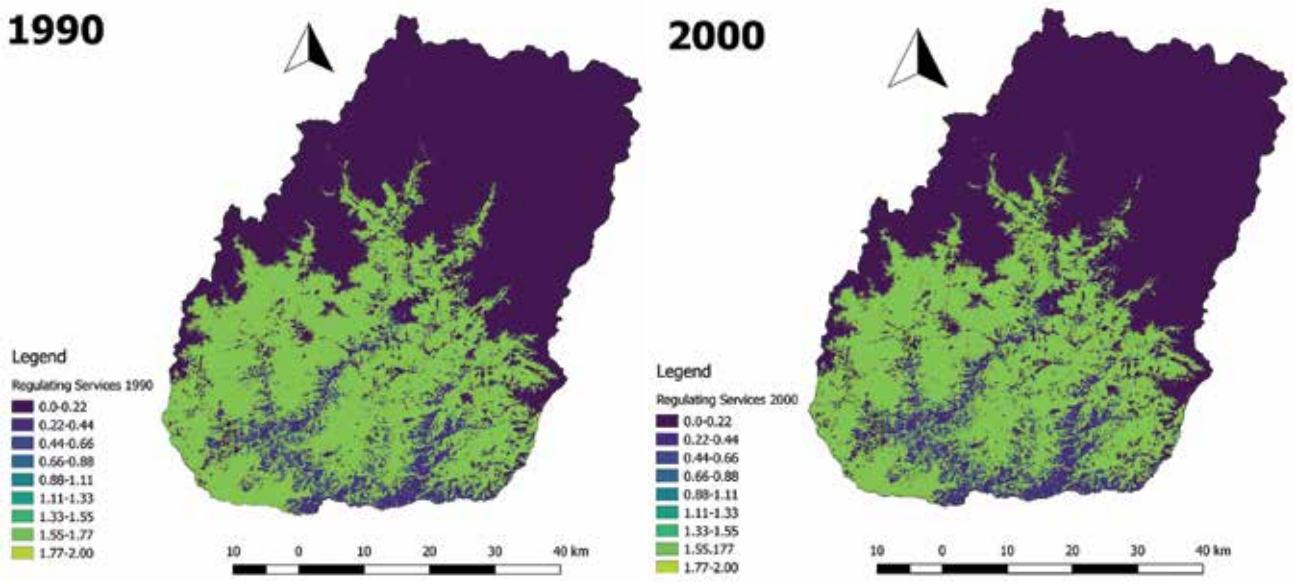
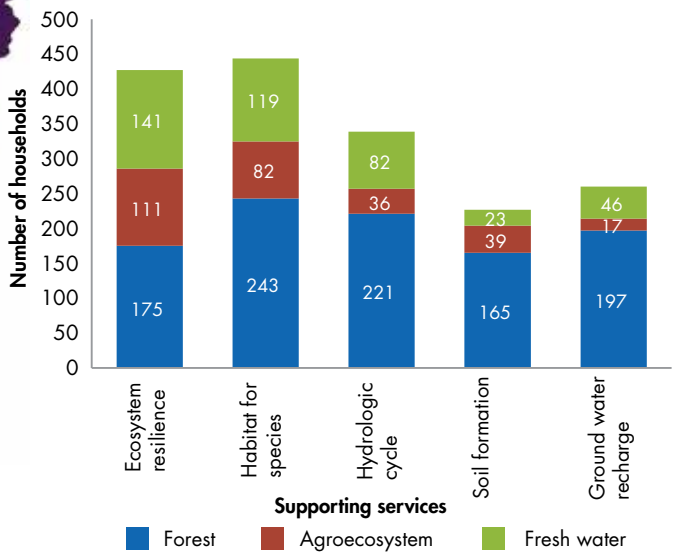


Figure 15: **Supporting services provided by various ecosystems in the study area**



Box 4: **Traditional/cultural use and beliefs**

Epiphytic Foliose Lichens (*Everniastrum nepalense*) that grow on Nepal Black Cedar (*Alnus nepalensis*) and Bhalayo (*Rhus wallichii Hook.*) are used fresh or in dried form and cooked as vegetables; it can also be used as a powdered condiment in pork dishes (traditional knowledge).

Whole pigs are not sold as such but their meat is sold (traditional practice).

People worship the Fawa River and sacrifice a hen at the river en route to Pathivara Temple (religious belief).

Some of the ponds that were dug in the village and the forest area by earlier generations have dried up; in most of these ponds the water level has decreased by about 50% (people's perception).

Source: Key Informant Survey at Sikecha, ward # 6

Figure 16: **Map showing distribution of supporting services in Taplejung District during 1990, 2000, and 2010**

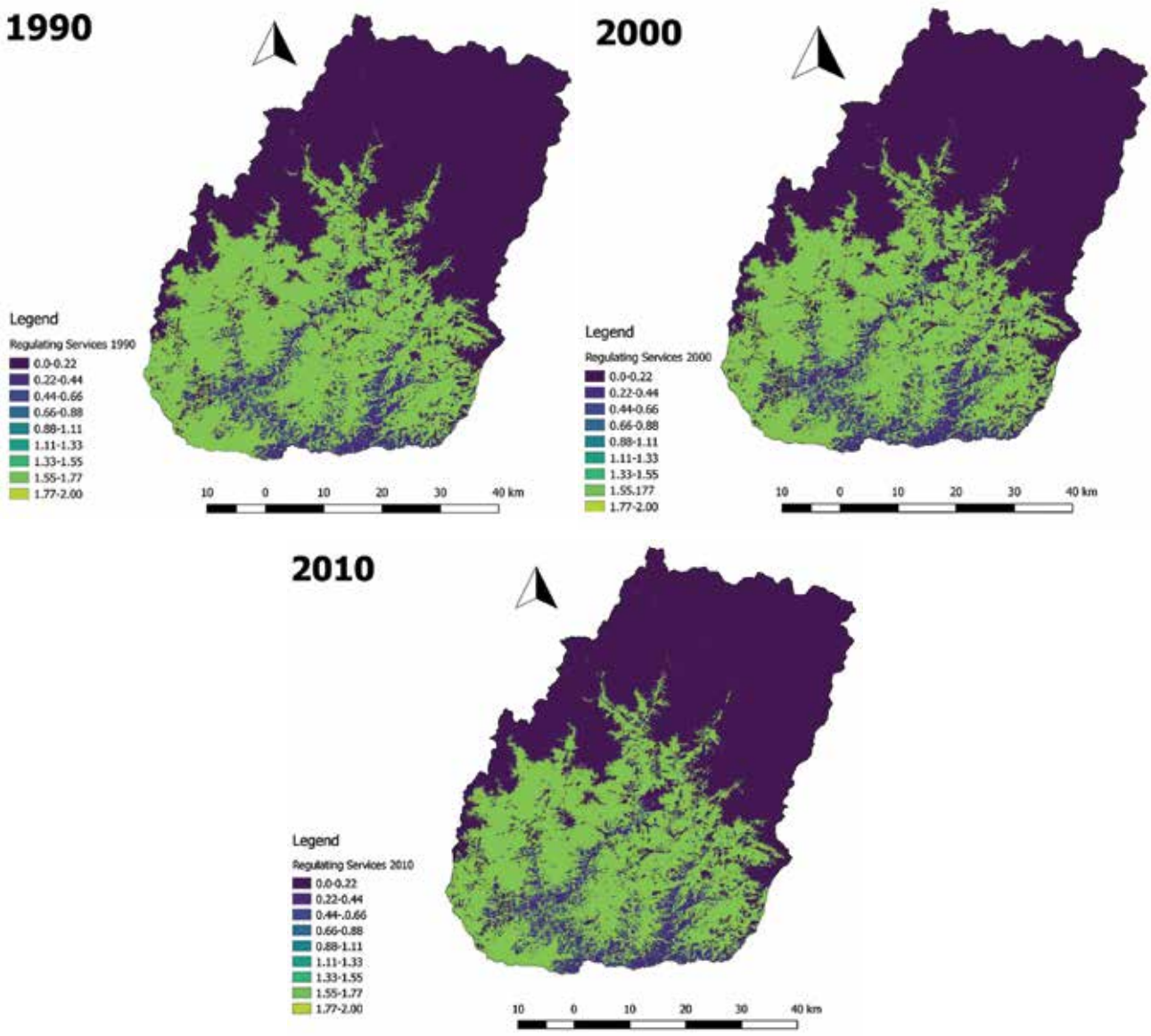


Figure 17: **Cultural services rendered by various ecosystems in the study area**

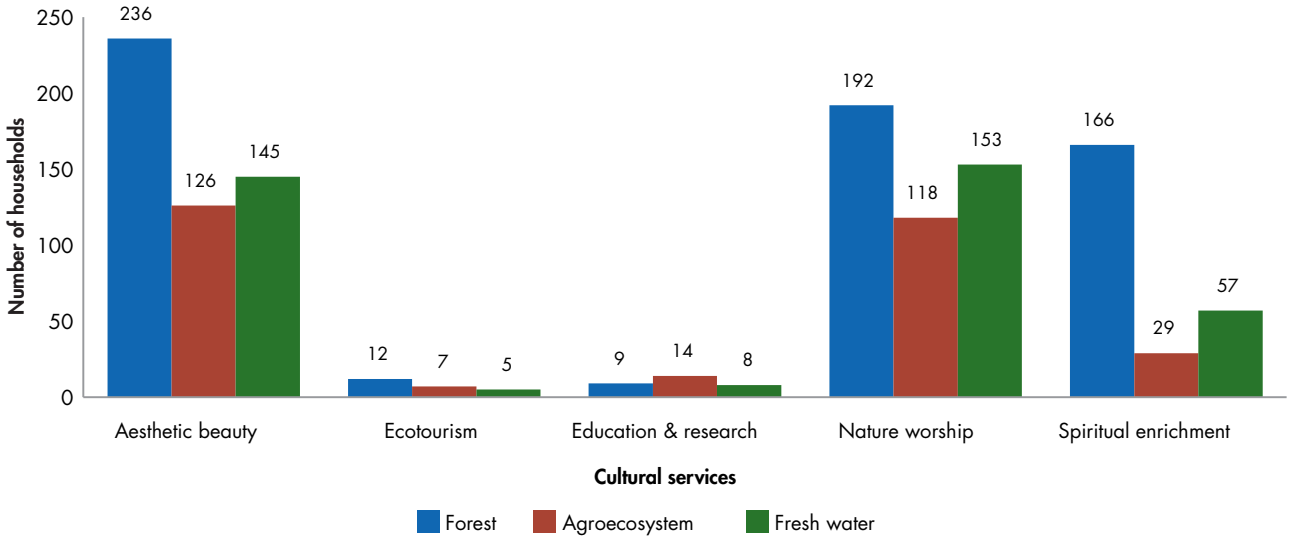


Figure 18: **Map showing distribution of cultural services in Taplejung District during 1990, 2000, and 2010**

