ICIMOD Working Paper 2017/20

Support to Rural Livelihoods and Climate Change Adaptation in the Himalayas (Himalica)

ICIMOD

FOR MOUNTAINS AND PEOPLE

A Multi-dimensional Assessment of Ecosystems and Ecosystem Services at Udayapur, Nepal

About ICIMOD

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.

About BCN

BCN is a membership based organisation with a Founder President, patrons, life members, friends of BCN and several supporters. Our membership provides strength to the society and is drawn from people of all walks of life from students, professionals and conservationists. Our members act collectively to set the organisation's strategic agenda. We are committed to showing the value of birds and their special relationship with people. As such, we strongly advocate the need for peoples' participation as future stewards to attain long-term conservation goals. As the Nepalese Partner of BirdLife International, a network of more than 120 organisations around the world, BCN also works on a worldwide agenda to conserve the world's birds and their habitats.

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Acronyms and Abbreviations

BCN	Bird Conservation Nepal
CBD	Convention on Biological Diversity
CFUG	Community Forest User Group
DFO	District Forest Office
ESA	Ecosystem Services Assessment
HKH	Hindu Kush Himalaya
ICIMOD	International Centre for Integrated Mountain Development
NTFP	Non-Timber Forest Product
PRA	Participatory Rural Appraisal
TEEB	The Economics of Ecosystem and Biodiversity
VDC	Village Development Committee
°	degree
′	minute
′′	second
%	percentage
E	East
ha	hectare
km	kilometre
m	metre
mm	millimetre
masl	metre above sea level
N	North
sq. km.	square kilometre
USD	United States Dollar

Executive Summary

The Rural Livelihoods and Climate Change Adaptation in the Himalayas (Himalica) initiative is aimed at supporting poor and vulnerable mountain communities in the Hindu Kush Himalaya (HKH) to mitigate and adapt to climate change impacts through socioeconomic development and conservation of ecosystem assets and services through active management and policy interventions. "Ecosystem Services" is one of the major elements of the programme, focusing on the detailed assessment of the ecosystems and ecosystem services in the identified project sites within the regional member countries of Nepal, Myanmar, and Bhutan. In order to carry out the assessment in Nepal and to prepare a comprehensive technical report, ICIMOD identified Bird Conservation Nepal (BCN) as a collaborating partner institution. A research framework supported by an agreed questionnaire for ecosystem assessment developed by ICIMOD in consultation with the collaborating partners was used to determine 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.

The research area includes households within nine administrative wards of Rauta Village Development Committee (VDC), Udayapur district in southeastern Nepal. Household surveys in 439 randomly selected houses, along with Land Use and Land Cover change analysis using Geographic Information System (GIS) and Remote Sensing (RS), were conducted to understand the state and dynamics of ecosystems and their linkages to human wellbeing in the project site and to facilitate mainstreaming the knowledge into planning and development strategies. A technical report has been prepared based on the assessment data, which produced the following findings:

Socioeconomic Profile

Household number is highest downstream (below 800 masl), at 44.4% of total sampled households. Predominantly, Janajati constitutes the majority of the population amongst the four tribes in the study area. Overall, male-headed households (52.7%) surpass female-headed households (47.3%). The mean size of households was 5.6 members, with greater family size (6.2) in midstream. Approximately 51.0% of sampled households (aged six years and above) are illiterate. Surprisingly, the literacy rate for females (61.2%) exceeds that for males (38.8%), given a male: female sex ratio of sampled households of 1.1:1.

The rural livelihood is sustained by farming and wage labour. The majority of households own rainfed terraces in one of four categories of agricultural land holdings, namely irrigated, rainfed, shifting cultivation, and waterlogged. The average annual income of the sampled households ranges from USD 60-2,500, with an average of USD 750. Paddy cultivation is the only profitable crop among eight major subsistence and cash crops. The livelihood of 96% of total sampled households is sustained by livestock rearing. These households in total receive an annual average income of USD 189 from livestock. However, in the last five years, the livestock numbers have been decreasing, other than for poultry. Microscale poultry farming is favoured by 16% of households.

State of Ecosystem and Dependencies

The study revealed that of the three major ecosystems, the communities are highly dependent on the agroecosystem, followed by forest and freshwater ecosystems. The majority of the villagers are subsistence farmers, and 45% of the households agreed that there is a decreasing trend in the attributes of ecosystem/land use, compared to 33% who said there has been no change. The community perceives major changes in the forest and freshwater ecosystems over the last decade. The survey revealed that the forest ecosystem provides around 43% of total ecosystem services, with agroecosystem and freshwater ecosystem providing nearly 32% and 24% of services, respectively. Specifically, these three ecosystems offer provisioning services which are about 52% of the total ecosystem services. Similarly, they supply regulating services which are 28% of the total ecosystem services. Supporting and cultural services share 10% of the total ecosystem services. Sal (*Shorea robusta*), uttis (*Alnus nepalensis*), and chilaune (*Schima wallichii*) are the timber species preferred in the area. Similarly, amriso (*Thysanolaena maxima*) and tejpat (*Cinnamomum tamala*) are the widely cultivated NTFPs. The community at Rauta VDC perceives 17 plants, 11 animals and four sacred places as socioecologically and culturally valuable. The household questionnaires indicated that nearly 80% of the households are willing to pay for environmental management to improve ecosystems and their livelihood options in their area.

Drivers of Change, Community Perception, and Impacts

Soil infertility caused by erosion and unavailability of organic manure, erratic weather (primarily precipitation), and problematic pests resulted in poor crop production, and net production by farmers is below subsistence levels. Overall, 21% of the households' crop production is consumed within three months. The local communities have perceived declining or worsening access to forest, changes in forest cover and soil fertility because of forest degradation, forest fragmentation, and uncertainty of rain (erratic precipitation) in the last 10 years. In contrast, school, transportation, communication, and health facilities have shown improved services in the same time period. Agroforestry practice has been highly beneficial to the communities in fulfilling their demands for wild-harvested goods and timber. Therefore, the establishment of "green enterprises" and other sustainable natural resource-based livelihood options is necessary to maximise the ecosystem services benefits and minimise the pressures. Estimating the value of ecosystem services and identifying the importance of conservation in providing benefits to local communities can facilitate understanding and create more awareness amongst decision-makers, leading to appropriate conservation-related outcomes which have public support.

Conclusion and Suggestive Actions

In Rauta VDC, where agro ecosystems have a higher significance on one hand and sustain rural livelihoods on the other, opportunities should be explored to incorporate an ecosystem services assessment component in agriculture management practices and policies. Enhance knowledge and awareness among local communities, create synergy among the development and conservation agencies, development of green enterprises are some of the suggested actions for the long term management of ecosystem services.

Introduction

Safeguarding ecosystems is one of the Aichi Targets (Target, 14) for biodiversity conservation under the Convention on Biological Diversity (Secretariat of the CBD, 2010). Ecosystems are principal belongings that offer a broad array of services. These services can be categorized as supporting services that uphold living conditions, such as soil formation and nutrient cycling; provisioning services that contribute to livelihoods and the economy, such as food and water; regulating services that aid regulation of ecosystem processes, such as regulation of floods, drought, land degradation, disease, etc.; cultural services that provide nonmaterial benefits, such as recreation, religious, or spiritual and historical sites (MEA, 2005). The Millennium Ecosystem Assessment defines ecosystem services as "the benefits people obtain from ecosystems" (MEA, 2005). Since ecosystem services are not sufficiently understood and prized (in pecuniary terms), they are unappreciated and do not register with many policy makers (Costanza et al., 1987; TEEB, 2008, 2009, 2010; Rasul et al., 2011). On the other hand, the demand for ecosystem services is growing due to an increasing human population and globalization (Seto et al., 2012; Motel et al., 2014). When beneficiaries are obsessed with short-term economic growth and are less concerned with nature, mainstream decision making is less inclined to incorporate ecosystem services in conservation (Daily et al., 2009). Resource users will not respond to the degradation of ecosystem services in their resource management decisions until and unless these services are assessed and their values recognized (Rasul et al., 2011; Pant et al., 2012).

However, a lack of knowledge of the economic value of ecosystem goods and services is not a single factor paramount to exploitation of the resource. There are many other related factors such as policies and practices, outsourcing demand on existing services, and the speculative investment on conserving services (Burkhard et al., 2010; Howe et al., 2014). These factors make the understanding of the value of these resources more complex (Hicks et al., 2015). Furthermore, suboptimal investment in conservation and management guide ecosystem deterioration (MEA, 2005). The degree of utilization of services can inform whether conserving (rather than converting) or restoring a site has broader benefits for society (Balmford et al., 2002; Turner et al., 2003; Sach et al., 2009). Therefore, growing advocacies towards ecosystem service assessment need to be included to support decision making (MEA, 2005; Griggs et al., 2013; Secretariat of the CBD, 2014).

An ecosystem assessment can be defined as "an overall process of finding the causes of ecosystem change, their consequences for human well-being, and management and policy options summon decision-makers" (MEA, 2005). The assessment focuses on the concept of ecosystem service, unveils the connection between environmental issues and people, considers both the ecosystems from which services are derived and the people who depend on it, and investigates the effect of changes in the supply of services (Ash, 2010).

Nepal, situated between India in the south and China in the north, harbours a rich biodiversity due to an extreme variability in altitude, climatic conditions, and the merging of Palaearctic and Oriental zoogeographic realms, as well as being at the crossroads of six Asiatic floristic provinces (MoFSC, 2014). Approximately 118 ecosystems, including 35 forest types, have been recognized in the country. According to Nepal's fourth National Report to the Convention on Biological Diversity (CBD), Nepal's major ecosystems include 29% forest area, 21% farmland, 12% grassland, 10.6% shrub land and degraded forest, 7% uncultivated inclusions, and 2.6% water body (MoFSC, 2014). The country is part of one of the 34 Global Biodiversity Hotspots – The Himalaya (Mittermier et al., 2004), and there are six biomes (Olson and Dinerstein, 1998). Globally, there are 200 ecoregions (Olson and Dinerstein, 1998); nine of the 60 found in the Hindu Kush Himalaya are in Nepal (Chettri et al., 2008). Nepal's biodiversity includes 192 mammal species (Thapa, 2014), 871 bird species (Thapa et al., 2014), 190 species of herpetofauna (Shah and Tiwari, 2004), 217 indigenous fish species (Shrestha, 2008), 660 species of butterfly (Smith, 2010), and over 6,600 species of plants (RBG, 2014).

Ecosystem for Sustainable Economic Development and Poverty Alleviation in Nepal

The diverse ecosystems found in Nepal are the major sources of ecosystem services supporting more than 70% of the rural communities directly (Mahat et al., 1987; Pant et al., 2012; MoFSC, 2014). The low-income economy is highly dependent on ecosystem services and other natural capital, including tourism (Nepal, 2012). Natural capital makes up about 31% of the national wealth (World Bank 2006). It is estimated that the total contribution of environment-related income to the country's economy may be over 50% (Sharma et al., 2015). Agriculture, combined with forestry and fisheries, accounts for more than 38% of the country's GDP (World Bank, 2008). About 80 to 90% of the population is dependent on forests and subsistence agriculture for their rural livelihoods (Poverty-Environment Initiative, 2010; Pant et al., 2012). Significant portions of the power, water, manufacturing, trade, and tourism sectors are also dependent on the environment in one form or another. It is estimated that the forestry sector alone contributes 15% to the GDP of the country (MoFSC, 2009). Similarly, non-timber forest products contribute about 5% of GDP. Tourism, much of which is nature-based, provides about 2% of the total GDP and about 25% of the total foreign exchange earnings (MoFSC, 2010). Therefore, the wise management of ecosystems and natural resources can be a key to sustainable economic development and poverty alleviation strategies in Nepal.

Ironically, attempts at assessing and valuing ecosystems and their services and ecosystem-based adaptation have been minimal in the Hindu Kush Himalaya (HKH), other than some empirical studies (e.g., Maharana et al., 2000a, b; Baral et al., 2007, 2008; Badola et al., 2010; Chen and Jim, 2010; Pant et al., 2012; Bhatta et al., 2014; Birch et al., 2014; ICIMOD and RSPN, 2014; ICIMOD and MoFSC, 2014; Sharma et al., 2015). However, the framework and mechanism for ecosystem-based valuation and adaptation are starting to grow in Nepal (Rasul et al., 2011; Pant et al., 2012; Sharma et al., 2015). The International Centre for Integrated Mountain Development (ICIMOD), an intergovernmental regional knowledge and enabling centre, is laudably fostering the valuation of ecosystems and their services in the HKH.

There is an urgent need to comprehend the complexities of the ecosystems and the biosocioeconomics related to its management so that appropriate policies and strategies can be developed to address emerging threats to ecosystems and to enhance services to benefit both nature and humans alike. The Support to Rural Livelihoods and Climate Change Adaptation in the Himalaya (Himalica) initiative is aimed at supporting poor and vulnerable mountain communities in the HKH to mitigate and adapt to climate change impacts through collaborative action research and pilot activities. The objective is to help build the capacity of institutions working on resilience to climate-induced vulnerability, which will subsequently improve the livelihoods of the mountain communities in the HKH. However, it is assumed that adaptive capacity can only be attained when the value of the ecosystem services provided by mountain communities to themselves and those downstream is understood, recognized, and maintained (Rasul et al., 2011; Thapa et al., 2014). Thus, ICIMOD in collaboration with BCN conducted an assessment of the ecosystem services in Rauta VDC, Udayapur District, Nepal.

The report highlights integrated ideas and scenarios of the state and dynamics of ecological, socioeconomic, and livelihood aspects of the study area. It also summarizes people's perceptions on climate change scenarios and potential impacts on biodiversity, ecosystem services, and their livelihoods. It highlights the overuse of resources, with an emphasis on land use and land cover change, and discusses the factors affecting people's vulnerability, including adaptive capacity, livelihood options, and adaptation practices adopted by local communities in response to environmental and socioeconomic changes. Finally, the report develops knowledge products to share and ensure mainstreaming for the effective planning and management of ecosystems.