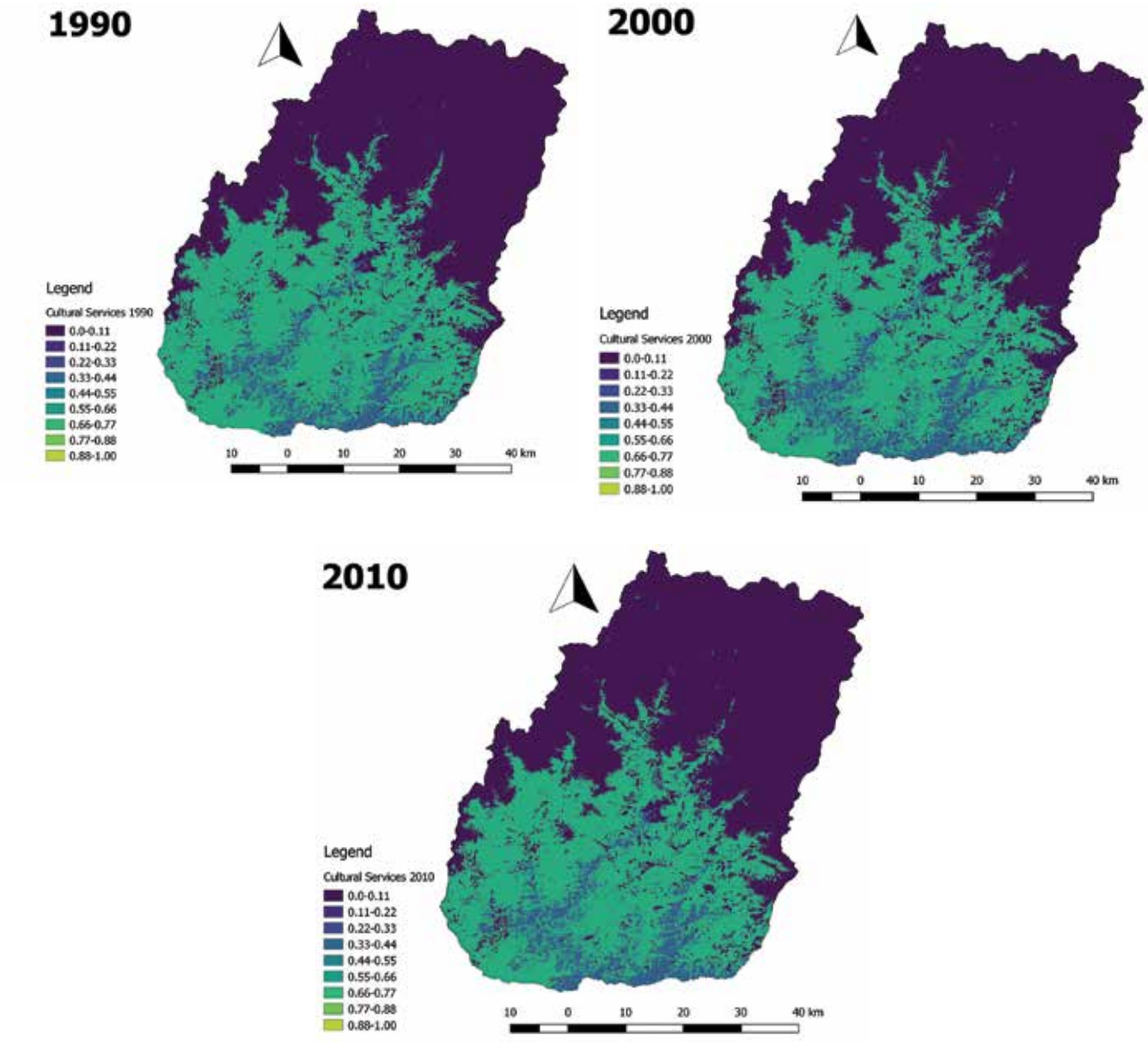


Table 10: **Selected provisioning services, their market value, production, consumption value**

Provisioning services	Market Value (USD)	Total Qty /year	Total amount (USD)/year	Total Qty / HH/day	Total amount/ HH (USD)/ day	# HHs consuming the services
Fuelwood	0.1/kg*	1,193,570 Kg	119,357	N/A	N/A	238
Fodder	1.3/day**	9,033,020 kg	93,440	24748 kg	256	226
Timber	5/cubic feet	44,769 cubic feet	223,845	N/A	N/A	14
Large cardamom	10/kg	35,942 kg	359,420	N/A	N/A	178
Medicinal herbs (Chiraito)	2.5/kg	400 kg	1,000	N/A	N/A	5
*Price at Phungling Bazaar						
**USD 4/day						

Almost all important provisioning services are collected with the participation of both male and female members of the households in the area (Table 11). Except fodder, which is collected on a daily basis, almost all other provisioning services are collected on an annual basis (Table 12). All provisioning services except fodder require more than four hours for collection (Table 13). Majority of households (84 HHs) spend two hours every day on collecting fodder.

Table 11: **Gender wise collection of selected provisioning services in the study area (Number of households)**

Important provisioning services	Services collected by		
	Male	Female	Both
Fuelwood	2	0	236
Fodder	3	1	222
Timber	4	0	10
Cardamom	0	0	178
Vegetables	0	0	25
Livestock	2	0	64
Crops (paddy, maize, wheat)	0	0	76
Medicinal herbs (chiraito)	0	0	5
Fruits (orange, banana, lemon)	0	0	7

Table 12: **Collection frequency of selected provisioning services (Number of households)**

Important provisioning services	Frequency of collection of services						
	Daily	Twice a week	Weekly	Monthly	Once in 3 months	Once in 6 months	Once a year
Fuelwood	3	0	0	1	0	2	232
Fodder	221	2	3	0	0	0	0
Timber	0	0	0	0	0	0	14
Cardamom	0	0	0	0	0	0	178
Vegetables	0	0	0	0	0	0	25
Livestock	0	0	0	0	0	0	66
Crops (paddy, maize, wheat)	0	0	0	0	0	0	76
Medicinal herbs (chiraito)	0	0	0	0	0	0	5
Fruits (orange, banana, lemon)	0	0	0	0	0	0	7

Table 13: **Time allocated for selected provisioning services in the study area (Number of households)**

Important provisioning services	Time required for one collection in hours						# HHs involved in collection
	30 minutes	1 hour	2 Hours	3 Hours	>4 hours*	Total time (hrs)	
Fuelwood	0	0	2	1	235	>947	238
Fodder	6	22	84	70	44	> 579	226
Timber	0	0	0	0	14	> 64	14
Cardamom	0	0	0	0	178	> 712	178
Vegetables	0	0	1	1	23	> 97	25
Livestock	0	0	0	0	66	> 264	66
Crops	0	0	0	0	76	> 304	76
Medicinal herbs	0	0	0	0	5	> 20	5
Fruits	0	0	0	0	7	> 28	7

* From 4 hrs to a month

4.5 Willingness to Pay

Out of the 250 HHs, 86% were willing to pay in cash or kind to manage their surrounding ecosystems and services (Figure 19). Majority of HHs (66.35 % among the willing HHs) wish to contribute labour rather than cash (18.6%). Among the willing HHs 13.8% agreed to contribute labour for 24 days in a year. Proposed cash contribution ranges from NPR 100 to 20,000 with a higher number of HHs agreeing to pay an average of NPR 2000. This amount is less compared to the benefits they receive from ecosystem services.

However, they are enthusiastic about participating and getting involved by contributing labour for the management of ecosystem services. However, 14% of the households were not willing to pay either cash nor in kind. They see locally available resources as common resources that everyone can use freely. They also say they cannot afford to pay their share for the management of such resources. But 14% of the willing households said they can provide both cash and in-kind support (Figure 19).

Majority of HHs (n=186) suggested managing the fund raised for ecosystems through the involvement of local communities or through various user committees such as forest user groups. They believe public participation in ecosystems management will have more chances of success because it will ensure greater transparency and proper utilization of the fund (Figure 20).

Figure 19: **Willingness to pay for ecosystem management**

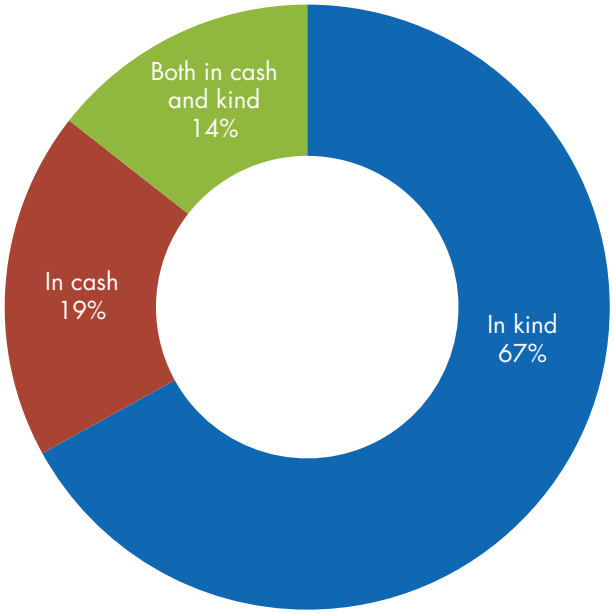
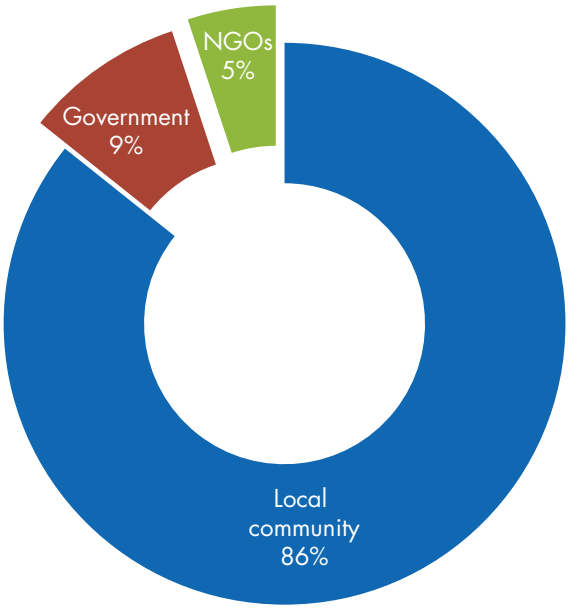


Figure 20: **Management of the fund**



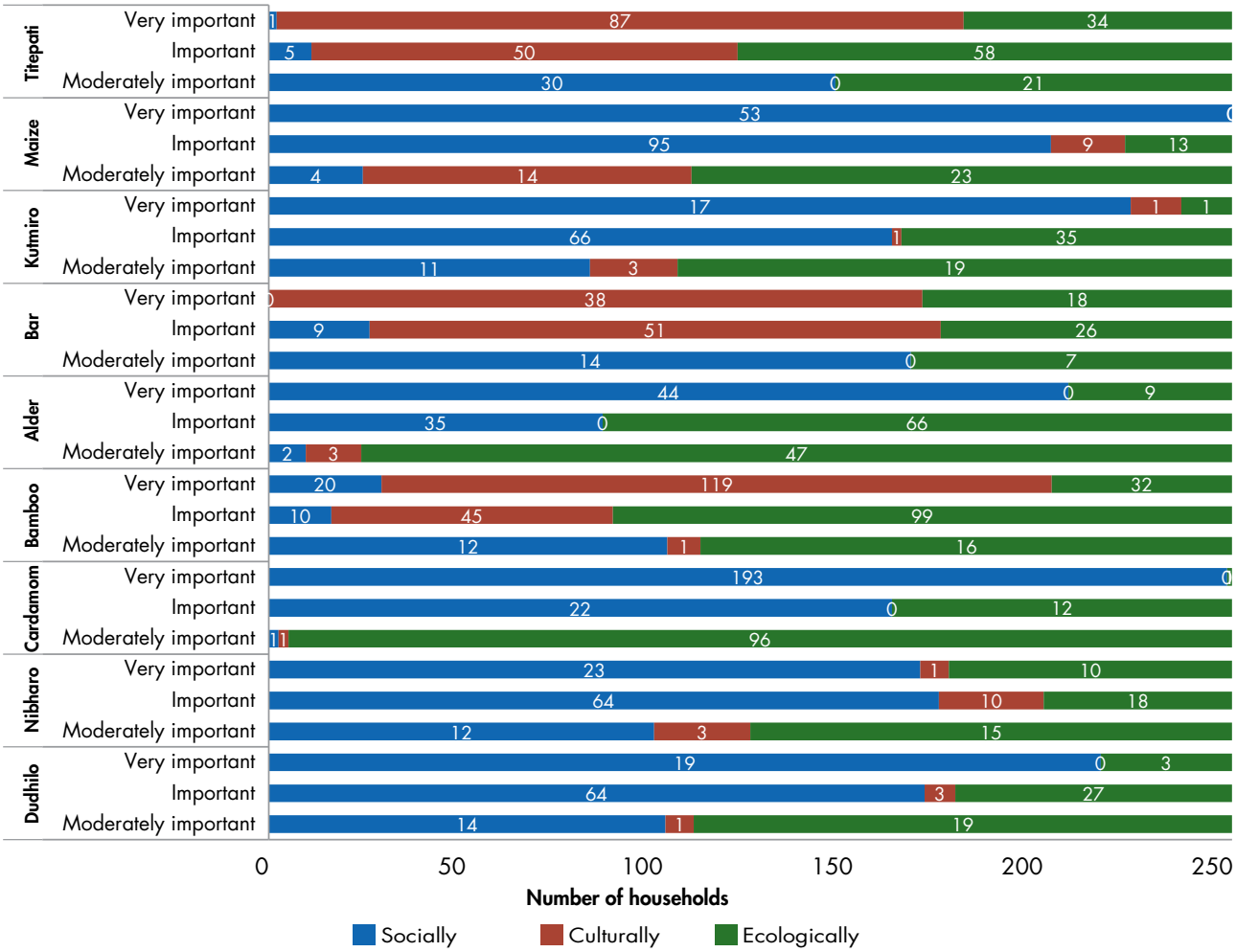
4.6 Socially, Culturally and Ecologically Valuable Species

Large cardamom, maize and Nepal Black Cedar are three socially most important plants in the area. This is not surprising, because large cardamom cultivation largely contributes to households' annual income. Nepal Black Cedar primarily provides fuelwood and timber to the community. People also sell timber to plywood and furniture companies and earn some money. Most people in the region grow maize as a subsistence crop (Figure 21).