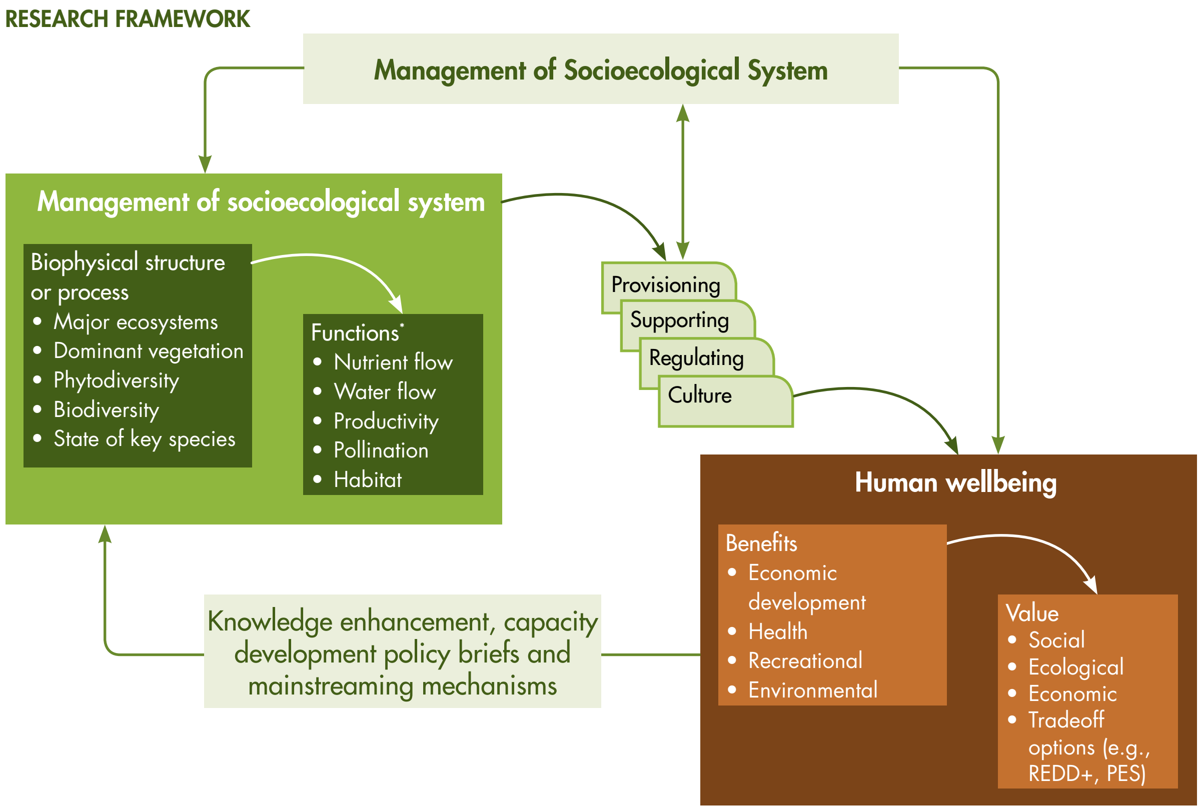
Research Framework and Methodology

Research Framework

A standard Ecosystem Services Assessment (ESA) research framework was prepared based on the "Ecosystem Services Cascade" Framework (de Groot et al., 2010; Müller et al., 2010) (Figure 1), which rationalizes the significance and dependence of ecosystem services to human wellbeing. It attempts to reorganize the necessary elements for systematic ecosystems services assessment studies and can be readjusted based on the needs and requirements of the study area. It focuses on elements of each of the components, namely ecosystems and biodiversity, ecosystem services, and human wellbeing, and considers the logical linkages between these elements which are necessary for developing connections between the ecosystem services and human wellbeing (Figure 1). This framework allows an understanding of the state of the ecosystem services and the dynamics of such services in a given study area, and links with people's dependency to strengthen the decision making processes. The current study deviates from a cyclic or virtual process of the conventional ecosystems assessment practice by focusing on the information and knowledge flow (shown by the shaded line in Figure 1) as part of the impact pathway.

The current study envisages two vital indicators in the research design for ecosystems services: (1) State — describing which ecosystem structure, process, and function is providing the services and how much (e.g., people's dependency), and (2) Performance - describing how much of the services are being used in a sustainable way

Figure 1: **A research framework for ecosystems assessment linking to impact pathways**



Source: Modified from DeGroot et al., 2010 and Müller et al., 2010; Chettri et al., 2014 (e.g., resources availability). The importance (value) of ecosystems and their services can be expressed in three value domains, namely biophysical (supply of ecosystem services), sociocultural, and economic (use of ecosystem services by beneficiaries) to link knowledge of ecosystem services with human wellbeing, following Castro et al., (2014). The biophysical value encompasses the health of a system (and not necessarily in economic terms) measured with ecological indicators such as diversity and integrity (and trend and projection if applicable), while sociocultural values include the importance of services to the people in terms of their cultural and traditional uses (for example, the cultural identity and practices that are related to use of ecosystem services) (Raymond et al., 2009). For the economic valuation some of the conventional methodologies suggested by Rasul et al., (2011) and contemporary tools such as Remote Sensing (RS) and Geographic Information System (GIS) were used to analyze and understand the state and dynamics of ecosystems services in relation to their ecosystems.

Indicators for ecosystem structure, process, function, and quantity were addressed by adopting a number of set questions from the global framework (de Groot et al., 2010) and developed in compliance with the objectives of this assessment (see Box 1).

Box 1: **Research questions to better integrate ecosystem services in ecosystem/landscape planning, management, and decision-making**

a. Understanding and quantifying the states of ecosystems and their goods and services

- What are the major ecosystems found in the study area and what is their status?
- What are the major ecosystems services provided by these ecosystems?
- What is the state of ecosystem services in the given study area?
- How can these ecosystems and the services provided by them be spatially mapped and show changes?
- How the spatio-temporal change of ecosystems effect the flow of ecosystem services?

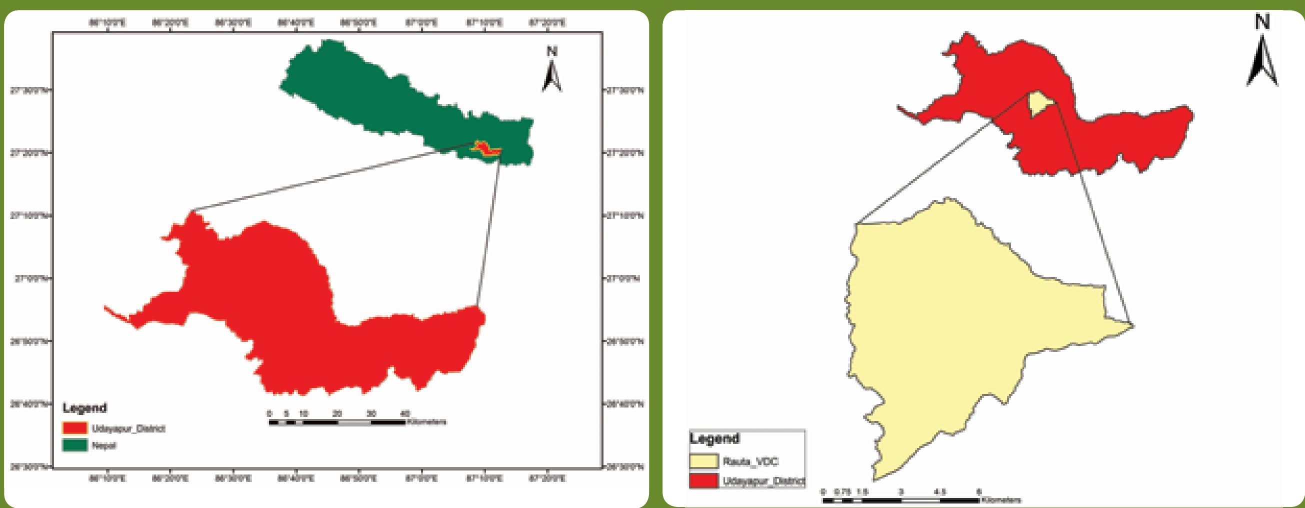
b. Valuing ecosystem services

- What are the most important ecosystem services contributing to the economic wellbeing of the communities?
- Are there any species or ecosystems that are socioculturally valuable?
- What are the ecologically significant species or ecosystems?

Study Area

Rauta Village Development Committee (VDC) (administrative unit of a District), extending from 26° 53′ 5″ to 26° 58′ 54″ N to 86° 36′ 7″ to 86° 42′ 6″ E, is one of the 44 VDCs of Udayapur District (Figure 2). From the Digital Elevation Model (DEM) the estimated area of the VDC is 5,332 hectares. This VDC is approximately 25 km

Figure 2: **Map of Udayapur District with Nepal in inset (left) and map of Rauta VDC with Udayapur District in inset (right)**



northwest from Gaighat, headquarters of Udayapur District. Physio-geographically, there are Tarais (foothills) and lower slopes of the Mahabharat range of the Himalaya with slopes ranging from 0° to 73°. The elevation ranges from approximately 312 m to 1,940 masl throughout the Rauta, from -1° to 360°. The administrative office of the VDC remains at Murkuchi, Ruata ward #9. Murkuchi is a heavily settled area with a rural contemporary market in the VDC.

It holds a small population of 7,630 within 1,535 households, with a population density of 159/sq.km. Female population is slightly greater than that of male (3,975 versus 3,655), with a sex ratio of 0.92. The average family size in each household is five. Besides temporary migration for employment, permanent migration also exists in this VDC. In 2012, the incoming population was 97, while the outgoing population was 52 individuals. According to the National Population Census 2011, 43.3% of households in the VDC use electricity. Also, 97.4% use fuel woods for cooking purposes, and 76.4% have a tap or piped water for drinking purposes, while 21.9% have a well-managed toilet. The total literacy rate is 71.8%, with male literacy at 79.8% and a female literacy rate of 64.6% (CBS, 2011). There are 13 child development centers, eight primary schools, four lower secondary schools, two secondary schools, one higher secondary school, and one private school. There is only one health post for the VDC.

The VDC consists of 789 ha of agricultural land, 2,883 ha (2,978 ha according to District Forest Office Udayapur) of forest, 21 ha of grazing grasslands, and 74 ha of wetlands and rocks. The forest occupies 79.1% of the total land in Rauta VDC. There are 10 Community Forest Users Groups (CFUGs) covering 1,703 ha, on which 1,233 households are dependent. The National Forest (government managed) occupies 1,275 ha. Major crops cultivated in the VDC are vegetables, cereals, corns, citrus fruits, pear, tea, coffee, mango, litchi, sunflower oil, and mushroom. This VDC is the subwatershed for three important streams, the Triyuga, Rasuwa, and Baruwa. The Gaighat-Nepaltar black-topped and gravel road and the Murkuchi-Bhutar track pass through this VDC (DDC Udayapur, 2013).

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 and taking into consideration the direct participation and involvement of experts and community members in the assessment through household surveys. ICIMOD organized a five-day regional orientation training on ESA, in collaboration with local implementing partners, BCN and Nabaprabhat Nepal, based on a Framework and research questions applicable for the assessments (Chettri et al., 2014). The training targeted a standard, comparable, and consistent methodology to ensure a common understanding and harmonization among implementing partners. The training provided learning opportunities on the theoretical aspects of Participatory Rural Appraisal (PRA) tools and hands-on training through a one-day theory session and a two-day field exercise. The theory sessions focused on management of ecosystems for sustaining services; ecosystem services assessment overview; household survey: why and how to extract useful data; importance of quantitative data in ecosystem services valuation; community-based participatory rural appraisal: concepts, opportunities, and challenges; and use of GPS and enumerators' role in effective data collection. Field exercises were mostly confined to practicing PRA tools and techniques, specifically, focused group discussion, resource mapping, institutional mapping, mobility mapping, seasonal calendaring, pair-wise ranking, and the historical timeline (see Karki et al., 2014). The household survey draft questionnaire was pre-tested in the field and further revised.

Following the training, a VDC-level PRA was organized by BCN at Murkuchi, Rauta VDC-9. Data on major ecosystems, major crops cultivated, provisioning services, socio-culturally and ecologically valuable plant and animal species, ecosystems, and sacred sites were used, based upon information collected through PRA, to finalize the pre-tested questionnaire. Enumerators for the household survey were oriented to the final questionnaire and trained on their primary and secondary roles during the survey. A demonstration of how to complete the household questionnaire was organized at Dumrithumka Adarsha Women Community Forest Users Group (DAWCFUG), Rauta ward number 5 before administration of the household survey.

Nine wards (administrative units of a VDC) of Rauta VDC — which is a crucial watershed for numerous streams originating from the VDC including the Triyuga, Rasuwa, Baruwa, Punware, and Chhahodiya — were selected as the study area. The sampling area was divided into upstream (above 1,400 masl), midstream (800-1,400 masl), and downstream (below 800 masl) based on socioeconomic conditions (availability and use of resources), land use practices (agricultural patterns), and forest covers and types. With reference to the VDC Water, Sanitation, and Hygiene-Coordination Committee (V-WASH-CC) 2013 data, 30% of the total households (N=1,464) were sampled. Individual household interviews were conducted primarily in the Nepali language and occasionally in other dialects (Magar language) to administer the questionnaires, which required an hour and a half per household. Completed questionnaires were collected and cross checks for discrepancies were carried out through close consultation among enumerators. Social mobilizers assisted the enumerators to reach each household and arranged the face-to-face interviews with household members.

The household questionnaire survey information was 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 analyzed deploying the SPSS version 16.0 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 about the average degree of shyness and the degree to which people differ in shyness.

Ecosystems and Ecosystem Services Assessment

Three major ecosystems - forest, agriculture, and freshwater - were identified through PRA. An extensive list of ecosystem 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 (MEA, 2005) framework. Provisioning services included fuel wood, 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 enlisted included aesthetic beauty, ecotourism, education and research, recreation, nature worship, and spiritual enrichment.

Based on the community's perception of the sense of importance and level of dependency, these services were ranked as high, medium, and low. Services that were widely used and essential for local subsistence were ranked high, those preferred by the community were ranked medium, and those which were 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.

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), orthorectified 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 thirteen 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 households 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.

Livelihood Vulnerability Assessment

For 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 ecosystems services and goods; crisis/ shocks; and the community's coping strategies to overcome those crises.

Research Results

Overview of Socioeconomic Features

Demographic profile

Rauta VDC holds a population of 7,630 in 1,535 households within nine administrative wards (DDC Udayapur, 2013). However, the study surveyed only 439 households having a total population of 2,485 members (Table 1) and also excluded family members who have lived more than six months away from the household. Household density is higher in downstream areas (Table 2). The Janajati constitute the majority of population amongst the four tribes in the study area. Overall, male-headed households (52.7%) surpass female-headed households (47.3%). In contrast, female-headed households (54.5%) exceed male-headed households (45.5%) in downstream areas. The mean size of households is 5.67 members, with greater family size (6.23) in midstream. About 51% of the sampled households population (aged six years and above) are illiterate (Figure 3). Interestingly, the literacy rate for females (61.2%) exceeds that for men (38.8%), given the male: female sum population of sampled households is 1.1:1.

Table 1: **Gender-wise population composition**

Sex/sampled area	Downstream	Midstream	Upstream	**Total**
Male	531	588	205	**1,324**
Female	460	515	186	**1,161**

Table 2: **Households in the sampled area**

Survey area	% of Total households	Household
Downstream	44.4%	195
Midstream	40.3%	177
Upstream	15.3%	67
Total	**100.0%**	**439**

Livelihood strategies

Local livelihoods include an amalgam of farming, animal husbandry, wage labour, petty business, employment, and remittances (Figure 4). Farming is the primary source of income to 65% and the secondary source of income to 60% of surveyed households. Other primary sources of income include petty business (12%), salaried employment (9%), remittance (8%), and wage labour (6%). Similarly, wage labour (22%), petty business (12%), salaried employment (5%), and remittance (1%) are other secondary sources of income. The annual income of sampled households ranges from US$60 to 2,500 with US$750 as an average. The rural livelihood is sustained by farming and wage labour.