Nivaro, bamboo, dudhilo and kutmero are the most preferred fodder plants for livestock stall-feeding. Bamboo, titepati and bar are three culturally valuable plants. All communities use bamboo during religious ceremonies, festivals and funerals. The Limbu tribe uses titepati during their ceremonies. Bar plant is worshipped and its leaves are used for various cultural purposes (Table 14). Bamboo and titepati are the two ecologically most important plants, as reported by the communities. According to them, bamboo plays an important role in holding the soil in steep terrain and reduces soil erosion. Titepati can be used as a bio-pesticide and for organic compost manure.

Cow, goat, pig, chicken and buffalo are the main livestock reared in the area. In addition, poultry farming and bee keeping contribute to the local livelihood. Cow and buffalo are reared for dairy products. Goats, chicken and

Figure 21: **Socio-culturally and ecologically valuable plants**



pigs are reared for meat products. Selling these animals also generates income. Selling goat and chicken brings in less money than selling cow, so local respondents ranked the former as socially important and the latter as socially very important. They ranked cow as culturally very important as dairy products are required during rituals and ceremonies; cow dung is used to clean the house; and cow urine is used to make '*panchamrit*' for religious rituals. They also ranked goat and chicken as culturally important as these animals are sacrificed during rituals, festivals and ceremonies. Again they ranked cow as ecologically very important as cow dung and urine are used as organic fertilizer and bio-pesticides (Figure 22).

4.7 Vulnerability Assessment

The vulnerability assessment of the community revealed that only 11.6 % of HHs obtain enough cereal from their own cultivation. 46.4% of HHs can only survive for less than three months on their own cereal production (Figure 23). This indicates the area is vulnerable from the perspective of food security; data shows high dependency on the market for food supply. The major cause of food insecurity is the shift of agricultural practice from crop production to more profitable cardamom cultivation as well as poor production of crops in the agricultural land.

Crops are harvested in August, September and January. A few households can survive on their harvest for a whole year and even sell the remainder (Figure 24). But during the rest of the year most households have to buy food from the market with cash generated primarily by selling large cardamom. This vulnerability can be overcome as in the past ten years; the possibilities of local income generation have increased along with possibilities of remittances to generate income as well as access to credit. Therefore, purchasing power of the local residents in the area has increased, which indicates that they can buy food from the local market.

Table 14: **Cultural significance of plants in the study area**

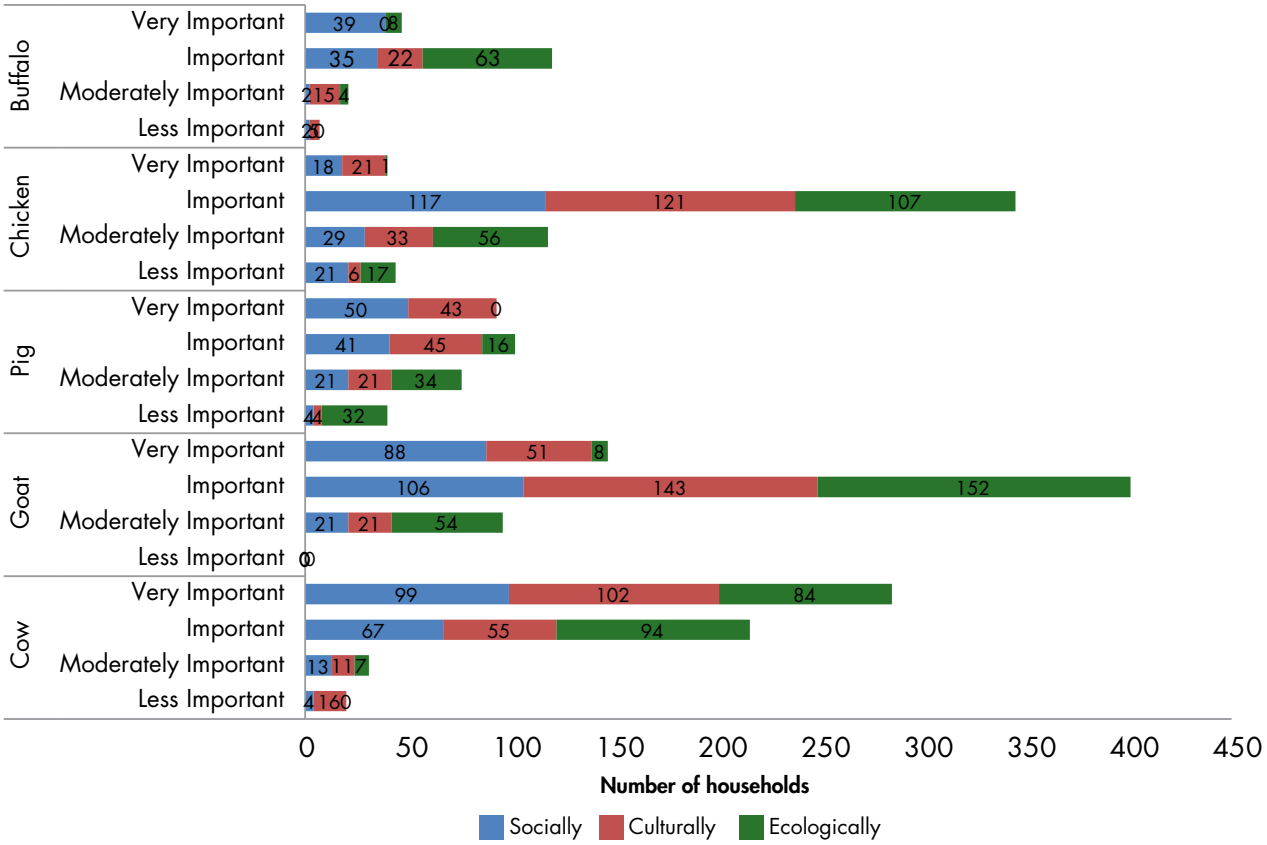
S.N.	Nepali name	Scientific name	Uses
1	Bar	*Ficus benghalensis* L.	Toran and worshipping
2	Peepal	*Ficus religiosa* L.	Toran and worshiping
3	Paiyeu	*Prunus cerasoides* Buch.-Ham. Ex D.Don	Jagge/linga (used as poles during religious ceremonies)
4	Aamp	*Mangifera indica* L.	Toran
5	Bel	*Aegle marmelos* (L.) Merr.	Worshipping
6	Titepati	*Artemisia indica* Willd.	Worshipping
7	Patebar	*Ficus* spp.	Making Tapari (leaf plates)
8	Katus	*Castanopsis indica* (Roxb. ex Lindl.) A.DC.	Making leaf plates
9	Chiuri	*Diploknema butyracea* (Roxb.) H.J.Lam	Making leaf plates
10	Kera	*Musa paradisiaca* L.	Fruits and Jagge
11	Ukkhu	*Saccharum officinarum* L.	Fruits and Jagge
12	Nivaro	*Ficus auriculata* Lour.	For leaf plates (Tapara)
13	Dudhilo	*Ficus neriifolia* Sm.	For leaf cups (Duna)
14	Kaulo	*Persea odoratissima* (Nees) Kosterm.	Used during traditional healing rituals'
15	Jhankri syaulo	*Phoebe lanceolata* (Ness) Ness	Used during traditional healing rituals'
16	Valayo	*Rhus wallichii* Hook. f.	Used during traditional healing rituals'
17	Bans	*Dendrocalamus hamiltonii* Neer & Arn. ex Munro	Funerals and rituals
18	Dubo	*Cyanodon dactylon* (L.) Pers	Worshipping and preparing garlands
19	Jau	*Hordeum vulgare* L.	Worshipping and for rituals
20	Teel	*Sesamum indicum* L.	Worshipping and for rituals
21	Kush	*Briza bipinnata* L.	Worshipping and for rituals
22	Dhupi	Thuja spp.	For preparing gates and garlands
23	Gurans	*Rhododendron* spp.	Worshipping
24	Babiyo	*Eulaliopsis binata* (Retz.) C.E. Hubbard	Making Toran for worshipping
25	Chabo	*Piper chaba* Hunter.	Death rituals
26	Amriso	*Thysanolaena maxima* (Roxb.) Kuntze	Various rituals
27	Tulasi	*Ocimum tenuiflorum* L.	Worshipping
28	Palas	*Butea monosperma* (Lam.) Taub.	For ritual ceremony
29	Chimphing	*Heracleum nepalense* D.Don	Used during traditional healing rituals
30	Totola ko phuol	*Oroxylum indicum* (L) Benth.ex. Kurz	Used during all Limbu religious ceremonies
31	Champ	*Michelia champaca* L.	Death ceremony

Most of the households faced an unexpected crisis last year due to fluctuation in the selling price of cardamom. They reported that this posed a major challenge in sustaining their livelihoods (Figure 25). This may have influenced the respondents' willingness to pay cash for the management of ecosystem and their services. Poor production of crops in small, fragmented agricultural lands is another serious problem people face in the area.

4.8 Coping Strategy

It takes communities in the project area a year or several years to cope with both major and minor crisis. Their coping strategies include taking loan, selling livestock, selling cardamom harvest, using income generated from labour migration (remittances) and by other means (salary and pension, selling vegetables, fruits and cereal crops), as shown in Figure 26. Although local people take loan at the first instance to overcome crisis, they eventually pay off the loan by selling animals, selling cardamom and using remittance money.

Figure 22: **Socio-culturally and ecologically valuable animals**



4.9 Perceived Changes in Socio-economic Sector

Over the last ten years, local people in the area have witnessed several changes (positive or negative) in the socio-economic sector (Figure 27). There is tangible evidence of improved status brought about by income generation possibilities at the local level due to several ongoing construction works, possibilities of trade across the nearby Chinese border, investment of remittances and establishment of rural cottage and small industries, and construction of hydropower projects including micro-hydro projects.

Although there are possibilities for temporary labour migration for employment abroad, local people are grabbing opportunities in their home region, and this has positively affected the socio-economic status of households in the area and increased the purchasing power of local people.