Figure 3: **Education status in sampled household's population**

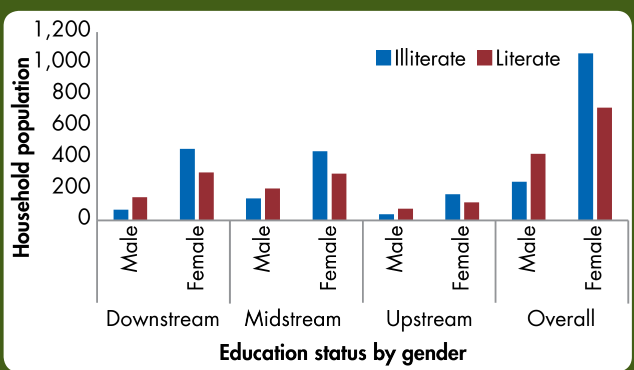
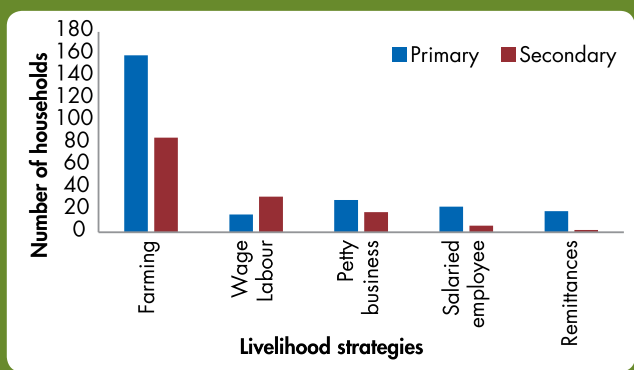


Figure 4: **Major occupations supporting local livelihood**



The majority of households own rain-fed terraces amongst four categories of agricultural land holdings (Table 3). Irrigated terraces (42% of total agricultural land) are abundant in downstream areas due to the availability of irrigation facilities. Of the total irrigated terraces, 16% are uncultivated (17% downstream). This might be the consequence of temporary migration for labour, employment, and remittances, as well as soil infertility and poor productivity.

Table 3: **Average agricultural land per household (in hectares)**

Categories of agricultural land holdings	Average area in Hectare/HH				
	Total owned	Self-cultivated	Uncultivated	Rented in	Rented out
Irrigated terraces	0.25	0.21	0.08	0.09	0.14
Rain-fed terraces	0.33	0.29	0.10	0.09	0.09
Shifting cultivation	0.13	0.12	0.08	0.08	0.08
Waterlogged terraces	0.08	0.08	0.08	0.08	0.08

Table 4: **Total agricultural land in the sample area (in hectares)**

Categories of agricultural land	Total owned	Self- cultivated	Uncultivated	Rented in	Rented out
Irrigated terraces	2,153.14	1,882.54	743.36	795.85	1,205.64
Rain-fed terraces	2,922.56	2,567.52	883.73	769.11	801.50
Shifting cultivation	1,117.77	1,082.27	701.50	696.90	693.00
Waterlogged terraces	732.29	727.29	694.50	693.00	695.50

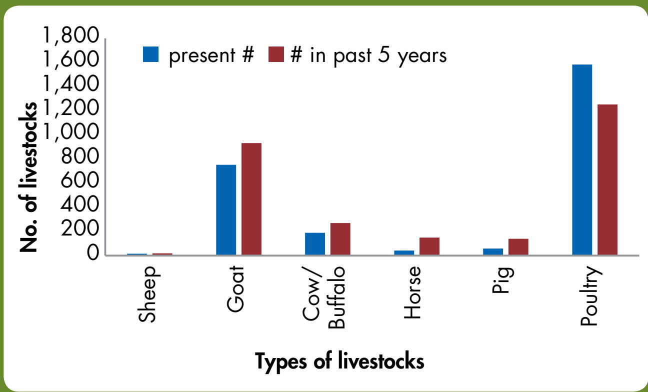
Major subsistence and cash crops cultivated in Rauta VDC are presented in Table 5. Seasonal production of paddy is the most profitable agro-practice; however, the net production is inadequate to provide rice year-round.

Livestock rearing was practiced by 96% of sampled households. However, in the last five years livestock numbers have decreased, except for poultry (Figure 5). Micro-scale poultry farming helps in sustaining the livelihoods of 16% households. Goat numbers have significantly decreased by nearly 20%. Unavailability of manpower and diseases ("deshan" in dialect) are plausible causes for the current decline. Upstream communities rear relatively fewer livestock. Both open grazing and stall-feeding livestock rearing are practiced.

Table 5: **Agricultural production with cost evaluation**

Crops	Cultivated area (in ha)	Total quantity (Kg)
Maize	6,341.87	6,077.12
Paddy	15,237.58	16,940.20
Millet	20,218.10	19,923.05
Soybean	34,092.60	32,658.04
Mustard	33,307.20	33,174.47
Wheat/Buckwheat	34,226.47	35,057.61
Pulses	39,784.84	44,376.53
Potato	39,021.69	39,422.55

Figure 5: **Number of livestock, present and past five years**



Drinking water sources

Piped water is the major source of drinking water. Ponds, streams, and springs are rarely used in upstream and midstream areas, as these sources are very distant from the settlement. Mean consumption of water per household (HH) per day is 90.05, 88.93, and 71.34 liters in downstream, midstream, and upstream areas, respectively, with an average consumption of 86.74 liters per HH per day. This includes drinking water, water for cooking for three meals (breakfast, lunch, dinner, and tea) and preparing feeds for animals.

State of the Ecosystems

Community Dependence on Major Ecosystems

The people in Rauta are highly dependent on all three ecosystems; however, they discern the level of dependency on these ecosystems in terms of their livelihood priorities. Sixty-nine percent of households admit a higher dependency on the agroecosystem given farming as the major primary and secondary source of income in the sampled area. The community is primarily reliant on agroecosystem resources for food, such as rice, corn, cereals, pulses, soya bean, vegetables, fruits and meat, milk and milk products from livestock and poultry. They also obtain mushrooms, wild vegetables (stinging nettle, ferns, etc.) to meet their nutrient supply. Agricultural byproducts are utilized as fodder for the livestock. Residents use agriculture fields and terraces in between harvest and cropping for grazing livestock. Communities collect fodder from their home gardens and the area surrounding their households during rainy and dry seasons. Livestock rearing has sustained the local livelihoods, providing animal products such as meat, milk, wool, and leather. Nevertheless, the agroforest ecosystem supplies thatch, timber/poles and similar resources for construction of houses, sheds, and furnishings. Bamboo is the most utilized agroforest product, and is used for construction, furnishings, and making handicraft tools. Medicinal plants such as Ghortapre (*Centella* sp.) are found in the surroundings of households, home gardens, and irrigated lowlands (*Khet*).

Although forest ecosystems provide many goods and services, overall the responses indicate a perception of lesser dependency upon the forest ecosystem in comparison to the agro-ecosystem. About 32%, 43%, and 21% of residents view the community as highly dependent, dependent, and moderately dependent on forest ecosystems, respectively (Figure 6). Also, 13%, 20%, 41%, 14%, and 12% concede they are highly dependent, dependent, moderately dependent, less dependent, and not dependent on the freshwater ecosystem, respectively.

Importance/Significance of Ecosystems

Again, the ecosystem-dependent communities perceive all three ecosystems as equally important; however, they distinguish the level of significance of these ecosystems in terms of their livelihood priorities. The households ranked the agro ecosystem as very important (55%) followed by freshwater, and forest ecosystems (Figure 7). Likewise, 46% and 23% of households ranked the forest ecosystem and freshwater ecosystem as very important.

For obvious reasons, the community perceives the greater significance of the agro ecosystem, as farming is the major primary and secondary source of income in the surveyed area. This is despite the forest ecosystem providing several tangible and intangible services or goods. The forest primarily provides fuel wood, daily fodder needs, and

Figure 6: **Dependency in major ecosystems**

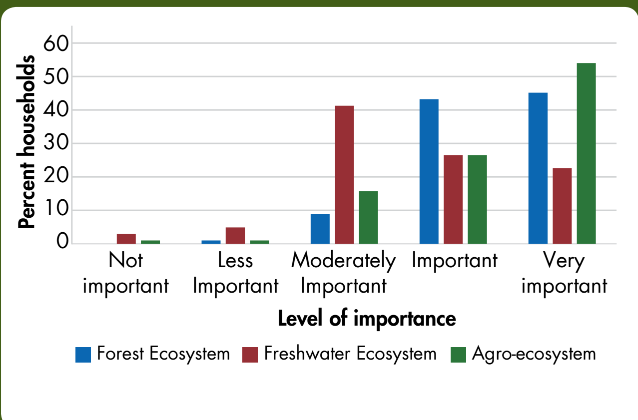
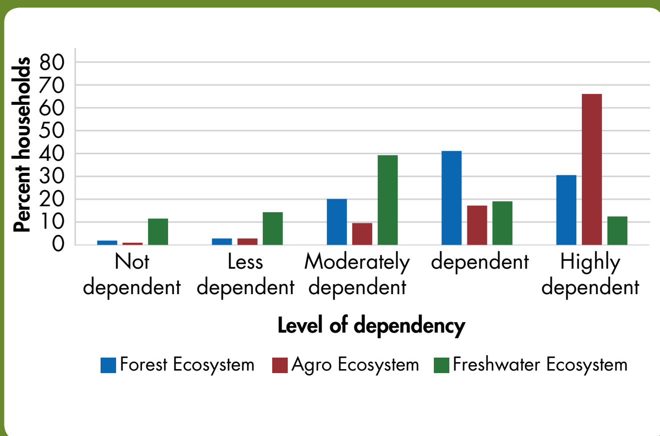


Figure 7: **Importance of major ecosystems**



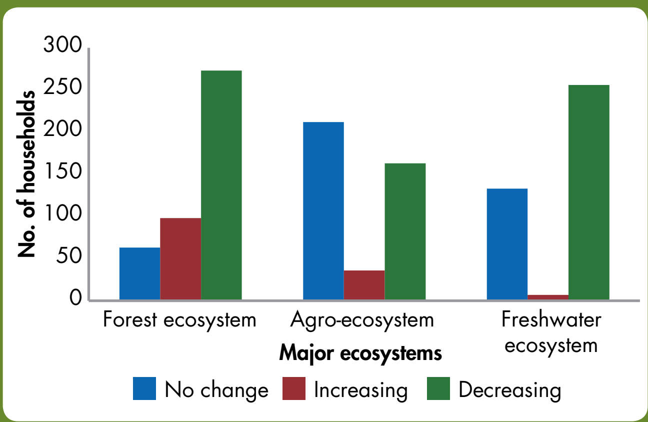
timber. Additionally, it supplies medicinal plants, dye, bush meat, edible wild vegetables and fruits, and mushrooms. However, in terms of importance, the agro ecosystem and forest ecosystem do not vary sharply as compared to the dependencies.

Freshwater is ranked lowest among the three services in spite of several benefits. Freshwater is needed for drinking, bathing, washing, and irrigating agricultural lands. It provides a habitat for the aquatic fauna such as invertebrates (crab, shrimp, mollusks), fishes, and herpetofauna (*Paha and Manpaha*), which are a protein-rich food supply. Edible wild vegetables such as stinging nettle and karkalo, as well as construction materials such as mud (kamero or red soil), pebbles, boulders, and sand, are extracted from stream banks. Boulders are turned into pasting and grinding tools such as *Lohoro-Silauto* and *Janto*.

Additionally, a high diversity of 92 bird species is recorded from the three ecosystems (Annex 1). Birds provide many ecosystem services, including pollination, pest control, and supplementing the food web in a given ecosystem, which by and large are invisible. In many cases, the activities of birds can have significant consequences for the ecosystems they inhabit by contributing ecosystem health and services to aid in their efficient functioning. However, the study of birds and their role in ecosystem management is beyond the scope of this study.

Perceived Change in the Major Ecosystems

Figure 8: **People's perception on changes in ecosystems**



Attributes of ecosystem/land use are a decreasing trend as perceived by 45% of the households, while 33% of households are unaware of any change (Figure 8). The communities perceive major changes in forest and freshwater ecosystems within the last decade. It is notable that 62% of households witnessed the depletion of forest, stating that "access to forest cover was becoming more distant". In contrast, 22% of households observed the extension of forest cover owing to the community forest management. In upstream areas, 56% of households described forest ecosystems as increasing in the last 10 years. This might be the consequence of migration, undergoing agroforest practices, and afforestation. Interestingly, 48% of households pronounced no change in the agricultural landscape. In contrast, 37% observed a diminishing of the agro ecosystem because of the unavailability of irrigation facilities and the diversification of livelihood. They also contend that agricultural lands are abandoned and left uncultivated because traditional agriculture practices are unprofitable. Meanwhile, 58% of households are convinced that a rapid deceleration of the freshwater ecosystem has occurred, although 30% are skeptical of such changes.

Land Use/Land Cover Change Analysis

Land Use Land Cover Change Status

Forest, agricultural lands, and water bodies (freshwater) are the major land cover types in Rauta VDC which have undergone minor changes over time (1992-2010). In 1992, the forest covered about 75% (3,982.8 ha) of the total land (5,332.5 ha), and 25% (1,327.4 ha) of the total land was utilized for agriculture. Water bodies and settlements constituted a minimal proportion of the land cover, about 17% and 6%, respectively. By 2002, agricultural land had increased by about 3% due to the conversion of forest land. Between 2002 and 2010, 2% of the agricultural land returned to forest (Figures 9, 10, 11, 12, and Table 6). Ostensibly, agroforest practices, for example,

Figure 9: **Map showing land cover types in 1992**

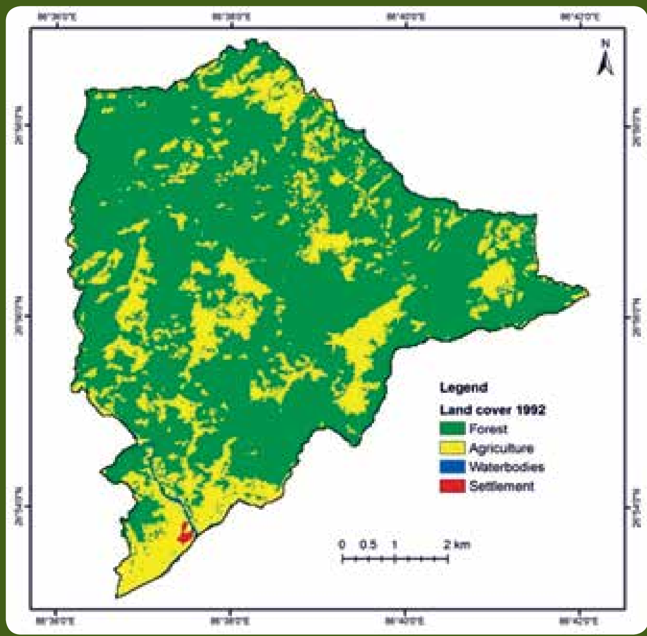


Figure 10: **Map showing land cover types in 2002**

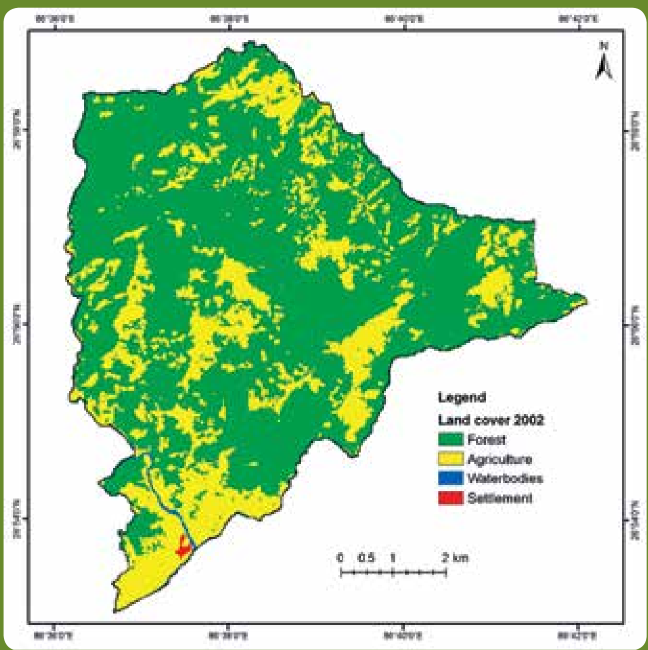


Figure 11: **Map showing land cover types in 2010**

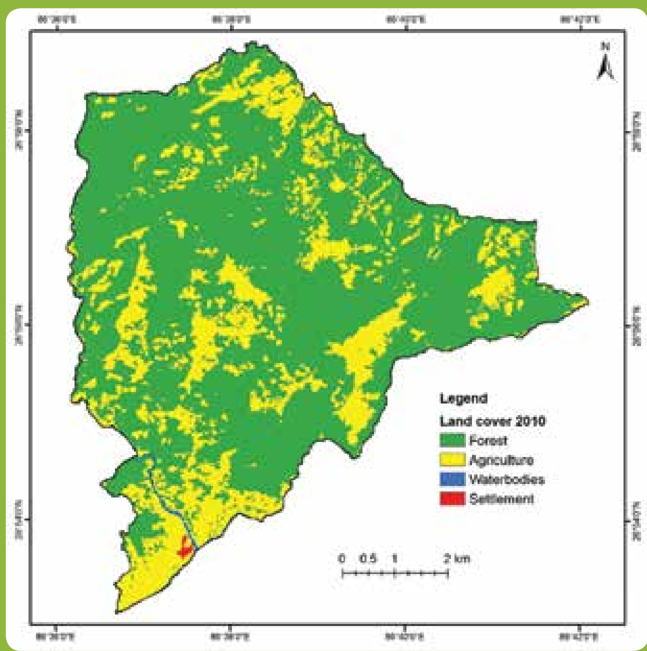
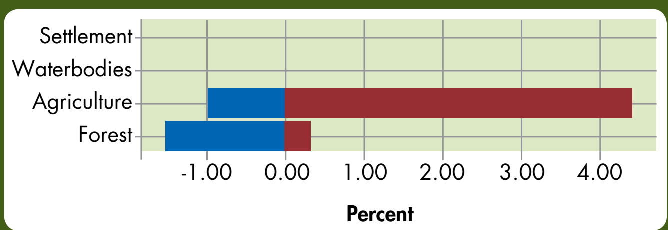


Figure 12: **Bar diagram showing land cover change (gain and losses) from 1992-2010**



bay leaves (*Cinnamon tamala*) plantation and community intervention to control the illegal timber trade supported re-forestation. 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, but any expansion may be balanced due to the temporary and permanent migrations of households from the Rauta VDC to other parts of the district and to other parts of the country as well.

More specific explanation is supported by the change matrices (Tables 7 and 8). From 1992-2002, 158.2 ha of forest was converted to agricultural land (Table 7). From 2002-2010, 108.2 ha of agricultural land reverted to forest (Table 8).

Table 6: **Summary of Landsat classification area statistics for 1992, 2002, and 2010**

ID	Land cover	Year 1992		Year 2002		Year 2010		LC changes % (1992-2010)
		ha	%	ha	%	ha	%	
1	Forest	3,982.8	74.69	3,834.7	71.91	3,935.1	73.79	-0.89
2	Agriculture	1,327.4	24.89	1,475.5	27.67	1,375.1	25.79	0.89
3	Freshwater	16.7	0.31	16.7	0.31	16.7	0.31	0.00
4	Settlement	5.7	0.11	5.7	0.11	5.7	0.11	0.00
8	**Total**	**5,332.6**	**100**	**5,332.6**	**100.00**	**5,332.6**	**100**	**0.00**

Table 7: **Change matrix of land cover (ha) from 1992 to 2002**

Land cover (ha)	Forest	Agriculture	Waterbodies	Settlement	Total (2002)
Forest	3,824.6	10.2	0.0	0.0	3,834.7
Agriculture	158.2	1,317.2	0.0	0.0	1,475.5
Waterbodies	0.0	0.0	16.7	0.0	16.7
Settlement	0.0	0.0	0.0	5.7	5.7
Total (1992)	**3,982.8**	**1,327.4**	**16.7**	**5.7**	**5,332.6**

Table 8: **Change matrix of land cover (ha) from 2002 to 2010**

Land cover (ha)	Forest	Agriculture	Waterbodies	Settlement	Total (2010)
Forest	3,826.9	108.2	0.0	0.0	3,935.1
Agriculture	7.8	1,367.3	0.0	0.0	1,375.1
Waterbodies	0.0	0.0	16.7	0.0	16.7
Settlement	0.0	0.0	0.0	5.7	5.7
Total (2002)	**3,834.7**	**1,475.5**	**16.7**	**5.7**	**5,332.6**

Status and Sources of Ecosystem Services

Ecosystem Services

Community consultations (PRA) identified a series of goods and services utilized by the local community which are provided by three major ecosystems in Rauta VDC. These goods and services fall under four categories: provisioning, regulating, supporting, and cultural (as listed in Table 9). Forest ecosystem provides about 43% of total ecosystem services (51 goods and services). Agro ecosystem and freshwater ecosystem share nearly 32% and 24%, respectively.

Table 9: **List of ecosystem services provided by ecosystems**

Provisioning (27)	Regulating (14)	Supporting (4)	Cultural (6)
Fuel wood, fodder, grazing, timber/poles, leaf litter, medicinal plants, mushrooms, ornamental plants, thatch, bush meat, wild edible fruits and vegetables, dyes, fiber, paddy, cereals, pulses/soyabean, vegetables, fish, crab, frog, drinking water, boulders, bathing water, irrigation water, Red mud, sand, Kamero (white soil)	Carbon sequestration, climate regulation, flood control, groundwater recharge, nutrient enrichment, pest regulation, pollination, seed dispersal, soil fertility, soil formation, soil stability, waste treatment, water purification, water retention	Ecosystem resilience, habitat for species, hydrologic cycle, soil formation	Aesthetic beauty, ecotourism, education and research, recreation, nature worship, spiritual enrichment

Provisioning services

Provisioning services constitute 53% of the overall ecosystem services (Figure 13). The forest ecosystem, which provides 40% of the total provisioning services, is the most productive compared to the agro and freshwater ecosystems, which provide 32% and 25% of the total provisioning services, respectively. Fuel wood is the most utilized provisioning service, reported by 97% of households. Fodder, timber/poles, grazing, paddy, cereals, vegetables, mushrooms, wild edible fruit and vegetables, pulses/soya bean, drinking water, water for bathing, and water for irrigation are other frequently utilized provisioning services, as indicated by 68% of the sampled households. Fuel wood and fodder are the most highly consumed among the 18 provisioning services provided by the forest ecosystem. Similarly, vegetables, cereals, paddy, and pulses/soya bean are most used among 11 such services provided by the agro ecosystem. The freshwater ecosystem supplies 10 such services, including water for bathing, drinking, and irrigation (Figure 14).

Figure 13: **Ecosystem services composition based on the number of services used by the local communities**

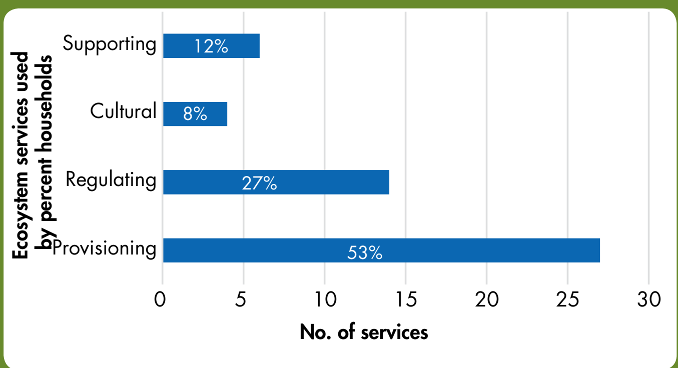
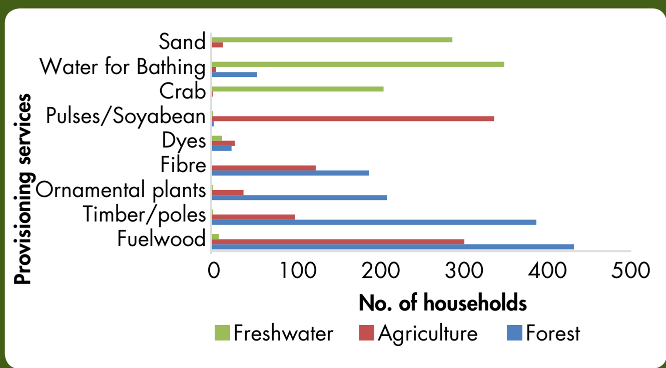


Figure 14: **Provisioning services in Rauta VDC**

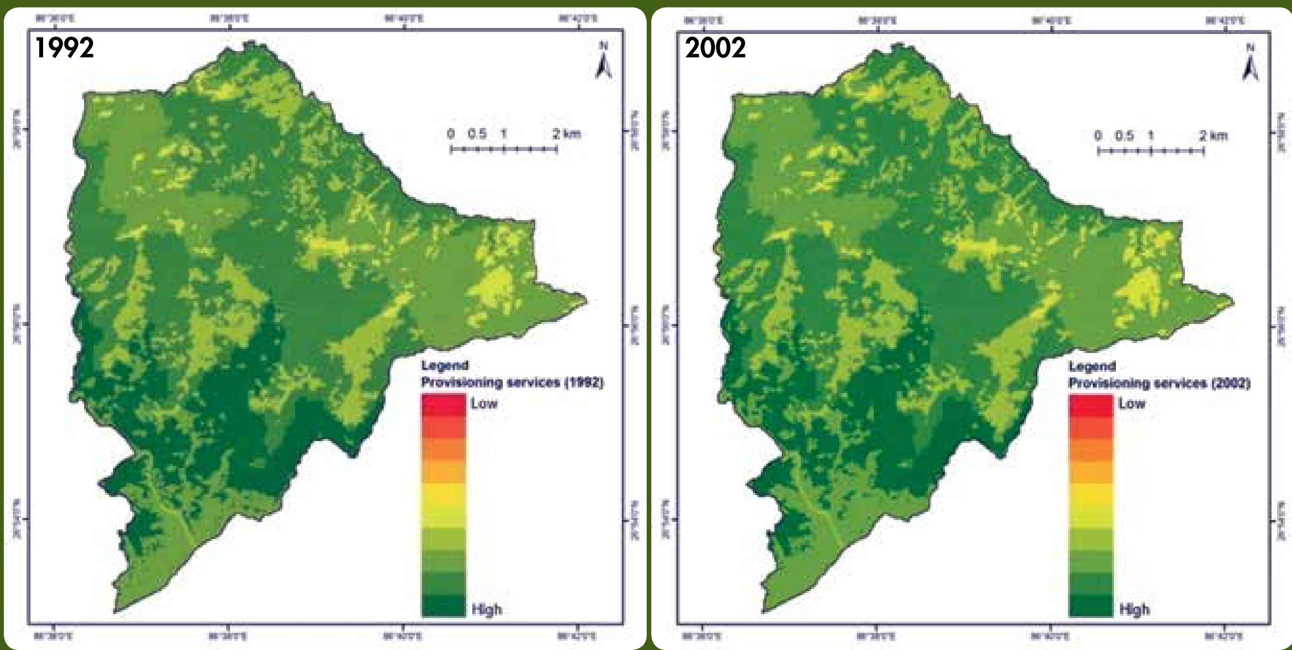


Forest ecosystems in downstream and midstream areas offer greater provisioning services (Table 10), which has gradually decreased over the 18-year period in Rauta VDC (Figure 15).

Regulating services

Regulating services supplied by the three major ecosystems in Rauta VDC account for 28% of all ecosystem services. The forest ecosystem, agro ecosystem, and freshwater ecosystem contribute 46%, 35%, and 19% of total regulating services, respectively. Local communities use 14 regulating services, more or less from each ecosystem. Erosion and flood control (n=309) are the predominant regulating services provided by the forest ecosystem. Similarly, nutrient enrichment (n=217) is the major regulating service provided by the agro ecosystem, while water purification (n=136) is a highly acknowledged regulating service provided by the freshwater ecosystem (Figure 16).