Figure 23: **Number of months for which households in the study area can rely on their cereal production for food self-sufficiency**

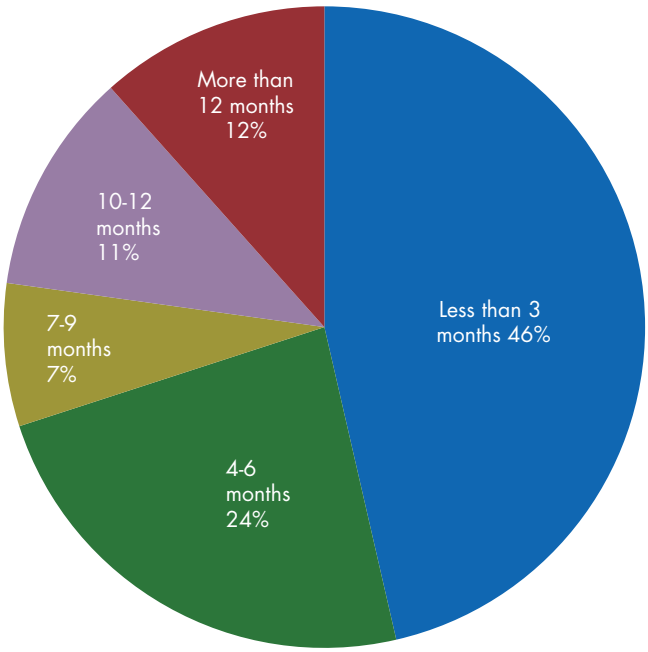


Figure 24: **Months in which households have adequate food**

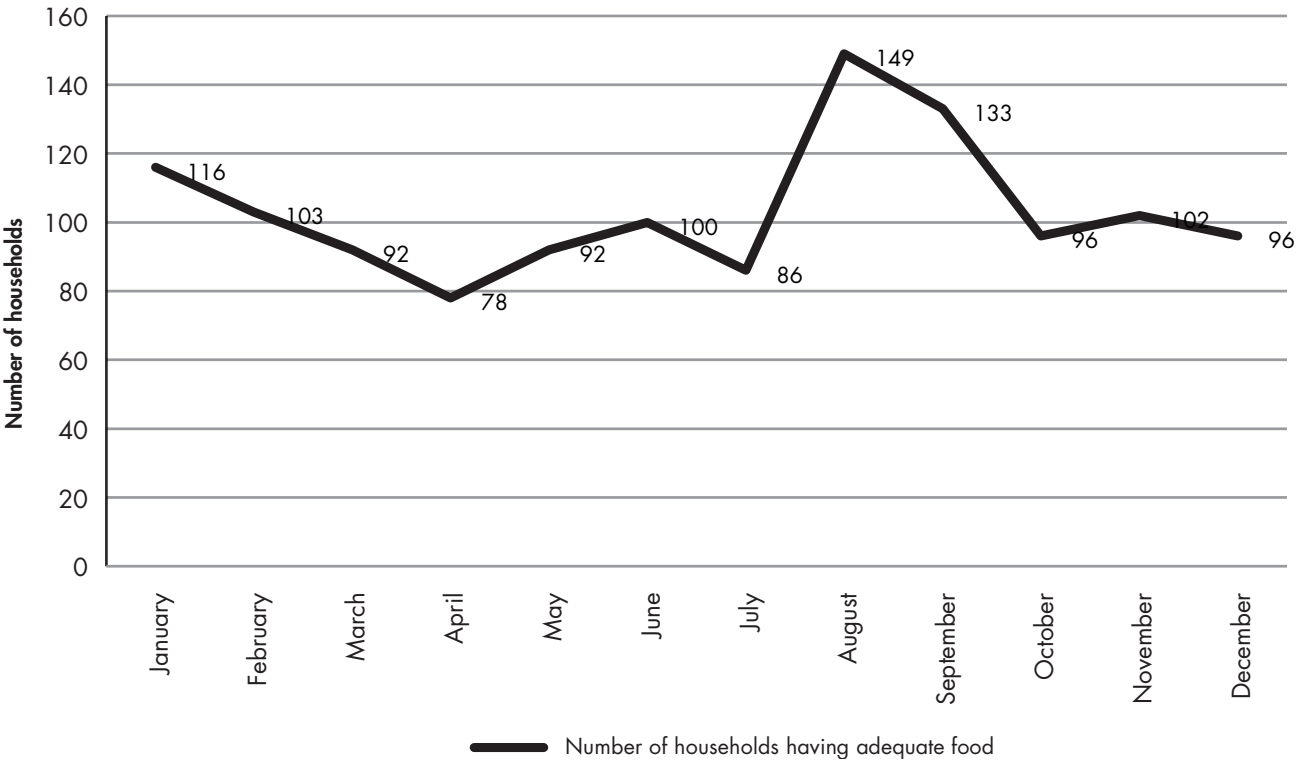


Figure 25: **Types of crises experienced by the households during the past 12 months**

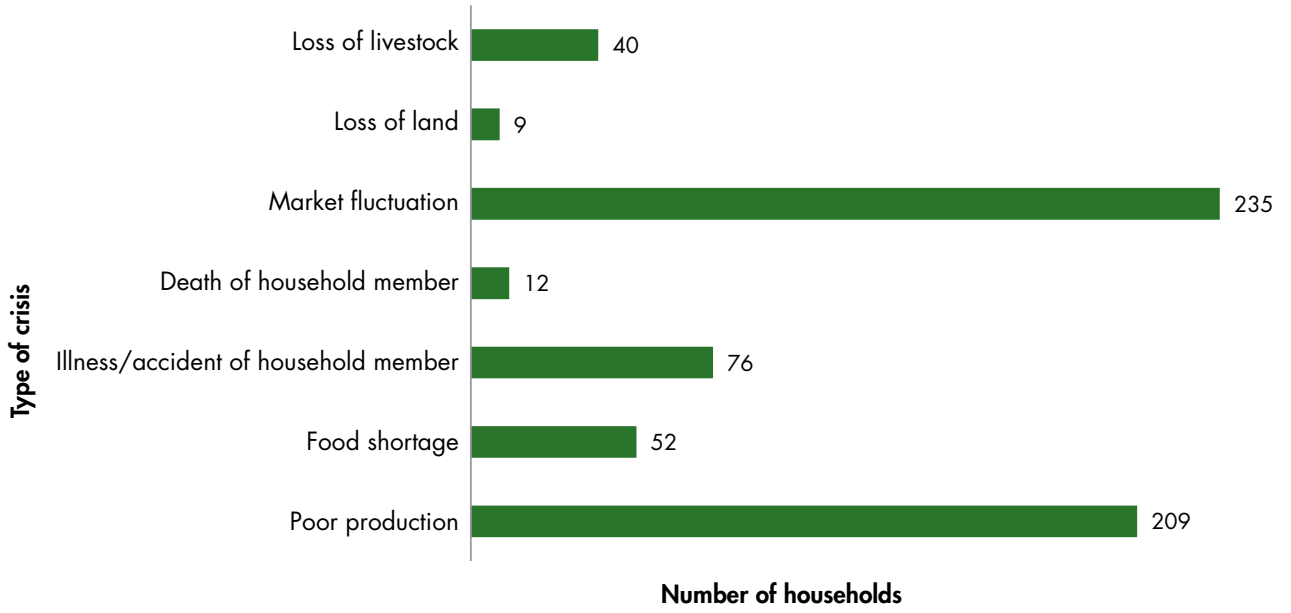
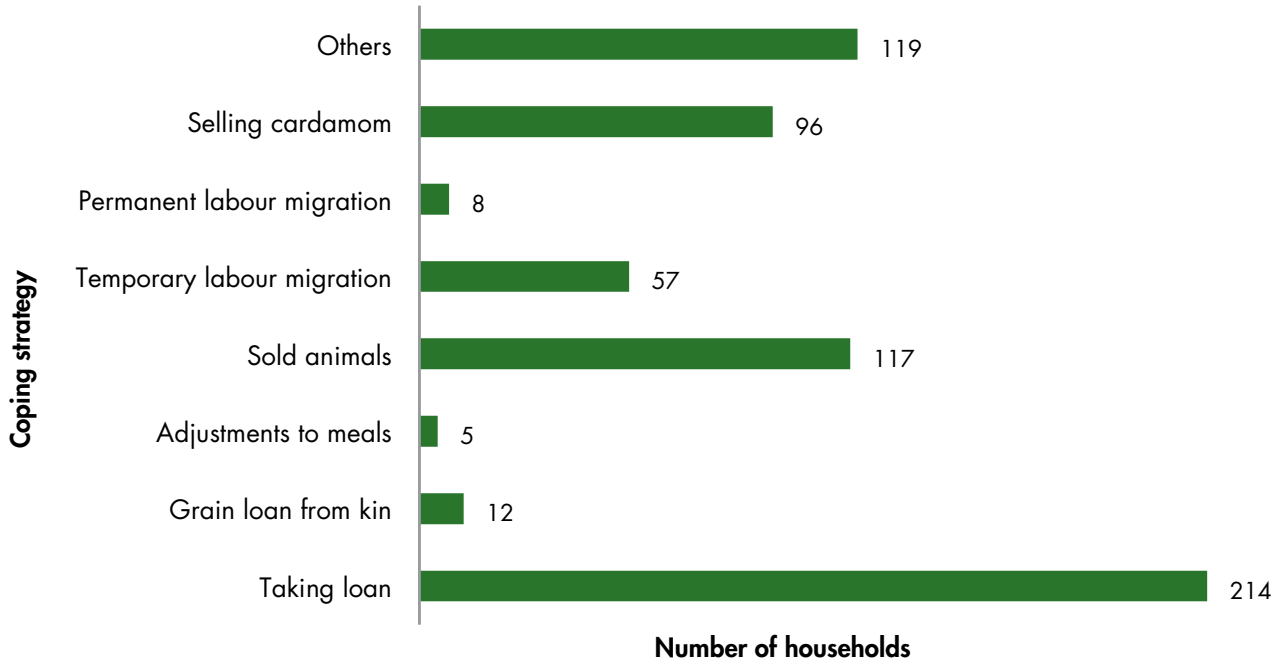


Figure 26: **Strategy to cope with crisis adopted by households during the past 12 months**



4.10 Key Opportunities

Promotion of ecotourism

Pathivara Devi is a well-known pilgrimage and cultural heritage site for people from the district and adjoining areas of Nepal as well as of India. The route to Pathivara is also a secondary route on Kangchenjunga Trek; hence it has further potential for ecotourism. The private tourism sector could be involved further to promote tourism in the area. Pathivara Temple at the top of the hill is a panoramic viewpoint from where the whole Mt. Kangchenjunga range can be viewed on clear days. It can be a new tourist destination for hiking and trail walking. The primary forest in the area is a prime habitat of Red Panda (*Ailurus fulgens*) and other wildlife. The study area can be a special site for bird watching since several bird species occur, including those listed in Annex I, along with butterflies, rhododendrons and orchids along the trails. It would be viable to start cardamom-based ecotourism catered to tourists and pilgrims visiting this area.

Kangchenjunga Conservation Area brings in fewer tourists (just 731 in 2015[2]) compared to other conservation areas in Nepal. Every year about 100,000 pilgrims and devotees visit the Pathivara area[3]. Integrating these various possibilities – tourism in Pathivara and Kanchenjunga Conservation Area, climbing Mt. Kangchenjunga, red panda conservation outside the protected area and cardamom-based ecotourism – would offer a new paradigm that could enhance the tourism sector as a whole and improve the livelihoods of people in Taplejung District and the Kangchenjunga landscape.