Figure 15: **Map showing distribution of provisioning services in Rauta VDC during 1992, 2002, and 2010**



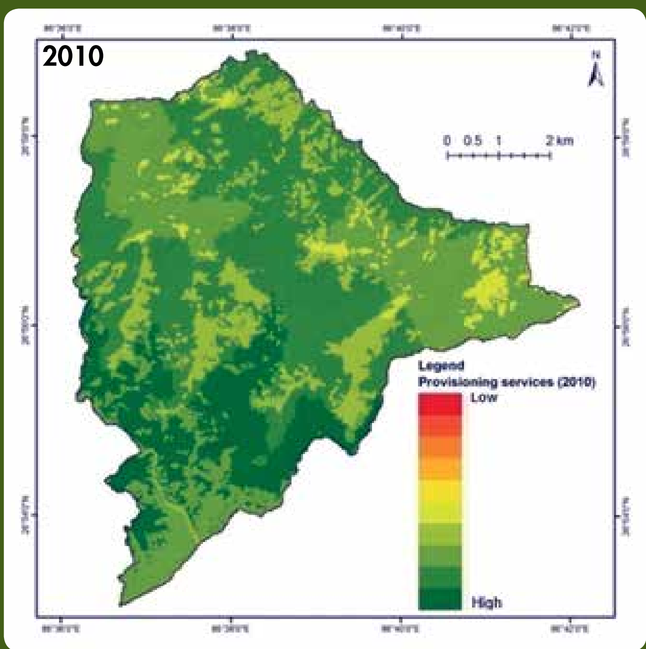


Figure 16: **Regulating services in Rauta VDC based on number of households**

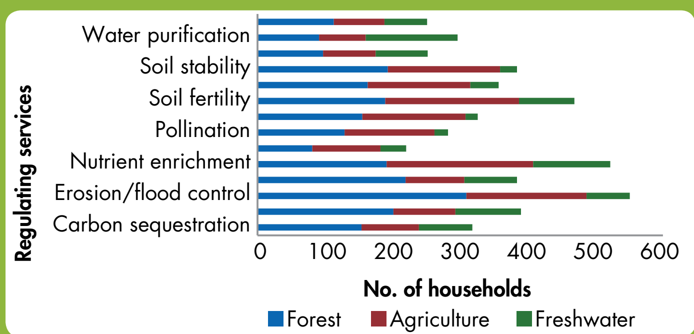


Figure 17: **Map showing distribution of regulating services in Rauta VDC during 1992, 2002, and 2010**

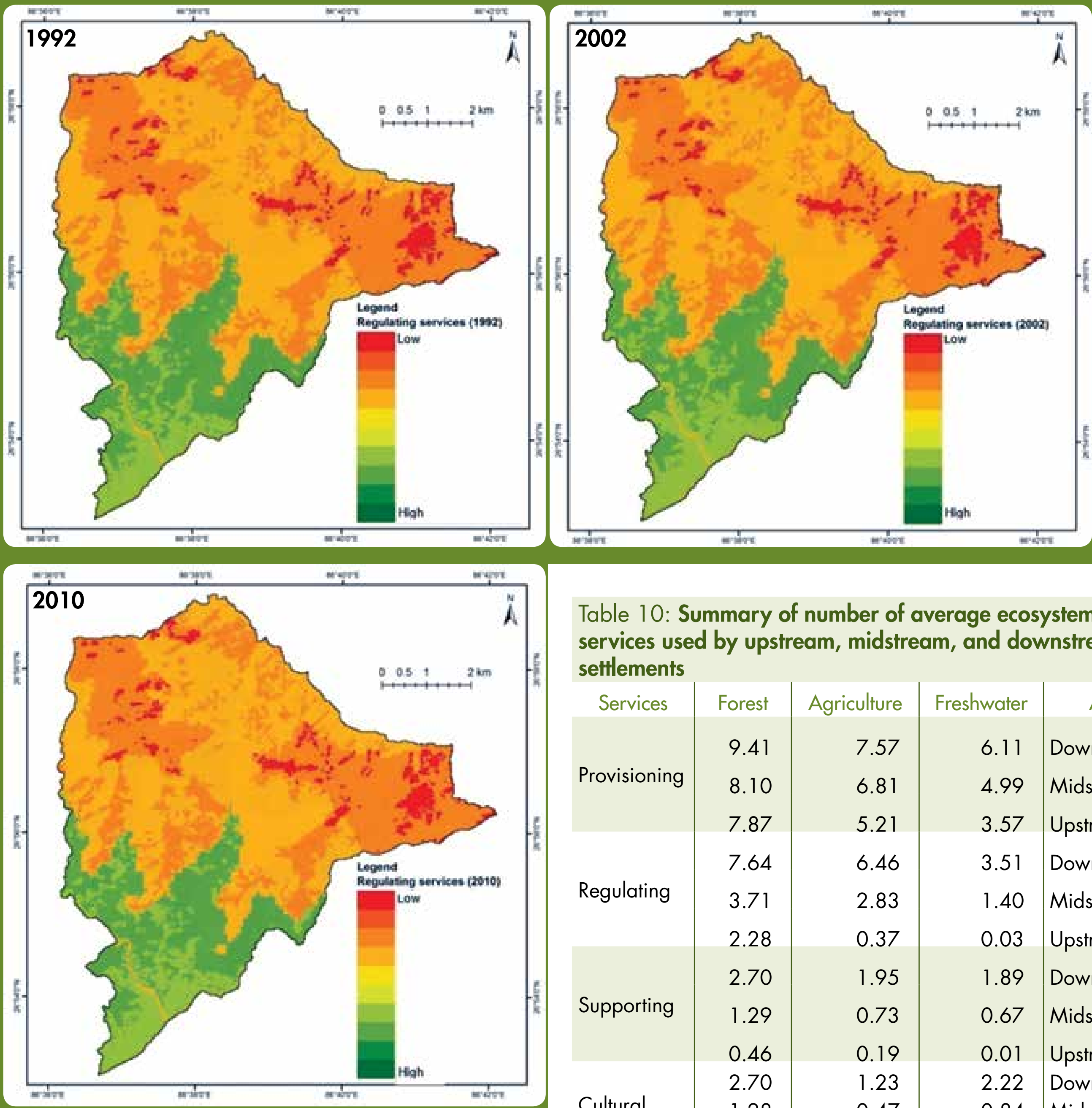


Table 10: **Summary of number of average ecosystem services used by upstream, midstream, and downstream settlements**

Services	Forest	Agriculture	Freshwater	Area
Provisioning	9.41	7.57	6.11	Downstream
	8.10	6.81	4.99	Midstream
	7.87	5.21	3.57	Upstream
Regulating	7.64	6.46	3.51	Downstream
	3.71	2.83	1.40	Midstream
	2.28	0.37	0.03	Upstream
Supporting	2.70	1.95	1.89	Downstream
	1.29	0.73	0.67	Midstream
	0.46	0.19	0.01	Upstream
Cultural	2.70	1.23	2.22	Downstream
	1.28	0.47	0.84	Midstream
	1.09	0.34	0.31	Upstream

The forest ecosystem and agro ecosystem in downstream areas in Rauta VDC provide a higher number of regulating services (Table 10). However, the provision and functioning of ecosystems bestowing these services has gradually decreased over the 18-year period in Rauta VDC (Figure 17).

Supporting services

Supporting services offered by the three major ecosystems in Rauta VDC account for 12% of the overall ecosystem services in the Rauta VDC. The forest ecosystem, agro ecosystem, and freshwater ecosystem supply 42%, 28%, and 30% supporting services, respectively. Forest (n=295), freshwater (n=198), and agriculture (n=175) provide important habitats for species (Figure 18). Communities are either unaware of the value of supporting services or supporting services have not impacted their livelihood (Table 10). However, provision and functioning of supporting services by ecosystems is relatively higher in downstream and midstream areas. The change in quantitative attributes of supporting services over the 18-year period is not significant (Figure 19).

Figure 18: **Supporting services in Rauta VDC**

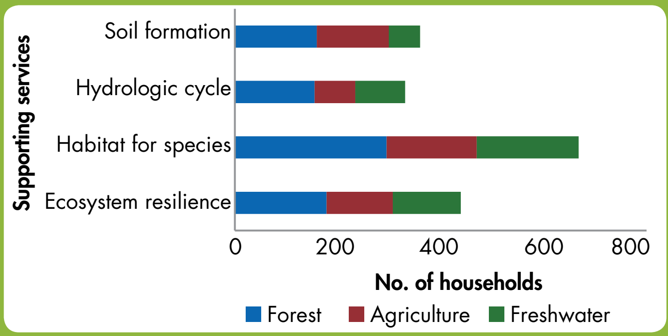
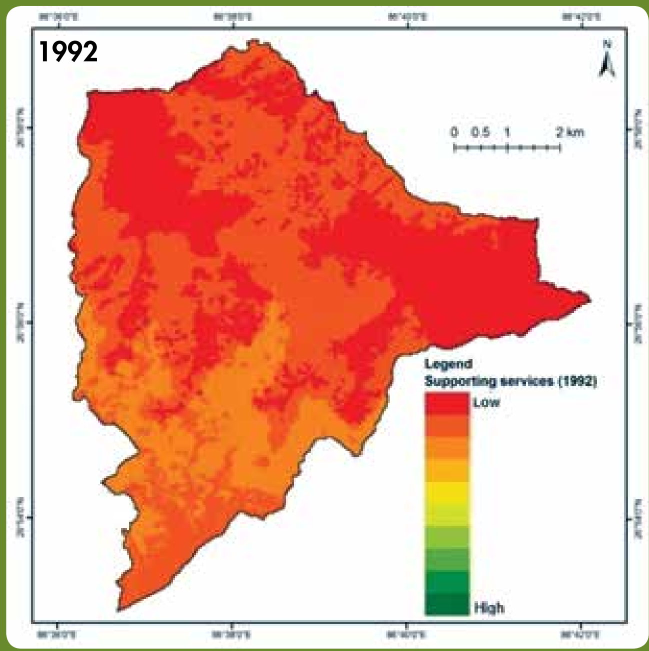
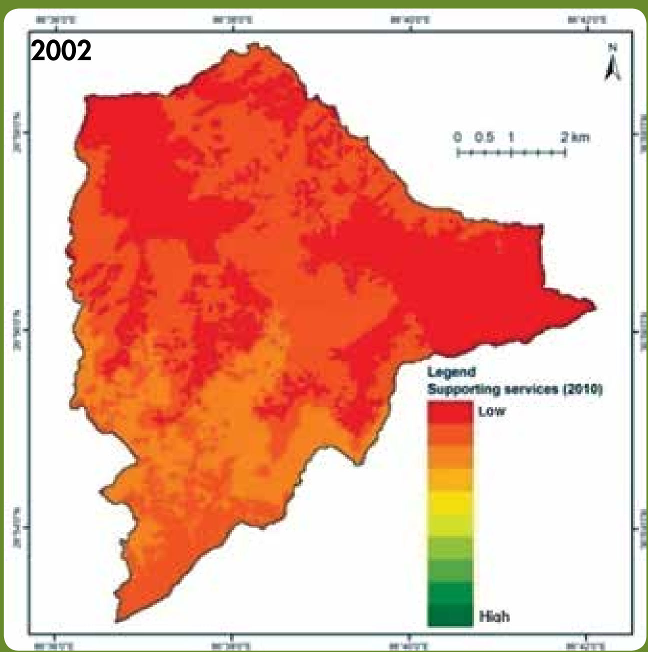
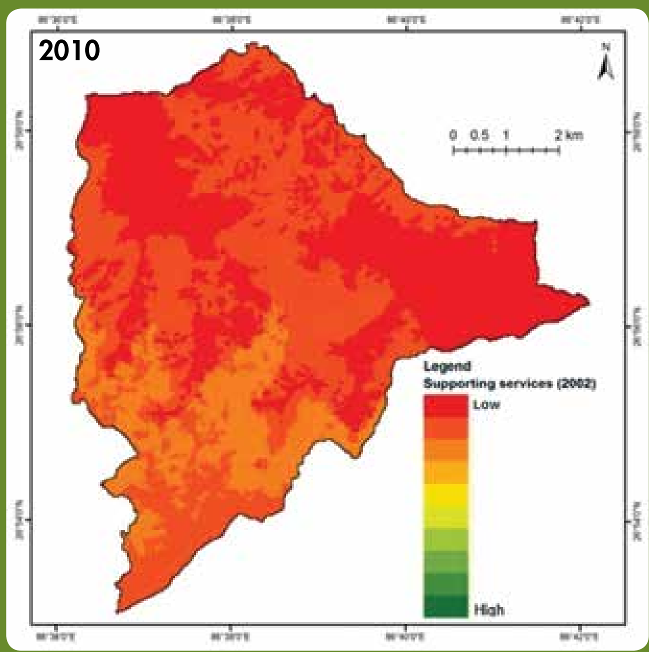


Figure 19: **Map showing distribution of supporting services in Rauta VDC during 1992, 2002 and 2010**







Cultural services

The three major ecosystems in Rauta VDC embrace cultural services which account for 8% of the overall ecosystem services. The forest ecosystem, agro ecosystem, and freshwater ecosystem contribute 46%, 20%, and 34% cultural services respectively. Forest (n=315), freshwater (n=219), and agriculture (n=210) are significant for aesthetic beauty (Figure 20). As with the case of supporting services, communities are either unaware of the value of cultural services or cultural services have not impacted their livelihood (Table 10). However, forests and streams in downstream areas support a higher provision and function of cultural services. Over the 18 years, the change in quantitative attributes of cultural services is as insignificant as with supporting services (Figure 21).

Selective Provisioning Ecosystem Services

Communities benefit from numerous ecosystem goods, which are utilized initially for subsistence living (fuel wood, fodder, and timber). Non-timber Forest Products (NTFP's), including medicinal plants, support income generation.

Figure 20: **Cultural services in Rauta VDC**

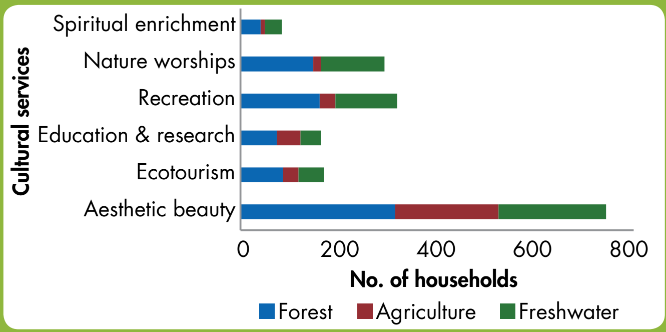
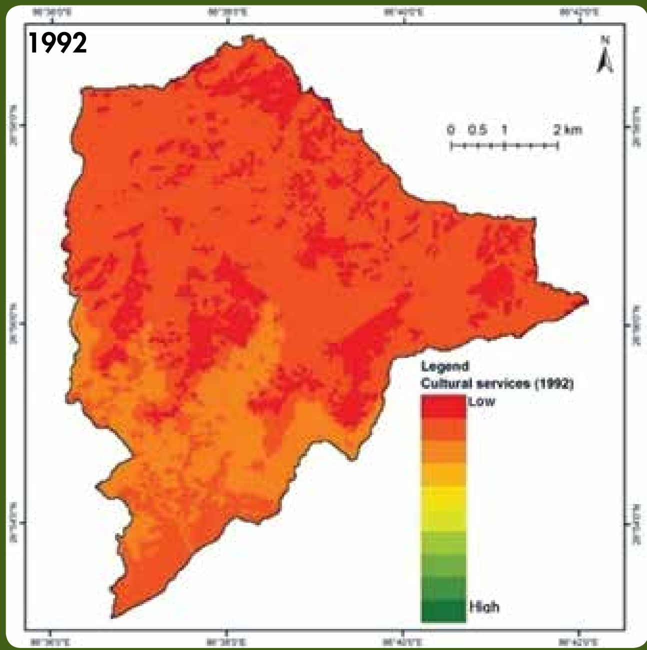
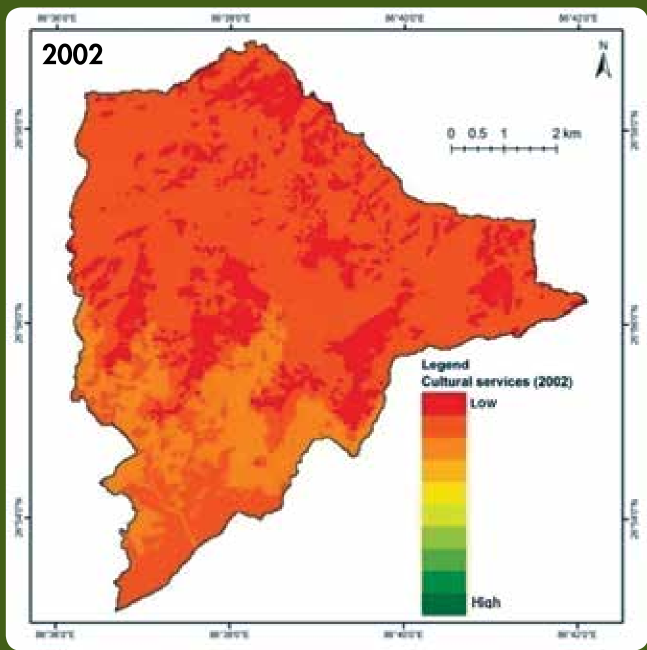
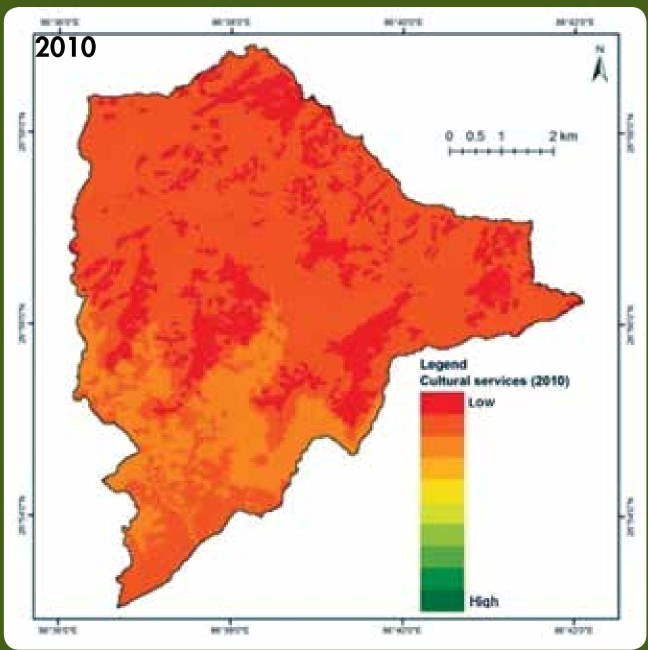