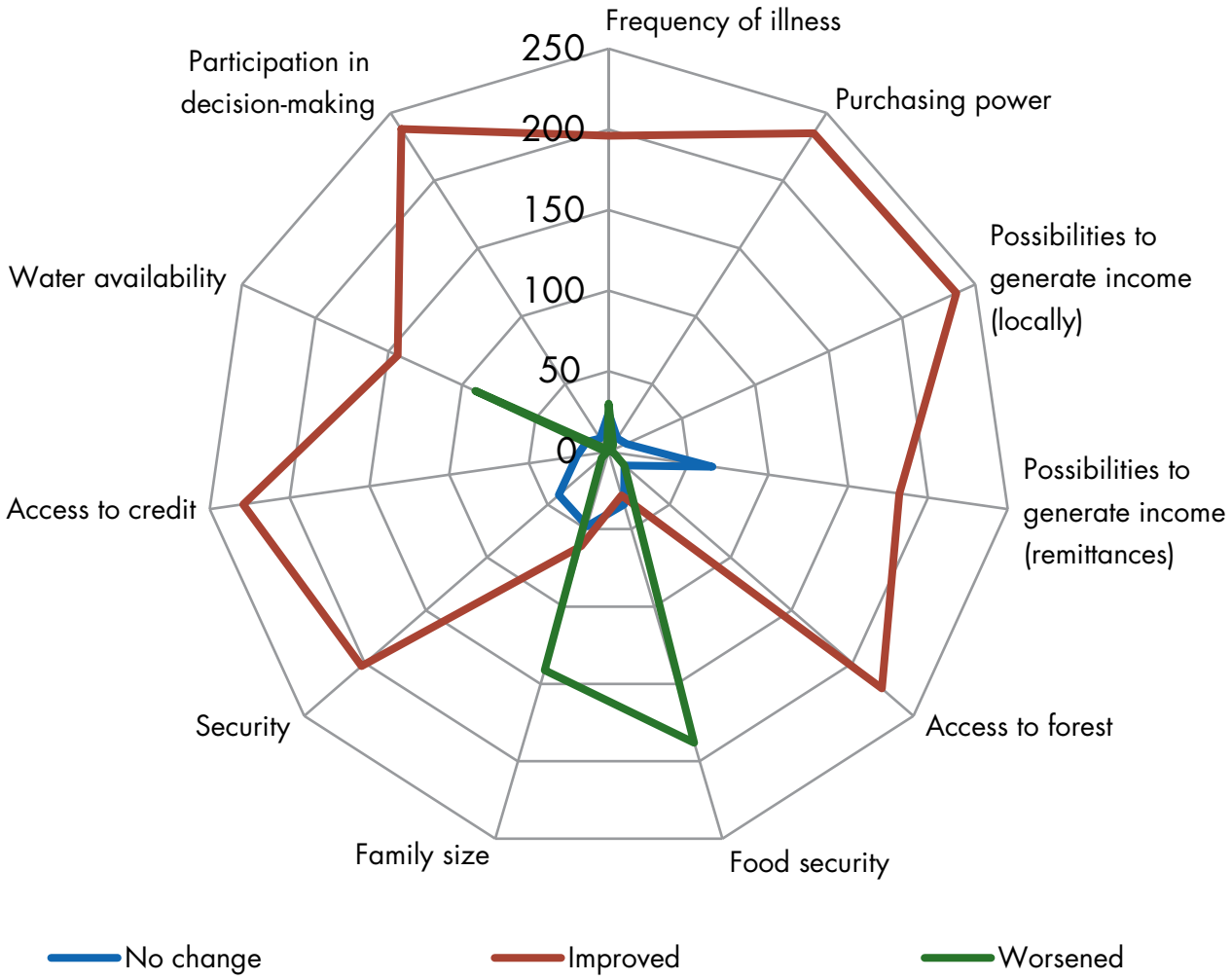
Cardamom ecotourism can include promotion of organic cardamom farming, promotion of cardamom-flavoured items, co-existence with wildlife such as civets, bats, rodents (including flying squirrels), and branding of cardamom consumed by civets.

Diversifying options

There are other livelihood improvement options such as developing a green enterprise for the value chain promotion of resources found in the area. Argeli (*Edgeworthia gardneri*) is the most viable option for value chain promotion in the Kangchenjunga landscape opined by the local lead farmers (Box 5). It is used for manufacturing handmade paper and other types of high-quality paper (Japanese currency note, stamps and passport). Kiwifruit (*Actinidia* spp.), wild Himalayan pear (*Pyrus pashia*; 'mayal' in Nepali), Nepali hog plum (*Choerospondias axillaris*;

[2] Nepal Tourism Statistics 2015
[3] Kanchenjunga Conservation Area Management Council, Taplejung

Figure 27: **Long-term changes perceived in the socio-economic sector of the area**



lapsi in Nepali), chestnut (*Castanopsis* spp.; Katus in Nepali), Indian butter tree (*Diploknema butyracea*; Chiuri in Nepali), peach and plum, etc. can be packaged, processed as fresh and dried fruits and exported. Similarly, Timur (*Zanthoxylum* spp.) can be processed as a spice and exported.

There are possibilities of value chain promotion of medicinal plants such as Pakhanved, Harchur, Satuwa, Vuichampa, Bako, Budhookhati, etc. in the area. Branding of lichens (*Everniastrum nepalense*) can support local livelihood and local development, since these lichens are known for being flavourful. Locals cook it alone or mixed with pork. It is in high demand among Limbu communities living abroad, especially Hong Kong and the UK. Local people recommend modernized cereal crop farming, organic orthodox tea and coffee cultivation, horticulture, commercial timber production, commercial livestock rearing, dairy cottage industry, vegetables farming, etc. as livelihood improvement options that could replace the declining large cardamom production.

Possibilities of income generation in the area have increased compared to the last ten years. Also, the Nepal-China border at Olangchungola area is now under operation and the road from Phungling municipality to the border area is under construction. This has opened new possibilities of trade and development in the area, including the possibility of boosting cottage and small industries. This will lead to the diversification of livelihood options in the area and may replace the declining production of large cardamom.

4.11 Value Addition to Large Cardamom

Although there are other options, so far large cardamom cultivation is the most profitable agro-forestry initiative undertaken in the area. It has been sustaining the livelihood of more than 80% of the households in the area for more than 30 years and it remains a promising rural enterprise. Although large cardamom cultivation faces severe

risks due to declining production, spread of disease, market value fluctuation, lack of human resources and climate change, local people still hope to improve the quality, demand and supply of cardamom by adopting advanced techniques and organic practices. Key informant survey revealed that even if the price of large cardamom drops to 40,000-50,000/mun i.e. 40 kg, it is still profitable compared to cereal/crop farming, which used to be a source of subsistence in the past.

It is a difficult task to change the social dynamics of the large cardamom enterprise in the area, in the sense that it may take a long time to change people's behaviour and attitude regarding large cardamom cultivation. Compared to cereal/crop farming, large cardamom farming is less labour intensive and less market risk. Himalica Pilot Project is providing support to improve the value chain of large cardamom in the area. Activities under the project include the development of a community participatory marketing strategy, building synergy with possible ecotourism partners, farm insurance, an integrated approach to livestock, inter-cropping practices, promoting utilization of resources and a climate smart vision.

Access to the forest has increased in the area because of plantations within the cardamom cultivation, which in turn has been fulfilling people's daily needs such as fodder, fuelwood, timber, leaf litters, edible plants, etc. Due to the cardamom plantation, livestock rearing has decreased compared to the past and the livestock rearing practice has changed from open grazing to stall-feeding. This has reduced human and livestock pressure on the national and community forests. However, although health facilities in the area have increased compared to the past, communities reported that the frequency of illnesses has not gone down; they attribute this to the change in diet to rice and fast foods, use of pesticides in crops and vegetables, and outbreak of diseases due to several factors including climate change.

Although the average family size is smaller than in the past, food security is perceived to be worsening in the area, as many households depend on imported food and goods. Access to credit has enabled local people to cope with vulnerabilities. There has been positive development in the case of water availability. People are happy that drinking water and irrigation facilities are now available in their homes; earlier they had to travel quite a distance to fetch drinking water. However, the water flow in springs and water channels has been decreasing, particularly in the winter and dry season.

Local participation in decision making has increased in recent times, and this can be evidenced in local people's involvement in the development committees set up for various activities taking place in the villages, such as construction of roads, schools, health facilities, hydropower projects, improving transport facilities, etc.

Box 5: **Farmers' opinions on how to enhance their livelihood**

- Fixing the cardamom market price; grading of cardamom; building a direct link with consumers so that businesspeople do not mix bad products with good ones
- Cardamon maintenance, soil testing for suitable varieties of cardamom
- Planting fruit trees such as orange, lemon, lapsi, etc.
- Planting alternative cash crop (tea, coffee, grapes, banana, amriso, ginger)
- Promotion of cash crops (rudraksha, sugandkokila, kiwi, budhachita)
- Electric dryers for large cardamom
- Coffee replacement for large cardamom; exposure visits; market management
- Lapsi and Mel marketing
- Livestock rearing; improved breed of livestock
- Market access for selling surplus vegetables and fruits; improved access to road
- New technologies for farming; satuwa and cardamom intermixed cropping; coffee plantation
- Very good possibilities for orthodox tea
- Pest management in agricultural crops and livestock
- Commercial vegetable farming
- Priority to local products in the market
- Beekeeping

5. Discussion and Recommendations

Taplejung District is the large cardamom pocket area with the highest production of large cardamom in Nepal. In terms of ethnicity, the population of the district is predominantly Janajati. In terms of age group, youth make up the largest proportion of the population. Most households are male-headed. Agro-forestry with Nepal Black Cedar interspersed in large cardamom farms is the primary source of income. Livestock rearing is another major source of income. Most farmers have shifted from traditional crop cultivation to the more profitable agro-forestry (cardamom cultivation), thus changing the land cover and land use. Therefore, rain-fed terraces and agricultural lands have been changed into irrigated cardamom plantation. Maize, paddy, and millet are the major crops cultivated by the farmers but limited to very small agricultural fields, whereas the land under cardamom cultivation is expanding every year. Whereas the crops are grown as a source of subsistence, large cardamom is cultivated to generate profits. In this scenario, local communities are highly dependent on the surrounding ecosystems. Understanding the linkages between ecosystems and human wellbeing and poverty alleviation is hence important (Daw et al., 2011; Perrings et al., 2011; Suich et al., 2015). This is especially true for a country like Nepal, where human dependency on natural resources is comparatively higher (Pant et al., 2012; Thapa et al., 2014; Sharma et al., 2015).

Although local people in the study area depend on forest ecosystems for wild edibles, firewood, fodder and timber and on freshwater ecosystems for household utility (drinking, washing, bathing), irrigation and micro-hydel projects, the respondents ranked agro-ecosystem as most important (52%) among all three ecosystems. In additon local people ranked agro-ecosystems under 'highly dependent' since most services and goods provided by the forests are obtained through the agro-ecosystem in the area, and the communities are not located close to the national and community forests, as in the case of Rauta VDC, Udayapur District (ICIMOD and BCN, 2017)

For obvious reasons, the agro-ecosystem is perceived by the community as having a higher significance, as farming is the major primary and secondary source of income in Nepal (Chalise et al., 2015; van Oort et al., 2015). This is despite the forest ecosystem providing several tangible and intangible services or goods. The forest primarily provides fuelwood, daily fodder, and timber. Additionally, it supplies medicinal plants, bush meat, edible wild vegetables and fruits, and mushrooms. However, in terms of importance, there is not much difference between agro-ecosystem, forest ecosystem and freshwater ecosystem. Freshwater is ranked lowest among the three service-providing ecosystems in spite of several benefits and its link to agro-ecosystem. This could be mainly because the benefits from the other ecosystems are obtained more directly, as also explained by other researchers (Pant et al., 2012; Thapa et al., 2014; Sharma et al., 2015).

The local communities are highly dependent on the surrounding ecosystems, particularly for provisioning services. Among the ecosystems, agro-ecosystems are critical for sources of provisioning services, as 77% are highly dependent on them, followed by freshwater ecosystem (29%) and forest ecosystem (15%). Interestingly, it was observed that the communities in higher elevations are receiving more fruits as they live near forests (national and community); communities in lower elevations receive more fish in comparison as they live near large water channels (rivers); and people in between higher and lower elevations receive more water. The communities in the area are aware and also recognize the importance of regulating, supporting and cultural services. This study includes visualization based on communities' perception, as other studies were unable to go into such detail regarding community perception of regulation services (e.g., Pant et al., 2012; Paudyal et al., 2015; Sharma et al., 2015).