Figure 21: **Map showing distribution of cultural services in Rauta VDC during 1992, 2002, and 2010**

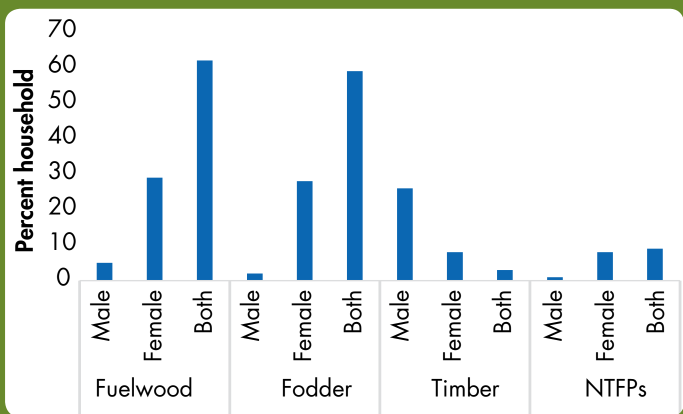






Both male and females equally participate in fuel wood (65%) and fodder collection (61%) (Figure 22). In downstream areas, fuel wood is collected daily (50% households) and weekly (30% households). Fuel wood collection increases during the winter season in upstream and downstream areas; however, midstream communities collect throughout the year, excluding the rainy season. Throughout the sampled area, fodder is collected daily. Normally, timber is required once in a year for construction. As expected, timber is collected mostly by males (71%). Similarly, households also harvest NTFPs, including medicinal plants only once a year.

Figure 22: **Collection of provisioning services based on gender**



Perceived Socioecological and Cultural Values of Ecosystem Services

Socio-cultural and ecological significance of plant species

Focus Group Discussion with the community identified five plant species considered socioecologically and culturally valuable in Rauta VDC, namely Khayar (*Acacia catechu*), Belpati (*Aegle marmelos*), Sal, Bans (*Dendrocalamus* sp.), and Amla (*Phylanthus emblica*). However, there were variations in vegetation composition along the elevation, with an additional 12 species which the local communities perceived as socioecologically and culturally valuable. Among a total of 17 plants assessed, most of them are primarily of social importance (Table 11). Bans (*Dendrocalamus* spp.) and Sal are the two species having socioecological as well as cultural importance in the local area (Figure 23). Bamboo is an extensively used NTFP. It is used as fodder, fuel wood, and a primary construction material (for constructing houses, sheds, and a variety of handicrafts and tools such as doko, nanglo, etc.). Edible shoots of bamboo, locally pronounced "*Tama*," are consumed as vegetables for delicacy. Other than these, bamboo has exclusive cultural significance. In death rituals, bamboo is used to carry the body. Fine bamboo needles (*sinka*) are used in weaving leaves of Sal to make leaf plates (*tapari*). These *tapari* are used in worship and ceremonies. Sal is the prefered timber species for the downstream and midstream residents. It is also used for fuel wood and fodder. Chilaune (*Schima walichii*) and Pine (*Pinus* spp.) are the preferred timber species in midstream and upstream areas, respectively.

Table 11: **Major plants, animal species, and sacred places having socioecological and cultural values of ecosystem services**

Plants	Animals	Sacred places
Khayer (*Acacia catechu*)	Cow (*Bos rachy*)	Rauta Pokhari
Bel (*Aegle marmelos*)	Pig (*Sus scrofa domesticus*)	Triyuga River
Sal (*Shorea robusta*)	Goat (*Capra aegagrus hircus*)	Kakani Mela
Bans (*Dendrocalamus* spp.)	Chicken (*Gallus gallus domesticus*)	Devithan
Amla (*Phyllanthus emblica*)	Paha (*Nanorana* sp.)	
Chilaune (*Schima wallichii*)	Kalij (*Lophura leucomelanos*)	
Utis (*Alnus nepalensis*)	Dumsi (*Hystrix rachyuran*)	
Katus (*Castonopsis indica*)	Barking deer (*Muntiacus vaginalis*)	
Mauwa (*Engelhardi tiaspicat*)	Fish	
Khanyu (*Ficus cunia*)	Domestic pigeon (*Columba livia domestica*)	
Bar (*Ficus bengalensis*)	Buffalo (*Babulus babulis*)	
Peepal (*Ficus religiosa*)		
Tejpat (*Cinnamon tamala*)		
Pine (*Pinus roxbughii*)		
Gogan (*Saurauia nepaulensis*)		
Ghotle (*Grewia optiva*)		
Chiuri (*Bassia butyracea*)		

Sociocultural and ecological significance of animal species

Among 11 socioculturally and ecologically significant animal species, goat is perceived as socially the most important (income generation through meat supply) by the community of Rauta VDC (Figure 24) (Table 11). Neverthless, it is culturally important too; they are sacrificed during festivals and religious events by Hindus and Kirants. Cows are religious animals for Hindus and are reared primarily for milk products. Cow dung is the only manure (fertilizer) in rural traditional agriculture. Chickens are favoured for subsistence consumption and to offer for sacrifice at religious places and sites. The community perceives fish as the most ecologically significant (Figure 24), in the sense that fish are an indicator of safe water in streams.

Figure 23: **Perceived importance of plant species**

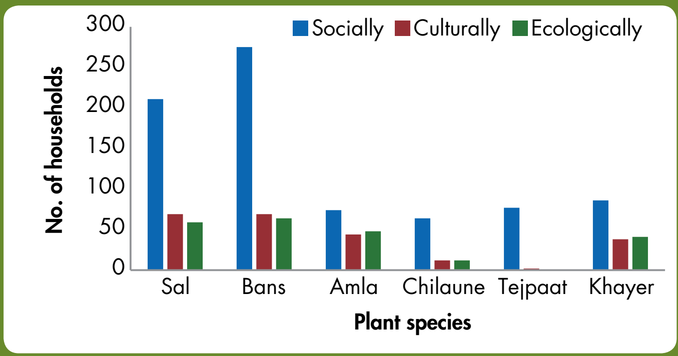
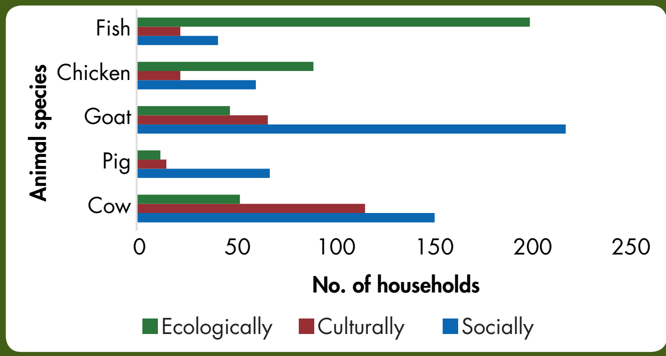


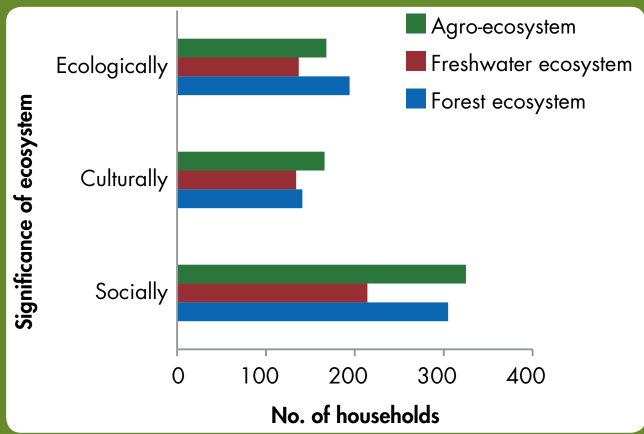
Figure 24: **Perceived importance of animal species**



Sociocultural and ecological significance of ecosystems

It is well known that forest, agriculture, and freshwater ecosystems are socio-culturally and ecologically significant. Here, communities perceive freshwater ecosystems as socio-culturally significant and forest ecosystems as ecologically significant (Figure 25).

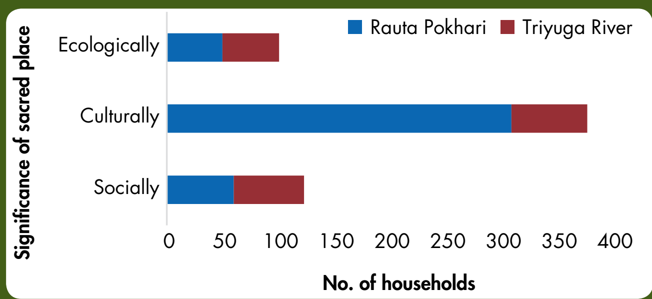
Figure 25: **Socioecological and cultural significance of major ecosystems**



Sociocultural and ecological significance of sacred places

Amongst four sacred places (Table 11), Rauta Pokhari and Triyuga River are the main holy sites community members frequently visit. Rauta Pokhari is more important from a cultural perspective than Triyuga River. Religious people visit the Rauta Pokhari for worship and to offer sacrifices. Besides its cultural heritage, Triyuga is also socially important to the communities, as the river provides services such as water for bathing, water for irrigation, and habitat for aquatic fauna. Aquatic fauna (fish, arthropods, etc.) from the river are consumed. From an ecological perspective, both sites are equal (Figure 26).

Figure 26: **Socioecological and cultural significance of main sacred places (Better presentation)**



Willingness to Pay (WTP) for Environmental Management

The environment provides numerous indirect goods and services without any explicit link between the service providers and the service users. This is usually due to the spatial separation between the environmental services providers and the users. Willingness to Pay (WTP) and the analysis of influencing factors contribute to the establishment of compensation mechanisms (financial incentives) for ecological management. In the current study, nearly 80% of the households are willing to pay. About 15% are unable to pay for environmental management to improve ecosystems and their livelihood options in their area (Figure 27). Most of the willing households prefer to pay in kind (through labour). The estimated aggregated contribution (cash and kind) by willing households is USD$ 266,517. This is the value that they attribute to the ecosystem services they utilize.

Sixty-seven percent of households suggest that the fund generated for healthy ecosystem management should be governed or managed by the local community. However, households from upstream areas give an option of a user committee (46%) besides the local community (51%) (Figure 28).

Figure 27: **WTP for environmental management**

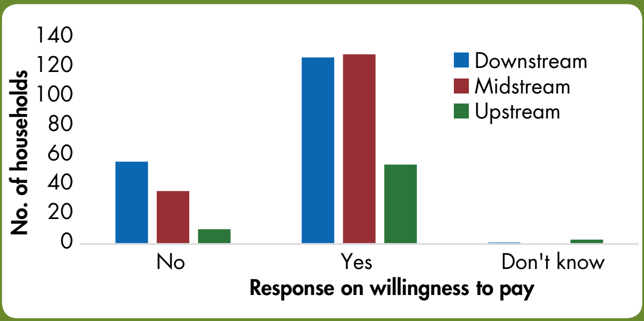
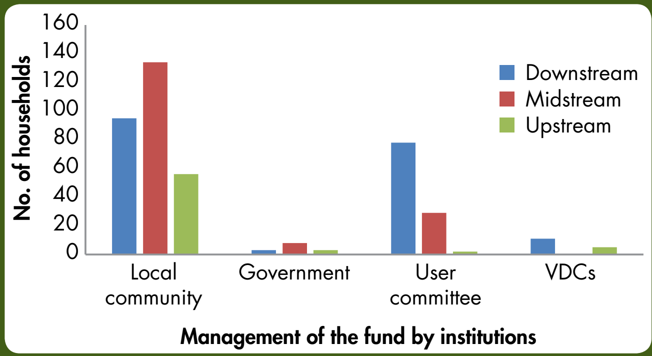


Figure 28: **Fund management by different institutions**



Livelihood Vulnerability Assessment

Vulnerability Assessment

Socioeconomic vulnerability is linked to key drivers causing changes in the sustainable delivery of ecosystem services. A vulnerability assessment uncovered that food security risks are prevalent. According to the households, soil fertility is decreasing because of erosion, unavailability of manure and irrigation facilities, erratic weather (primarily precipitation), and problematic pests, resulting in poor crop production. The net production by farmers is therefore inadequate for their subsistence. Overall, 21% of households consume their total crop production within three months and 45 % of households consume them in four to six months. Only 8% of households get adequate food for more than a year (Figure 29). About 80% of households suffer a food shortage for six months from August to January. Food is available for nearly 60% of households for four months, from March to June (Figure 30).

Figure 29: **Number of months in which HH can live from their own food production**

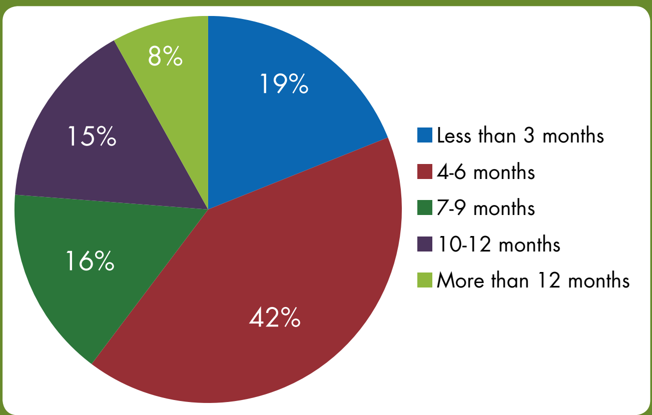
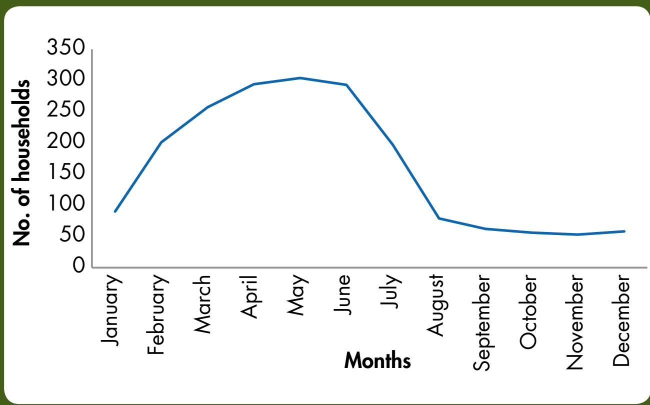


Figure 30: **Difficult months to provide adequate food**



Coping and Adaptation Strategies

Of the 11 crises faced by the community in the 12 months preceding the household questionnaire survey, the three main crises were shortage of food (26.32%), loss of livestock (21.43%), and poor crop production (17.67%) (Figure 31). Communities have adopted six adaptive coping strategies, such as free support by family/kin/neighbours/community, selling livestock, taking a cash or cereal loan from merchants, occupation diversification, and temporary labour migration (Figure 32).

Potential Long-Term Changes

The local communities in the last 10 years have perceived a reduction in access to forest, forest cover, and soil fertility because of forest degradation, forest fragmentation, and uncertainty of rain (erratic precipitation). In contrast, they believe school, transportation, communication, and health facilities have improved with better services (Figure 33). In spite of the customary difficulties, communities (upstream, midstream, and downstream) feel their household livelihood has improved over the last 10 years through ecosystem management. They are interested in cash crop farming, afforestation, construction of irrigation facilities, and NTFP's promotion and commercialization to improve their livelihoods (Table 12).

Figure 31: **Crises faced by households**

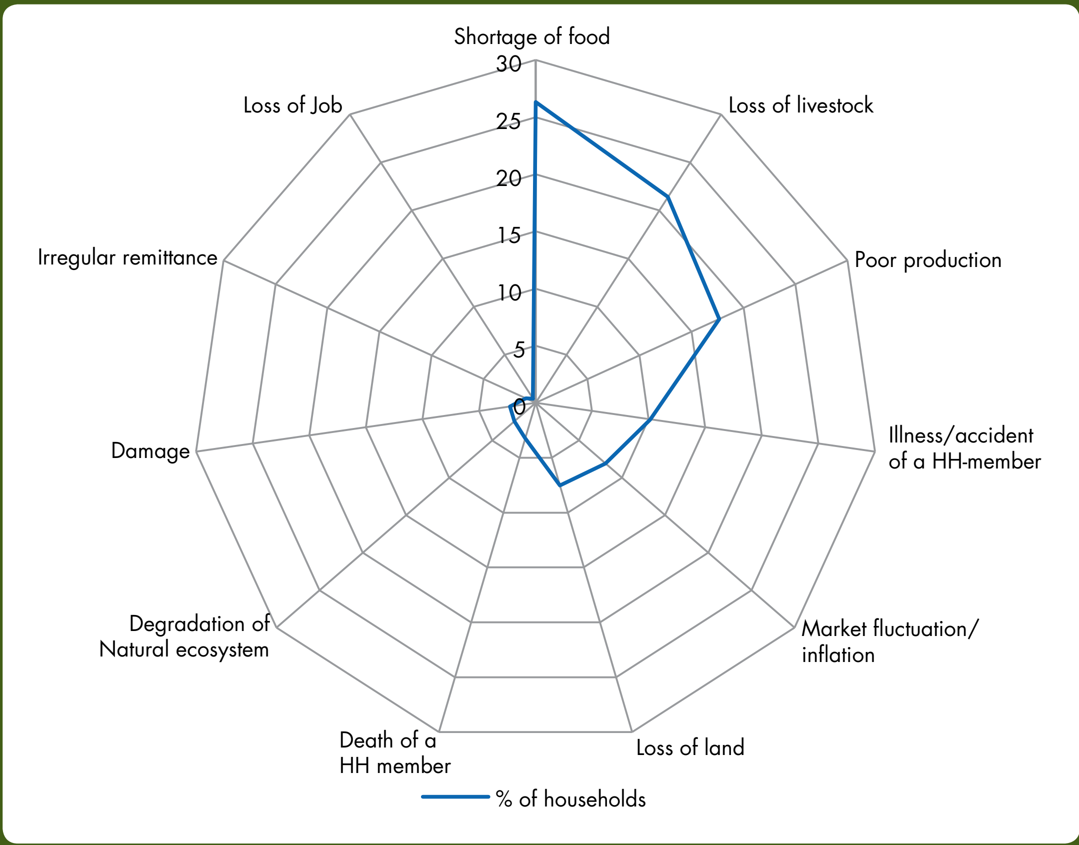


Figure 32: **Coping strategies for crises**

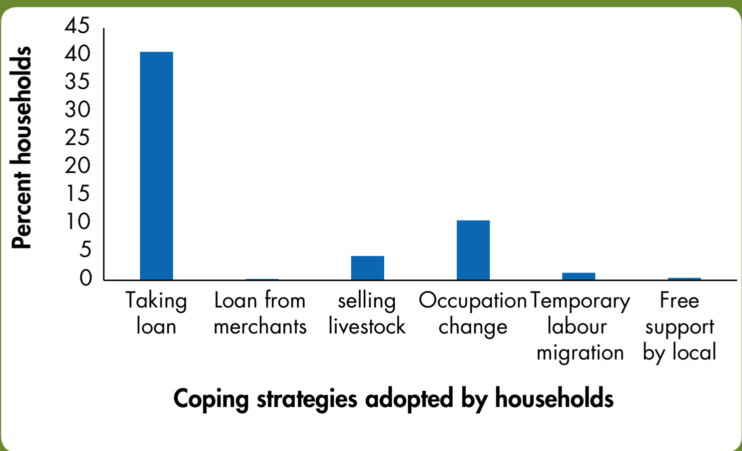
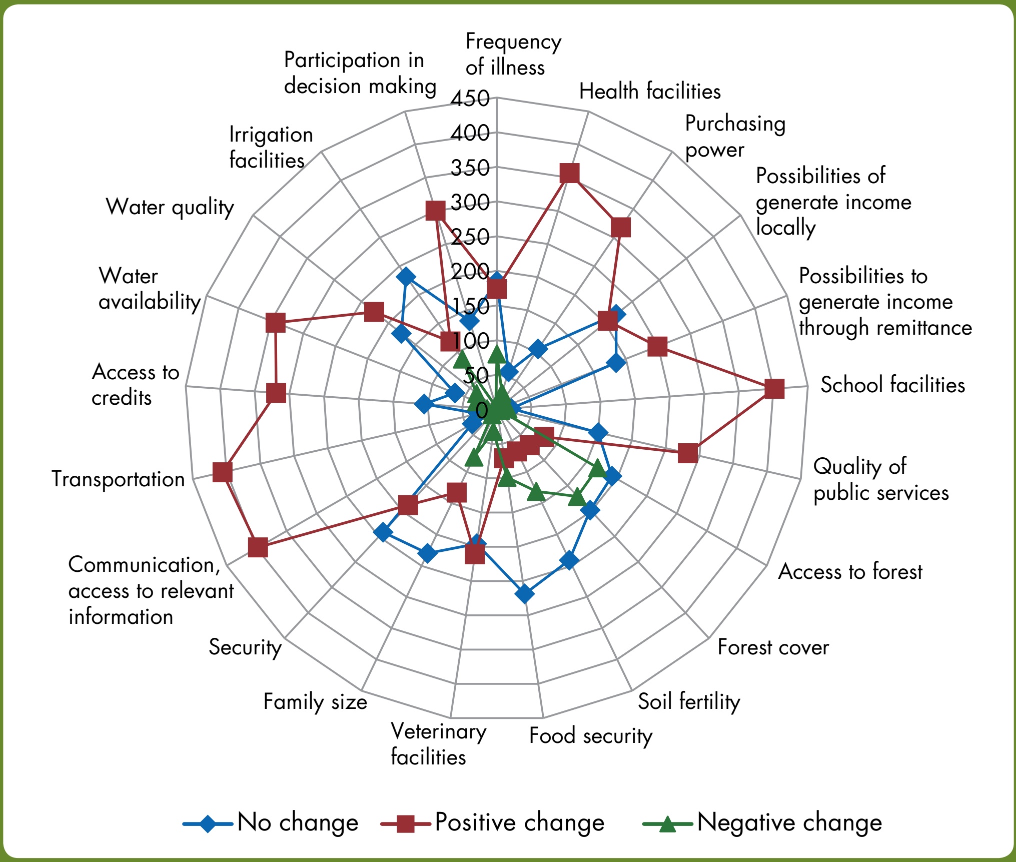


Table 12: **Local opportunities to improve the livelihood of HH**

Survey area	Helpful works for improving livelihood
Downstream	Afforestation
	Cash crop farming
	Irrigation facilities
	Improved livestock and commercialization
Midstream	Cash crop farming
	NTFP's promotion
	Improved livestock and commercialization
	Irrigation facilities
Upstream	Afforestation
	Cash crop farming
	Improved livestock and commercialization

Figure 33: **Long-term changes in socioeconomic sectors over last 10 years (perceived by households)**



Discussion and Recommendation

The study area, Rauta VDC in Udayapur, is an ideal place to understand linkages between human development and ecosystems, as well as upstream-downstream linkages. The VDC has mixed ethnic groups, with a majority being Janajati, mostly with male-headed households and with about half the sampled houses literate. Farming is the primary source of income, including livestock rearing. The majority of households own rain-fed terraces. Maize, paddy, and millet are the major crops cultivated by the farmers. Some of these crops are grown on a subsistence basis without generating profits. As a result, local communities are highly dependent on the surrounding ecosystems. Understanding the linkages between ecosystems and human wellbeing and poverty alleviation is gaining importance (Daw et al., 2011; Perrings et al., 2011; Suich et al., 2015). This is more prevalent in a country like Nepal, as human dependency on natural resources is comparatively higher (Pant et al., 2012; Thapa et al., 2014; Sharma et al., 2015).

The Rauta VDC is primarily reliant on agro ecosystem resources for food such as rice, corn, cereals, pulses, soya bean, vegetables, and fruits. They are also dependent on forest ecosystems for wild edibles, firewood, fodder, and timber, and on wetland ecosystems for various goods and services. The households ranked the agro ecosystem as very important (55%) among agro, freshwater, and forest ecosystems. Likewise, 46% and 23% of households ranked forest ecosystem and freshwater ecosystem as very important. 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 having several tangible and intangible services or goods. The forest primarily provides fuel wood, daily fodder needs, and timber. Additionally, it supplies medicinal plants, dye, bush meat, edible wild vegetables and fruits, and mushrooms. However, in terms of importance, the agro ecosystem and forest ecosystem do not vary sharply as compared to the dependencies. Freshwater is ranked lowest among the three service-providing ecosystems in spite of several benefits. This could be mainly due to the direct benefits the community gets from other ecosystems, as also explained by other researchers (Pant et al., 2012; Thapa et al., 2014; Sharma et al., 2015).

The GIS and RS analysis revealed that the forest has slightly decreased by about 2% from 1992 and about 1% from 2002 baselines. However, the perception of agricultural land contradicts what has been perceived by the local communities. There has been at least a 1% increase in agricultural land since 1992. A similar trend on ecosystem depletion due to change in forest ecosystems has been explained in Nepal (Paudyal et al., 2015) and elsewhere (Xiaoli and Jianping, 2004; Metzger et al., 2006; Carreño et al., 2012).

The local communities are highly dependent on the surrounding ecosystems, particularly for provisioning services. Among the ecosystems, forests are critical for sources of provision services, as 40% are directly dependent on them, followed by agro ecosystem (32%) and freshwater ecosystem (25%). Interestingly, it was observed that the upstream communities are receiving a lesser number of options in terms of services compared to the downstream communities. The Rauta community also recognizes the importance of regulating services and directly relates them to the condition of the forest ecosystem. This is a surprising new development in Nepal, as other studies were unable to go into such detail in terms of community perception of regulation services (e.g., Pant et al., 2012; Paudyal et al., 2015; Sharma et al., 2015). Likewise, the forest ecosystem has a higher significance in terms of 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 monitoring terms, as also reported by others (Sharma et al., 2015). In addition, people also value the goods and services, including plants and animals, with their livelihood, culture, and traditions, and appreciated that the surrounding ecosystems are the sources for such services.

However, being in remote areas, the local communities are highly dependent on these ecosystems for subsistence and are vulnerable due to limited production and opportunities, as well as a changing lifestyle, so they now practice various coping strategies. Because of the deteriorating ecological conditions and environmental changes, the communities have already started perceiving changes in the availability of food from decreasing agricultural productivity due to forest degradation, forest fragmentation, and the uncertainty of rain (erratic precipitation). These perceptions could be directly related to the changing climate in the eastern Himalaya (Shrestha and Devkota,

2010) and its consequences on biodiversity and ecosystem services (Chettri et al., 2010; Gopal et al., 2010). Therefore, scientific principles of ecosystem management should be incorporated to enhance increased production. The conservation and enhancement of biodiversity in cropping systems also lead to improved biodiversity beyond the cropland – such as water bodies and the broader agricultural landscape. Building capacity, developing tools, methodologies, and strategies (e.g., reduced pesticide use), and implementing best management practices for agricultural development are crucial to health, nutrition, food security, and critical livelihood for poor farmers (FAO, 2015).

Communities have so far not been able to use good farming technologies and linkages to income-generating activities. The agro ecosystem based on agroforestry practice has been highly beneficial to the communities in fulfilling their demands for wild-harvested goods and goods for subsistence. Otherwise, the depletion of the forest would continue in order to fulfil the increasing demands of the local communities. Community forestry has become a good strategy for livelihood improvement and environmental protection. However, analysis of the social, economic, and environmental impacts of community forestry is inadequate, restricted 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, provisioning services from forests in the current study are perceived to be both quantitatively and qualitatively insufficient by the local communities. It suggests the forest ecosystem has been under pressure and delivery of its embedded services is deteriorating. Hence the CFUGs themselves impose regulations for forest restoration and sustainable use. Freshwater ecosystem services benefits are also not well captured.

The local people are either unaware or have scarce knowledge of intangible ecosystem services such as regulating (linked to biodiversity, water cycle, and carbon sequestration), supporting, and cultural services, which causes insignificant recognition of the absolute value of ecosystems and their services. This study indicates the general population is only interested in environmental conservation provided it brings opportunities for household livelihood improvement.