They are aware that forest ecosystem has greater significance in terms of regulating, supporting and cultural services. The results also revealed that the community is beginning to recognize the value of the services they use if they are valued in monetary terms, as also reported by others (Sharma et al., 2015). In addition, people also acknowledged that the surrounding ecosystems provide them goods and services necessary for their livelihood and cultural survival.

The agro-ecosystem based on agro-forestry has enabled the communities to obtain wild-harvested goods and goods for subsistence. This in turn has helped reduce the depletion of the forest and increased the land cover. Besides community forestry, the agro-forestry option has become a good strategy for livelihood improvement and

environmental protection. However, analysis of the social, economic, and environmental impacts of the agro-forestry initiative and community forestry is inadequate and limited to a narrow set of benefits (e.g., non-timber forest products), and rarely makes comparisons with alternative land-use options (e.g., agriculture) (Birch et al., 2014). In contrast, local people perceive the provisioning services from forests in the current study area to be both quantitatively and qualitatively insufficient. This suggests the forest ecosystem is under pressure and delivery of its embedded services is deteriorating. Hence the CFUGs themselves impose regulations for forest restoration and sustainable use. Benefits derived from freshwater ecosystem services are also not well captured.

Communities have so far been unable to use good farming technologies and linkages to income-generating activities. In addition depredation of cardamom by pests (mainly civets) at the time of harvest has induced human-wildlife conflict and loss to the farmers as well as loss of biodiversity. In order to save their crops, farmers harvest the crop before harvest time, which affects the quality of the yield and brings farmers a low price. Therefore, crop depredation by wildlife in agro-forestry should be addressed in ways that can favour both the farmers and biodiversity. Local communities do have some idea about intangible ecosystem services such as regulating (linked to biodiversity, water cycle, and carbon sequestration), supporting, and cultural services, but their knowledge and awareness in this regard should be raised so that local people can significantly recognize the absolute value of ecosystems and their services. This study indicates that the general population is only interested in environmental conservation provided it brings opportunities for improving the large cardamom enterprise and other livelihood options such as cash crop alternatives, large-scale crop farming and livestock rearing.

Learning from existing successful ecosystem service-based approaches to conservation and development (Daily and Ellison, 2002; Sánchez-Azofeifa et al., 2007), it is desirable to plan and implement programs considering ecosystems (Carpenter et al., 2009; Steffen, 2009).

This assessment provided a preliminary estimation of the value of a few provisioning ecosystem services that provide benefits to local communities in Taplejung District. Inclusive valuation of all essential ecosystem services can create more awareness and encourage greater public support for development and environmental conservation.

Based on the findings of this study, the following key actions are suggested:

Action 1. Build local communities' awareness of sustainable use of ecosystem resources

Local communities in Taplejung District are highly dependent on surrounding ecosystems, the knowledge and awareness of the social, cultural, ecological and economic values and importance of these ecosystems should be raised. Rural communities should be educated on human-wildlife conflict mitigation and on sustainable use of resources from their surrounding ecosystems to mitigate ecosystem degradation in the long run.

Action 2. Develop integrated strategies and create synergies to mitigate food insecurity

Strengthening stakeholders and local institutions to develop integrated strategies and create synergies to promote integrated crop farming, cardamom intermixed cropping, commercial vegetable farming and horticulture, large-scale commercial improved breed livestock rearing; and establishing an insurance policy, compensation schemes or relief fund for crop-raiding and livestock depredation by wildlife to reduce and mitigate poor production and food shortage in the area.

Action 3. Improve value chain of large cardamom

Promote organic cardamom farming, improve the quality of cardamom, develop community participatory market price valuation, establish a direct linkage between the suppliers and the cardamom entrepreneurs as well as an insurance policy, compensation schemes or relief fund for cardamom raiding by wildlife, branding the cardamom and cardamom-based products including civet raided cardamom, construct a well-engineered irrigation facility and rural farm roads. Improving the value chain of large cardamom will enhance sustainable local and rural livelihoods and also reduce people's dependency on agro- and forests ecosystems.

Action 4. Develop green enterprises:

Taplejung District has great potential for ecotourism due to its strategic location, i.e., China in the north and India in the east. Also, as the Nepal-China border adjoining Olangchungola area is now under operation, investments to foster rural cottage industries in the sector of high-value low-volume NTFPs should be prioritized.

Action 5. Institutional development of federal administration

Nepal is currently going through federal state restructuring. Therefore, capacity building of key personnel at local level administration (municipalities and rural municipalities) for resources identification as well as institutional development of local level administration for inclusion of an ecosystem services management component in their planning and management will be a key step.

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ESA Training Report http://lib.icimod.org/record/29730

ESA Framework http://lib.icimod.org/record/29731

Annex I: List of Birds found in the project area

Common name	Scientific name
Black Francolin	*Francolinus francolinus*
Hill Partridge	*Arborophila torqueola*
Kalij Pheasant	*Lophura leucomelanos*
Ruddy Shelduck	*Tadorna ferruginea*
Speckled Piculet	*Picumnus innominatus*
Fulvous-breasted Woodpecker	*Dendrocopos macei*
Rufous Woodpecker	*Celeus brachyurus*
Grey-headed Woodpecker	*Picus canus*
Greater Flameback	*Chrysocolaptes lucidus*
Great Barbet	*Megalaima virens*
Golden-throated Barbet	*Megalaima franklinii*
Blue-throated Barbet	*Megalaima asiatica*
Common Hoopoe	*Upupa epops*
Indian Roller	*Coracias benghalensis*
Common Kingfisher	*Alcedo atthis*
White-throated Kingfisher	*Halcyon smyrnensis*
Crested Kingfisher	*Megaceryle lugubris*
Chestnut-headed Bee-eater	*Merops leschenaulti*
Large Hawk Cuckoo	*Hierococcyx sparverioides*
Eurasian Cuckoo	*Cuculus canorus*
Indian Cuckoo	*Cuculus micropterus*
Oriental Cuckoo	*Cuculus saturatus*
Lesser Cuckoo	*Cuculus poliocephalus*
Grey-bellied Cuckoo	*Cacomantis passerinus*
Asian Koel	*Eudynamys scolopacea*
Green-billed Malkoha	*Phaenicophaeus tristis*
Slaty-headed Parakeet	*Psittacula himalayana*
Himalayan Swiftlet	*Collocalia brevirostris*
House Swift	*Apus affinis*
Barn Owl	*Tyto alba*
Asian Barred Owlet	*Glaucidium cuculoides*
Spotted Owlet	*Athene brama*
Rock Pigeon	*Columba livia*
Oriental Turtle Dove	*Streptopelia orientalis*
Spotted Dove	*Streptopelia chinensis*
Wedge-tailed Green Pigeon	*Treron sphenura*
Black Kite	*Milvus migrans*
Himalayan Griffon	*Gyps himalayensis*
Besra	*Accipiter virgatus*
Common Buzzard	*Buteo buteo*

Common name	Scientific name
Long-legged Buzzard	*Buteo rufinus*
Cattle Egret	*Bubulcus ibis*
Indian Pond Heron	*Ardeola grayii*
Orange-bellied Leafbird	*Chloropsis hardwickii*
Long-tailed Shrike	*Lanius schach*
Grey-backed Shrike	*Lanius tephronotus*
Yellow-billed Blue Magpie	*Urocissa flavirostris*
Red-billed Blue Magpie	*Urocissa erythrorhyncha*
Grey Treepie	*Dendrocitta formosae*
House Crow	*Corvus splendens*
Large-billed Crow	*Corvus macrorhynchos*
Large Cuckooshrike	*Coracina macei*
Long-tailed Minivet	*Pericrocotus ethologus*
Scarlet Minivet	*Pericrocotus flammeus*
Bar-winged Flycatcher-shrike	*Hemipus picatus*
Yellow-bellied Fantail	*Rhipidura hypoxantha*
White-throated Fantail	*Rhipidura albicollis*
Black Drongo	*Dicrurus macrocercus*
Ashy Drongo	*Dicrurus leucophaeus*
Spangled Drongo	*Dicrurus hottentottus*
Common Iora	*Aegithina tiphia*
Brown dipper	*Cinclus pallasii*
Blue-capped Rock Thrush	*Monticola cinclorhynchus*
Blue Whistling Thrush	*Myophonus caeruleus*
White-collared Blackbird	*Turdus albocinctus*
Grey-winged Blackbird	*Turdus boulboul*
Dark-throated Thrush	*Turdus ruficollis*
Dark-sided Flycatcher	*Muscicapa sibirica*
Rufous-gorgeted Flycatcher	*Ficedula strophiata*
Ultramarine Flycatcher	*Ficedula superciliaris*
Verditer Flycatcher	*Eumyias thalassina*
Small Niltava	*Niltava macgrigoriae*
Rufous-bellied Niltava	*Niltava sundara*
Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*
Indian Blue Robin	*Luscinia brunnea*
Orange-flanked Bush Robin	*Tarsiger (cyanurus) rufilatus*
Golden Bush Robin	*Tarsiger chrysaeus*
Oriental Magpie Robin	*Copsychus saularis*
Black Redstart	*Phoenicurus ochruros*
Hodgson's Redstart	*Phoenicurus hodgsoni*
Blue-fronted Redstart	*Phoenicurus frontalis*
White-capped Water Redstart	*Chaimarrornis leucocephalus*
Plumbeous Water Redstart	*Rhyacornis fuliginosus*
White-tailed Robin	*Myiomela leucura*
Slaty-backed Forktail	*Enicurus schistaceus*
Spotted Forktail	*Enicurus maculatus*
Common Stonechat	*Saxicola torquata*

Common name	Scientific name
Pied Bushchat	*Saxicola caprata*
Grey Bushchat	*Saxicola ferrea*
Chestnut-tailed Starling	*Sturnus malabaricus*
Common Myna	*Acridotheres tristis*
Chestnut-bellied Nuthatch	*Sitta castanea*
White-tailed Nuthatch	*Sitta himalayensis*
Velvet-fronted Nuthatch	*Sitta frontalis*
Eurasian Treecreeper	*Certhia familiaris*
Winter Wren	*Troglodytes troglodytes*
Great Tit	*Parus major*
Green-backed Tit	*Parus monticolus*
Black-lored Tit	*Parus xanthogenys*
Black-throated Tit	*Aegithalos concinnus*
Barn Swallow	*Hirundo rustica*
Red-rumped Swallow	*Hirundo daurica*
Asian House Martin	*Delichon dasypus*
Nepal House Martin	*Delichon nipalensis*
Himalayan Bulbul	*Pycnonotus leucogenys*
Red-vented Bulbul	*Pycnonotus cafer*
Mountain Bulbul	*Hypsipetes mcclellandii*
Black Bulbul	*Hypsipetes leucocephalus*
Striated Prinia	*Prinia criniger*
Grey-breasted Prinia	*Prinia hodgsonii*
Oriental White-eye	*Zosterops palpebrosus*
Common Tailorbird	*Orthotomus sutorius*
Tickell's Leaf Warbler	*Phylloscopus affinis*
Buff-barred Warbler	*Phylloscopus pulcher*
Ashy-throated Warbler	*Phylloscopus maculipennis*
Lemon-rumped Warbler	*Phylloscopus chloronotus*
Hume's Warbler	*Phylloscopus humei*
Greenish Warbler	*Phylloscopus trochiloides*
Large-billed Leaf Warbler	*Phylloscopus magnirostris*
Whistler's Warbler	*Seicerus whistleri*
Grey-hooded Warbler	*Seicercus xanthoschistos*
White-throated Laughingthrush	*Garrulax albogularis*
White-crested Laughingthrush	*Garrulax leucolophus*
Striated Laughingthrush	*Garrulax striatus*
Streaked Laughingthrush	*Garrulax lineatus*
Black-faced Laughingthrush	*Garrulax affinis*
Rusty-cheeked Scimitar Babbler	*Pomatorhinus erythrogenys*
Scaly-breasted Wren Babbler	*Pnoepyga albiventer*
Black-chinned Babbler	*Stachyris pyrrhops*
Spiny Babbler	*Turdoides nipalensis*
Chestnut-tailed Minla	*Minla strigula*
Rufous-winged Fulvetta	*Alcippe castaneceps*
White-browed Fulvetta	*Alcippe vinipectus*
Rufous Sibia	*Heterophasia capistrata*

Common name	Scientific name
Whiskered Yuhina	*Yuhina flavicollis*
Stripe-throated Yuhina	*Yuhina gularis*
Yellow-bellied Flowerpecker	*Dicaeum melanoxanthum*
Thick-billed Flowerpecker	*Dicaeum agile*
Fire-breasted Flowerpecker	*Dicaeum ignipectus*
Purple Sunbird	*Nectarinia asiatica*
Mrs Gould's Sunbird	*Aethopyga gouldiae*
Green-tailed Sunbird	*Aethopyga nipalensis*
Black-throated Sunbird	*Aethopyga saturata*
Crimson Sunbird	*Aethopyga siparaja*
Fire-tailed Sunbird	*Aethopyga ignicauda*
House Sparrow	*Passer domesticus*
Eurasian Tree Sparrow	*Passer montanus*
White Wagtail	*Motacilla alba*
White-browed Wagtail	*Motacilla maderaspatensis*
Grey Wagtail	*Motacilla cinerea*
Paddyfield Pipit	*Anthus rufulus*
Olive-backed Pipit	*Anthus hodgsoni*
Rosy Pipit	*Anthus roseatus*
Rufous-breasted Accentor	*Prunella strophiata*
White-rumped Munia	*Lonchura striata*
Scaly-breasted Munia	*Lonchura punctulata*
Dark-breasted Rosefinch	*Carpodacus nipalensis*
Common Rosefinch	*Carpodacus erythrinus*
Crested Bunting	*Melophus lathami*

Annex 2: List of mammals found in the area

Species	Common Name
Ailurus fulgens F.G. Cuvier, 1825	Red Panda
Callosciurus pygerythrus (I. Geoffroy Saint Hilaire, 1832)	Hoary-bellied Squirrel
Canis aureus Linnaeus, 1758	Golden Jackal
Capricornis thar (Hodgson, 1831)	Himalayan Serow
Dremomys lokriah (Hodgson, 1836)	Orange-bellied Himalayan Squirrel
Felis chaus Schreber, 1777	Jungle Cat
Herpestes auropunctatus (Hodgson, 1836)	Small Indian Mongoose
Herpestes edwardsii (È. GeoffroySaint-Hilaire, 1818)	Indian Grey Mongoose
Hystrix brachyura Linnaeus, 1758	Malayan Porcupine
Macaca assamensis (M'Clelland, 1840)	Assam Macaque
Macaca mulatta (Zimmermann, 1780)	Rhesus Macaque
Manis pentadactyla Linnaeus, 1758	Chinese Pangolin
Martes flavigula (Boddaert, 1758)	Yellow-throated Marten
Muntiacus vaginalis (Zimmermann, 1780)	Barking deer
Naemorhedus goral (Hardwicke, 1825)	Himalayan Goral
Panthera pardus (Linnaeus, 1758)	Leopard
Paguma larvata (C.E.H. Smith, 1827)	Masked Palm Civet
Petaurista magnificus (Hodgson, 1836)	Hodgson's Giant Flying Squirrel
Semnopithecus schistaceus Hodgson, 1840	Nepal Gray Langur
Ursus thibetanus G. [Baron] Cuvier, 1823	Himalayan Black Bear

List of fishes from the rivers and streams preferred by local communities

Local Name	Species
Asala	*Schizothoraichthys labiatus*
Buche	*Schizothorax richardsonii*
Budhuna	*Garra annandalei*
Hallude	
Kabre	*Pseudecheneis serracula*
Katle	*Neolissocheilus hexagonolepis*
Lule	
Telgamre	
Tite	*Psilorhynchoides pseudecheneis*

Annex 3: List of plant species found in the study area

S.N	English name	Nepali name	Scientific name
List of plant species used for timber in the study area			
1	Nepal Black Cedar	Utis	*Alnus nepalensis* D.Don
2	Needle wood	Chilaune	*Schima wallichii* (DC.) Korth.
3	Indian butter	Mahuwa	*Engelhardia spicata* Leschenault ex Blume
4	White siris	Siris	*Albizia procera* (Roxb.) Benth.
5	Bamboo	Bans	*Dendrocalamus hamiltonii* Nees& Arn. ex Munro
6	Chestnut	Katus	*Castanopsis indica* (Roxb. ex Lindl.) A.DC.
7	Nepalese hog plum	Lapsi	*Choerospondias axillaris* (Roxb.) B.L.Brutt. & A.W.Hill
8		Patale Katus	*Castanopsis lanceifolia* (Oerst.) Hickel & A.Camus
9		Jhingane	*Eurya acuminata* DC.
10	Box byrtle	Kaphal	*Myrica esculenta* Buch.-Ham. ex D. Don
List of plant species for fodder in the study area			
1		Jhankri Syaula	*Phoebe lanceolata* (Nees) Nees
2	Pink bauhinia	Tanki	*Bauhinia purpurea* L.
3	Mountain ebony	Koiralo	*Bauhinia variegata* L.
4	Bounquet grass	Amliso	*Thysanolaena maxima* (Roxb.) Kuntze
5		Kharane	*Symplocos ramosissima* Wall. ex G. Don
6	Monkey jack	Badhar	*Artocarpus lakoocha* Roxb.
7		Gayo	*Bridelia retusa* (L.) A.Juss.
8	Nepal fodder fig	Khaniyu	*Ficus semicordata* Buch.- Ham ex Sm.
9		Patpate	*Gaultheria hookeri* C.B.Clarke
10	Nepal butter fruit	Chiyuri	*Diploknema butyracea* (Roxb.) H.J.Lam
11		Dudhilo	*Ficus neriifolia* Sm.
12		Gogun	*Saurauia napaulensis* DC.
13	Common fig	Nivaro	*Ficus auriculata* Lour.
14		Chuletro	*Brassaiopsis hainla* (Buch.-Ham.) Seem.
15		Kutmero	Litsea monopetala (Roxb.) Pers.
16	Java fig	Kavro	*Ficus lacor* Buch.- Ham.
17	Bamboo	Bans	*Dendrocalamus hamiltonii* Nees& Arn. ex Munro
18	Himalayan cherry	Paiyeu	*Prunus cerasoides* Buch.-Ham. ex D.Don
19		Pate Bar	*Ficus* spp.
20	Cutch tree	Khayar	*Acacia catechu* (L.f.) Willd.
21	China berry tree	Bakaino	*Melia azedarach* L.
22	Indian cranberry	Kapase	*Acer campbelli* Hook.f. & Thomson ex Hiern
23		Bilaaune	*Maesa chisia* Buch.-Ham. ex D. Don
24		Tusare	*Debregeasia salicifolia* (D.Don) Rendle
25		Thotne	*Ficus hispida* L.f.
26	Mulberry	Kimbu	*Morus serrata* Roxb.
27		Fhurke	*Pittosporum napaulense* (DC.) Rehder & E.H.Wilson
28		Mauwa	*Engelhardtia spicata* Lechen ex Blume
29		Dabdabe	*Garuga pinnata* Roxb.
30		Kharuki	*Arundinella nepalensis* Trin.
31		Maleto	*Macaranga pustulata* King ex Hook.f.

S.N	Nepali name	Scientific name
List of shrubs and herbs for fodder in the study area		
1	Kalijhar	*Ageratina adenophora* (Spreng.) R.M.King & H.Rob.
2		*Alternanthera sessilis*(L.)R.Br. ex DC.
3	Titepati	*Artemisia indica* Willd.
4	Niguro	*Dryopteris cochleata* (D. Don) C. Chr.
5	Banso	*Digitaria sanguinalis* (L.) Scop.
6	Siru	*Imperata cylindrica* (L.) Raeusch.
7	Khar	*Themeda triandra* Forssk.
8	Chiple (sano)	*Pouzolzia zeylanica* (L.) Benn.
9	Napier	*Pennisetum* purpureum Schumach.

S.N	English name	Nepali name	Scientific name
List of plants for leaf litter in the study area			
1	Nepal Black Cedar	Utis	*Alnus nepalensis* D.Don
2	Needle wood	Chilaune	*Schima wallichi* (DC.) Korth
3	Fern	Unyu	*Dryopteris cochleata* (D. Don) C. Chr.
4	Croften weed	Kalijhar	*Ageratina adenophora* (Spreng.) R.M.King & H.Rob.
List of plants for pig feed in the study area			
1		Gaglato	*Elatostema sessile* J.R. Forst.& G.Forst.
2	Stinging nettle	Sisnu	*Urtica dioca* L.
List of vegetables grown in the study area			
1	Bitter gourd	Karela	*Momordica charantia* L.
2	Pumpkin	Farsi	*Cucurbita maxima* Duchesne
3	Potato	Aalu	*Solanum tuberosum* L.
4	Cucumber	Kakro	*Cucumis sativus* L.
5	Radish	Mula	*Raphanus sativus* L.
6	Eggplant, Guinea squash	Baigun, Bhanta	*Solanum melongena* L.
7	Tomato	Tamatar	*Lycopersicum esculentum* L.
8	Carrot	Gaajar	*Daucus carota* L.
9	Sponge gourd	Ghiraula	*Luffa cylindrica* (L.) M.Roem
10	White gourd, ash pumpkin	Kubindo	*Benincasa hispida* (Thunb.)Cogn.
11	White flower gourd	Lauka	*Lagenaria siceraria* (Molina) Standl.
12	Okra	Bhindi	*Hibiscus esculentus* L.
13	Cauliflower	Cauli, Fulgobi	*Brassica oleraceae* var. botrys L.
14	Cabbage	Banda	*Brassica oleraceae* var. capitata L.
15	Chayote	Ischus	*Sechium edule* (Jacq.) Sw.
16	Tree Tomato	Tymatar/rukh tamatar	*Cyphomandra betacea* (Cav.) Sendtn.
17	Pea	Kerau/matar	*Pisum sativum* L.
18	Mustard	Tori	*Brassica campestris* var. *toria*
19	Indian colza, Sarsyun	Sarsyun	*Brassica campestris* L. var. sarson Prain
20	Spinach	Palungo	*Spinacia oleraceae* L.
21	Broadleaf mustard	Rayo	*Brassica juncea* (L.) Czern.
22	Cress	Chamsur	*Lepidium sativum* L.
23	Lamb's quarter	Bethe	*Chenopodium album* L.
24	Onion	Pyaaj	*Allium cepa* L.
25	Garlic	Lasun	*Allium sativum* L.
26	Taro	Pidaalu	*Colocasia esculenta* (L.) Schott
27	Yam	Tarul	*Doiscorea alata* L.

S.N	English name	Nepali name	Scientific name
28		Sakarkhanda	*Ipomoea batatas* (L.) Lam.
29	Chilli	Khursani	*Capsicum frutescens* var. *grossum* (Mill) L.H Bailey
30		Jaringo	*Phytolacca acinosa* Roxb.
31		Paryang	*Himalayacalamus hookerianus* (Munro) Stapleton
32	Stinging nettle	Sisno	*Urtica dioca* L.
33	Pink bauhinia	Koiraalo	*Bauhinia purpurea* L.
34	Amaranth	Latte sag	*Amaranthus* spp.
35	Green beans	Bodi	*Vigna unguiculata* (L.) Walp.
36		Tane bodi	*Vigna unguiculata* subsp. sesquipedalis (L.) Verdc.
37	Lablab, Hyacinth bean	Hiude simi	*Dolichos lablab* L.
38	Balsam apple	Chuche Karela (Barela)	*Momordica balsamina* L.
39	Young bamboo shoots	Tama	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro
40	Passion fruit	Lahare aamp	*Passiflora edulis* Sims
41	Chinese okra	Toraiya	*Luffa acutangula* (L.) Roxb.
42	Squash	Lamo farsi	*Cucurbita pepo* L.
List of fruits grown in the study area			
1	Plum	Aaru bakhada	*Prunus domestica* L.
2	Peach	Aaru	*Prunus persica* (L.) Batsch
3	Pear	Naaspati	*Pyrus communis* L.
4	Banana	Kera	*Musa paradisiaca* L.
5	Pomegranate	Anaar	*Punica granatum* L.
6	Grapes	Angur	*Vitis vinifera* L.
7	Guava	Amba	*Psidium guajava* L.
8	Papaya	Mewa	*Carica papaya* L.
9	Mango	Ampa	*Mangifera indica* L.
10	Walnut	Okhar	*Juglans regia* L.
11	Apple	Syaau	*Pyrus malus* L.
12	Jack fruit	Katahar	*Artocarpus heterophyllus* Lam.
13	Sugarcane	Ukkhu	*Saccharum officinarum* L.
14	Hogplum	Lapsi	*Choerospondias axillaris* (Roxb.) B.L.Burtt& A.W.Hill
15	Apricot	Khurpani	*Prunus ameniaca* L.
16	Persimmon	Haluwabed	*Diospyros virginiana* L.
17	Kiwi	Kiwi	*Actinidia chinensis* Planch.
18	Ground apple	Bhui syaau	*Smallanthus sonchifolius* (Poepp.) H.Rob
19	Pineapple	Bhui katahar	*Ananas comosus* (L.) Merr.
20	Litchi	Litchi	*Litchi chinensis* Sonn.
21	Chestnut	Katus	*Castanopsis indica* (Roxb. ex Lindl.) A.DC.
22	Box byrtle	Kafal	*Myrica esculenta*. Buch
23	Indian Gooseberry	Amala	*Phyllanthus emblica* L.
24		Mel	*Pyrus pashia* Buch-Ham.ex. D.Don.
25	Mulberry	Kimbu	*Morus serrata* Roxb.
26	Orange	Suntala	*Citrus reticulata* Blanco.
27	Lemon	Kagati	*Citrus aurantifolia* (Christm.) Swingle
28	Custard apple	Sarifa	*Annona squamosa* L.
29	Pomelo	Bhogate	*Citrus maxima* (Burm.) Herr.
30	Sweet orange	Mausami	*Citrus sinensis* (L.) Osbeck.
31	Betel palm	Supari	*Areca catechu* L.

S.N	English name	Nepali name	Scientific name
32	Strawberry	Strawberry	*Fragaria ananassa* (Duchesne ex Weston) Duchesne ex Rozier
33	wood apple	Bel	*Aegle marmelos* (L.)Correa
List of trees for timber in the study area			
1	Nepal Black Cedar	Utis	*Alnus nepalensis* D.Don
2	Needle wood	Chilaune	*Schima wallichi* (DC.) Korth
3		Rato Siris	*Albizia julibrissin* Durazz.
4	Cotton tree	Simal	*Bombax ceiba* L.
5	Chestnut	Patle Katus	*Castanopsis tribuloides* (Sm.) A. DC.
List of wild edible plants in the study area			
1	Edible fern shoot	Niuro	*Dryopteris cochleata* (D. Don.) C. Chr.
2	Himalayan Bamboo	Nigalo	*Drepanostachyum falcatum* (Munro) Keng f.
3	Stinging nettle	Sisnoo	*Urtica dioca* L.
4	Soap nut	Reetha	*Sapindus mukorossi* Gaerh.
5	Tufted bamboo	Bamboo young shoots	*Dendrocalamus hamiltonii* Nees& Arn. ex Munro
6	Lichen	Jhyaau	*Everniastrum nepalense* (Taylor) Hale ex Sipman
7	Mushroom	Chyaau	*Agaricus* spp.
8	Indian madder	Majito	*Rubia manjith* Roxb. ex Fleming
9		Mandre Chutro	*Mahonia nepaulensis* DC.
10		Chutro	*Berberis aristata* DC.
11	Asparagus, Wild Asparagus	Kurilo	*Asparagus racemosus* Willd.
12	Sword fern	Pani amala	*Nephrolepis cordifolia* (L) Presl.
13	Banana	Bankera	*Musa balbisiana* Colla.
14	Red Himalayan Bamboo	Malingo	*Thamnocalamus spathiflorus* (Trin.) Munro
15		Singuata/ Sigauto	*Tetrastigma* spp.
16	Golden evergreen raspberry	Ainselu	*Rubus ellipticus* Sm.
17	Air potato, Potato yam	Ban Tarul	*Dioscorea hamiltonii* Hook.f.
18	Oleaster	Kankoli	*Elaeagnus parvifolia* Wall. ex Royle
19	Watercress	Sim Sag	*Rorippa nasturtium - aquaticum* (L.) Hayek
20		Bhakimlo	*Rhus javanica* Miller
21		Bhui Aiselu	Fragaria nubicola Lindl.ex. Lacoita
22	Ivy gourd, Kavai fruit	Golkakri	*Coccinia grandis* (L.) Voiget
23		Bako	*Arisaema flavum* (Forssk.) Schott
24		Pani amala	*Nephrolepis cordifolia* (L.) Pres;
25		Theki fal	*Actinidia callosa* Lindl.
26	Magnolia Vine		*Schisandra grandiflora* (Wall.)
27	Crab eyes	Ratigedi	*Abrus precatorius* L.
28	Himalayan bird cherry	Aarupate	*Prunus cornuta* (Wall. ex Royle) Steud.
29		Marcha Jhar	*Polygala arillata* Buch.- Ham. ex D. Don
List of crops cultivated in the study area			
1	Wheat	Gau	*Triticum aestivum* L.
2	Barley	Jau	*Hordeum vulgare* L.
3	Rice	Dhaan	*Oryza sativa* L.
4	Maize	Makai	*Zea mays* L.
5	Finger millet	Kodo	*Eleusine coracana* (L.) Gaertn.
6	Amaranth	Chino	*Amaranthus* spp.
7	Buck-wheat	Faphar	*Fagopyrum esculentum* Moench

S.N	English name	Nepali name	Scientific name
8	Tatary buck-wheat	Tite- faphar	*Fagopyrum tataricum* (L.)Gaertn.
List of pulses cultivated in the study area			
1	Beans	Simi	*Phaseolus vulgaris* L.
2	Broad bean	Bakulla (kakula simi)	*Vicia faba* L.
3	Peas	Keraau	*Pisum sativum* L.
4	Horse gram	Gahat	*Pedilanthus tithymaloides* Poit
5	Gram	Chana	*Cicer arietinum* L.
6	Rice bean	Masyang	*Vigna umbellata* [Thumb] Ohwi & Ohashi
7	Adzuki bean	Guras	*Vigna angularis* (Wild.) Ohwi & Ohashi
8	Lentil	Masuro	*Lens culinaris* Medic.
9	Black gram	Maas	*Vigna mungo* (L.) Hepper
10	Pigeon pea, congo pea	Rahar, Arhar	*Cajanus cajan* (L.) Huth
11	Soyabean	Bhatmas	*Glycine max* (L.) Merr.
List of condiments and spices cultivated in the study area			
1	Nepal pepper, prickly ash	Timur	*Zanthoxyllum armatum* DC.
2	Ginger	Aduwa	*Zingiber officinale* Rosc.
3	Turmeric	Besar	*Curcuma longa* L.
4	Mint	Pudina	*Mentha arvensis* L.
5	Fennel	Saufa	*Foeniculum vulgare* Mill.
6	Cumin	Zeera	*Cuminum cyminum* L.
7	Bay Leaf	Dalchini	*Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm.
8		Tej patta	*Cinnamomum zeylanicum* Blume
9	Cardamom	Alaichi	*Amomum subulatum* Roxb.
10	Fenugreek	Methi	*Trigonella foenum-graecum* L.
11	Ajowan Lovage	Jywaano	*Trachyspermum ammi* (L.) Sprague
12	Indian butter tree	Chiuri	*Diploknema butyracea* (Roxb.) H.J. Lam
13	Sunflower	Suryamukhi	*Helianthus annus* L.
14	Chilli	Khursani	*Capsicumfrustescens* L.
15	Coriander	Dhaniya	*Coriandrum sativum* L.
16	Shallot	Chyapi	*Allium ascalonicum* L.
17	Sesame	Teel	*Sesamum indicum* L.
18		Filingo	*Guizotia abyssinica* (L.f.) Cass.

List of Invasive plants in the study area	
S.N.	Species
1	*Ageratina adenophora* L. King & Robinson
2	*Chromolaena odorata* L. R.M. King & H.Rob.
3	*Ageratum conyzoides* L.
4	*Oxalis latifolia* Kunth
5	*Lantana camara* L.
6	*Bidens pilosa* L.
7	*Ageratum houstonianum* Mill.
8	*Parthenium hysterophorus* L.

List of medicinal plants found in the study area

S.N.	English name	Nepali name	Scientific name	Uses
1	Crofton weed	Kalijhar	*Ageratina adenophora* (L.) King & Robinson	Cuts/wounds
2	Mugwort, Indian worm wood fleabane	Titepati	*Artemisia indica* Willd.	Cuts/wounds
3		Chiraito	*Swertia chirayita* (Roxb. ex Fleming) H. Karst.	Fever, cough and cold
4	Rock foil	Pakhanved	*Bergenia ciliata* (Haw.) Sternb.	Reduce body pain
5	Common mistletoe	Harchur	*Viscum album* L.	For joining broken limbs
6	Mint	Pudina	*Mentha arvensis* L.	Cough and cold
7		Timur	*Zanthoxyllum armatum* DC.	Toothache
8		Mel	*Pyrus pashia* Buch-Ham.ex. D.Don.	Jaggery is to cure dysentery
9	Flag root, myrtle flag	Bojho	*Acorus calamus* L.	Cough and sore throat
10	Dodder	Aakas beli	*Cuscuta reflexa* Roxb.	For curing jaundice
11		Satuwa	*Paris polyphylla* Smith.	Curing Jaundice and anti-cancer medicine
12		Vuichampa	*Kaempferia rotunda* L.	For leg and hand fracture and cramps
13		Bako	*Arisaema flavum* (Forssk.) Schott	Bone and muscle cracks and blood clotting; making alcohol
14	Lichen	Jhyaau	*Everniastrum nepalense* (Taylor) Hale ex Sipman	Clean intestine and remove fish bone
15		Marcha Jhar	*Polygala arillata* Buch.- Ham. ex D. Don	Plants extracted to prepare Marcha (starter cake for alcohol fermentation)
16		Marigold	*Tagetes* L.	Throat pain and Pneumonia
17		Neem	*Azadirachta indica* A. Juss.	For skin allergies
25		Budo Okhati	*Astilbe rivularis* Buch.-Ham. ex D.Don	used as tonic for weakness
26				

Annex IV: Glossary

Duna: Smaller leaf plates

Jagge: Small area prepared for ritual performances using various plants and flower species

Janajati: Indigenous and ethnic communities

Jhankri: A shaman who performs rituals and also acts as a local healer

Jharphook: Healing rituals for warding off evil spirits and curing diseases

Linga: A long pole used during ritual ceremonies

Mool: Head stream (source of water)

Mun: Local measurement unit equivalent to 40 kilograms

Panchamrit: Mixture of five foods used in Hindu worship, usually honey, jaggery, milk, yoghurt and ghee

Tapari/Tapara: Large leaf plates

Toran: A long string made up of leaves and flowers; it is hung during Hindu ceremonies to ward off evil

Project funded by the European Union

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ISBN 978 92 9115 610 8 (electronic)