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 based on the ecosystems taking careful consideration of local conditions (Carpenter et al., 2009; Steffen, 2009).

This assessment initiated a preliminary estimation of the value of the few provisioning ecosystem services which provide benefits to local communities residing in the Rauta VDC. Inclusive valuation of overall essential ecosystem services can create more awareness and facilitate greater public support for development and environmental conservation.

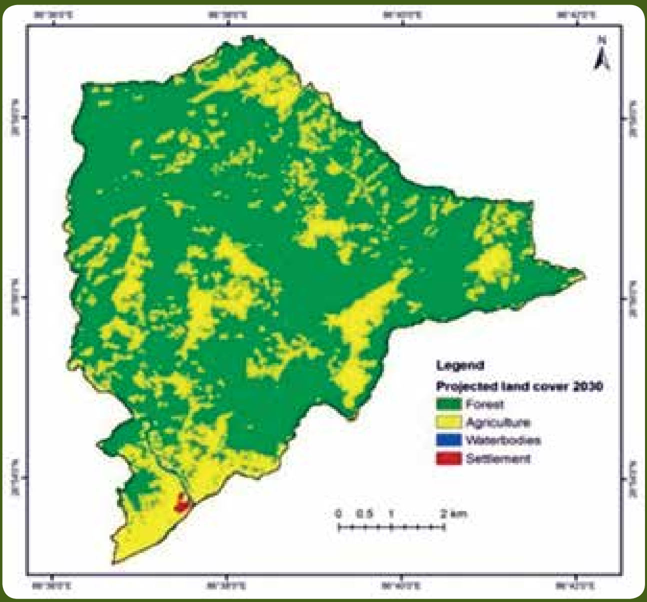
Rauta Pokhari is a cultural heritage for the people from the district and adjoining areas. It has potential for cultural tourism. The private tourism sector could be involved to promote tourism in the area.

Future Projection of State of Ecosystem Services based on the Past and Current Trend

This assessment reveals subtle decrease in land use and land covers (forest, agriculture, and freshwater) and a declining trend of ecosystem services (provisioning, regulating, and supporting) delivery due to overarching collection and consumption of natural resources. Considering the last 10 years, soil fertility, irrigation facilities, food security, forest cover, and access to forest have declined. Shortages of food, loss of livestock, and poor production are the prevailing issues. Agricultural lands are being abandoned and left uncultivated because of the unprofitability of traditional agriculture practices, unavailability of irrigation facilities, and overseas and local migration of manpower.

With this background, it is anticipated that in the future there will be a trend toward increased degradation of forest and most of the agricultural land that is unproductive or barren (uncultivated) being converted to shrub land (Figure 34). Changes in land use result in changes in the attributes of services provided by ecosystems. Since it is not possible to maximize all services at the same time (Birch et al., 2014), there may be synergies and tradeoffs between some services (increase in some services come at the expense of others). These tradeoffs can involve both spatial aspects (for example, people living farther away might benefit from a land use change, while people living locally at

Figure 34: **Projected land cover map of Rauta VDC for the year 2030**



a site sustain a loss) and temporal aspects (people living now receive the benefit, but at the expense of people living in the future). Given the current drivers of change which are already having an impact on the ground (species and ecosystems), it is expected that, if current trends continue, land use changes will occur in the future and some ecosystem services will decrease, while others will increase. For example, harvested wild goods (including wild food and natural medicines) and water provision that are important services at the site would decline. Conversely, cultivated food would become more widespread. Overall, the changes predicted to occur in the foreseeable future would have the greatest negative impact on local communities.

Possibility of Upscaling a Similar Approach Across the HKH Region

Other than a few ecosystem services assessments in the HKH (e.g., Pant et al., 2012; Garrad et al., 2013; Birch et al., 2014; ICIMOD and RSPN, 2014; ICIMOD and MoFSC, 2014; Thapa et al., 2014), we still lack enough information to initiate ecosystem management in the region. In order to enlighten local decision making, ecosystem services have to be measured at individual sites at a fine spatial grain (where many land use decisions are typically made) (Peh et al., 2013).

The current multidimensional approach deployed in this study can be upscaled to the HKH, considering amendments required by the local conditions, to support regional collaboration in conservation. The methodology includes a framework and methods which focus on three ecosystems, the typology of ecosystem services, significant drivers of changes, market-based valuation of key ecosystem services, and willingness to use environment management and livelihood vulnerability assessments. The concrete evidence of livelihood strategies, the state of ecosystems and ecosystem services, changes in ecosystems and ecosystem services, the significant drivers of change, the socioecological and cultural values of selected ecosystem services, the market value of selected provisioning services, and the willingness to pay for environment management and livelihood vulnerability assessment from the Rauta VDC provide ample understanding and knowledge to policy makers to formulate their decision making.

Possible Policy Implications

Even though benefits derived from the ecosystems are critical to human wellbeing and economic prosperity, they are undervalued not only in economic analysis but also in decision making (Watson, 2012). As a result, poor choices are often made, which destroy or degrade natural habitats, resulting in the decline of many services, along with the biodiversity that supports them, often with severe impacts on poor and vulnerable people. In other parts of the globe, the view on ecosystem services from paired human-natural systems has been widely recognized in science, management, and governance (Daily et al., 2009). The scenario does not translate to the HKH. Understanding, assessing, and monitoring ecosystem services can lead to better policy formulation, resulting in land use and management options that deliver more effective conservation, resilient livelihoods, and poverty reduction. Focussing on the value of ecosystem services and identifying the importance of conservation in providing benefits to local communities can facilitate understanding and create more awareness among decision makers, leading to appropriate conservation-related outcomes which have public support.

Findings from this study suggest policy makers need to take into account the following items: the socioecological and cultural value of selected ecosystem services and goods, the estimated value of selected provisioning services and goods, the dependency and significance of ecosystems, the drivers of changes, and the vulnerability context while developing plans and allocating budgets for infrastructure construction and implementing conservation of the ecosystems. Doing so is necessary to ensure the sustained delivery of ecosystem services in HKH. Appropriate frameworks and mechanisms need to be developed that provide incentives to local people to support conservation measures that can improve their lives. Since agricultural lands occupy a large area of total land use, it could constitute a prime target in any strategy (Kroeger and Casey, 2007). In Rauta VDC, where agro ecosystems have a higher significance on one hand and sustain rural livelihoods on the other, opportunities should be explored to incorporate an ecosystem services assessment component in agriculture management practices and policies such as the National Agricultural Policy, National Agro-biodiversity Policy, and forest management practices and policies.

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

Action 1. Enhance knowledge and awareness: Since local communities are highly dependent on the surrounding ecosystems, the knowledge and awareness of ecosystem dynamics, tangible and intangible benefits from the ecosystems, and knowledge of demand and supply of ecosystem services are prerequisite. It is important to understand the values through its ecological, social and cultural lens and not limited to economic terms.

Action 2. Develop strategies with an integrated approach: Human wellbeing is intricately linked to natural capital. Local communities are highly dependent on water, agriculture, and forest resources. It is imperative to develop strategies considering both ecological and socioeconomic wellbeing. Interventions are suggested to identify vulnerable areas (landslide, erosion prone, degraded forest) and strengthen local institutions for better management of forest and other resources.

Action 3. Create synergy among the development and conservation agencies: The conservation of biodiversity and human development have been seen as conflicting concepts. However, there are possibilities to overcome this dilemma by creating synergy and working toward a win-win situation. Understanding the potential for economic development and environmental challenges with common goals and a thorough multidisciplinary approach could produce better development and conservation options.

Action 4. Develop Green Enterprises: The study area has great potential for agriculture, agroforestry, and carbon trade through a forestry programme. Organic farming, village tourism, micro-hydel projects, and livestock farming could lead to a "Green Enterprise" tag for the village. Moreover, payment for ecosystem services (PES) should also be explored as part of REDD+ and water supply to downstream.

References

Ash, N. (2010). *Ecosystems and human well-being. A manual for assessment practitioners*. Washington, DC: Island Press

Badola, R., Hussain, S. A., Mishra, B. K., Konthoujam, B., Thapliyal, S. & Dhakate, P. M. (2010). An assessment of ecosystem services of Corbett Tiger Reserve, India. *The Environmentalist*, 30(4), 320-329.

Balmford, A., Bruner, P., Cooper, R., Costanza, R., Farber, S., Green, R. E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Trumper, S. & Turner, R. K. (2002). Economic reasons for conserving wild nature. *Science*, 297(5583), 950-953.

Baral, N., Gautam, R., Timilsina, N. & Bhat, M. G. (2007). Conservation implications of contingent valuation of critically endangered white- rumped vulture Gyps bengalensis in South Asia. Th*e International Journal of Biodiversity Science and Management*, 3,145-156.

Baral, N., Stern, M. J. & Bhattarai, R. (2008). Contingent valuation of ecotourism in Annapurna Conservation Area, Nepal: Implications for sustainable park finance and local development. *Ecological Economics*, 66, 218-227.

Bhatta, L. D., van Oort, B. E. H., Rucevska, I. & Baral, H. (2014). Payment for ecosystem services: Possible instrument for managing ecosystem services in Nepal. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 10(4), 289-299.

Birch, J. C., Thapa, I., Balmford, A. P., Bradbury, R. B., Brown, C., Butchart, S. H. M., Gurung, H., Hughes, F. M. R., Mulligan, M., Pandeya, P., Peh, K. S. H., Stattersfield, A. J., Walpole, M. & Thomas, D. H. L. (2014). What benefits do community forests provide, and to whom? A rapid assessment of ecosystem services from a Himalayan forest in Nepal. Ecosystem Services, 8,118-127.

Burkhard, B., Petrosillo, I. & Costanza, R. (2010). Ecosystem services - bridging ecology, economy and social sciences. Ecological Complexity, 7(3), 257-259.

Carpenter, S. R., Mooney, H. A., Agard, J., Capistrano, D., DeFries, R. S., Dıaz, S., Dietz, T., Duraiappah, A. K., Oteng-Yeboah, A., Pereira, H. M., Perrings, C., Reid, W. V., Sarukhan, J., Scholes, R. J. & Whyte, A. (2009). Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. *Proceedings of the National Academy of Sciences*, 106, 1305-1312.

Carreño, L., Frank, F. C. & Viglizzo, E. F. (2012). Tradeoffs between economic and ecosystem services in Argentina during 50 years of land-use change. *Agriculture, Ecosystems & Environment*, 154, 68-77.

Castro, A. J., Verburg, P. H., Martín-López, B., Garcia-Llorente, M., Cabello, J., Vaughn, C. C. & López, E. (2014). Ecosystem service trade-offs from supply to social demand: A landscape-scale spatial analysis. *Landscape and Urban Planning*, 132, 102-110.

CBS (2011). N*ational Population and Housing Census National Report*. Kathmandu: National Planning Commission Secretariat.

Chalise, S., Maraseni, T. N. & Maroulis, J. (2015). Adapting to climate variability: The views of peasant farmers in Nepal. *International Journal of Global Warming*, 7(3), 380-394.

Chaudhary, S., Chettri, N., Uddin, K., Khatri, T. B., Dhakal, M., Bajracharya, B., and Ning, W. (2016). 'Implications of land cover change on ecosystems services and people's dependency: A case study from the Koshi Tappu Wildlife Reserve, Nepal'. *Ecological Complexity*, 28, 200-211.

Chen, W. Y. & Jim, C. Y. (2010). Resident motivations and willingness-to-pay for urban biodiversity conservation in Guangzhou (China). *Environmental Management*, 45, 1052-1064.

Chettri, N., Shakya, B., Thapa, R. & Sharma, E. (2008). Status of protected area system in the Hindu Kush Himalaya: An analysis of PA coverage. *International Journal of Biodiversity Science and Management*, 4(3), 164-178.

Chettri, N., Aryal, K., Kandel, P., Karki, S. & Uddin, K. (2014). *Ecosystem services assessment: A framework for Himalica*. Kathmandu: ICIMOD

Chettri, N., Sharma, E., Shakya, B., Thapa, R., Bajracharya, B., Uddin, K., Oli, K. P. & Choudhury, D (2010). *Biodiversity in the Eastern Himalayas: Status, trends and vulnerability to climate change; Climate change impact and vulnerability in the Eastern Himalayas - Technical Report 2*. Kathmandu: ICIMOD.

Costanza, R., d'Arge, R., de Groot, R. S., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P. & van den Belt, M. (1987). The value of the world's ecosystem services and natural capital. *Nature*, 387, 253-260.

Daily, G. C. & Ellison, K. (2002). *The new economy of nature: The quest to make conservation profitable*. Washington, DC: Island Press.

Daily, G. C., Polasky, S., Goldstein, J., Kareiva, P. M., Mooney, H. A., Pejchar, L., Ricketts, T. H., Salzman, J. & Shallenberger, R. (2009). Ecosystem services in decision making: Time to deliver. *Frontiers in Ecology and the Environment*, 7, 21-28.

Daw, T., Brown, K., Rosendo, S. & Pomeroy, R. (2011). Applying the ecosystem services concept to poverty alleviation: The need to disaggregate human well-being. *Environmental Conservation*, 38(4), 370-379.

DDC Udayapur (2013). *District Profile of Udayapur*. Udaypur: District Development Committee.

De Groot, R. S., Alkemade, R., Braat, L., Hein, L. & Willemen, L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological complexity*, 7(3), 260-272.

FAO (2015). *Ecosystem services sustain agricultural productivity and resilience*. FAO, Rome URL. http://www.un.org/esa/sustdev/csd/csd16/documents/fao_factsheet/ecosystem.pdf (accessed 15 September 2015).

Gopal, B., Shilpakar, R. & Sharma, E. (2010). *Functions and services of wetlands in the Eastern Himalayas*. Climate change impact and vulnerability in the Eastern Himalayas - Technical report 3. Kathmandu: ICIMOD.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M. C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N. & Noble, I. (2013). Sustainable development goals for people and planet. *Nature*, 495, 305-307

Hicks, C. C., Cinner, J. E., Stoeckl, N. & McClanahan, T. R. (2015). Linking ecosystem services and human values theory. *Conservation Biology*, 29(5), 1471-1480.

Howe, C., Suich, H., Vira, B. & Mace, G. M. (2014). Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. *Global Environmental Change*, 28, 263-275.

ICIMOD & MoFSC (2014). *An integrated assessment of the effects of natural and human disturbances on a wetland ecosystem: A retrospective from the Koshi Tappu Wildlife Reserve, Nepal*. Kathmandu: ICIMOD.

ICIMOD & RSPN (2014). An integrated assessment of the effects of natural and human disturbances on a wetland ecosystem: A retrospective from Phobjikha Conservation Area, Bhutan. Kathmandu: ICIMOD.

Karki, S., Kandel, P., Thandar, A. M., Sherpa, C. L., Aryal, K. & Chettri, N. (2014). *A regional orientation training on ecosystem services assessment under the Himalica Programme 3-7 April, 2014, ICIMOD Knowledge Park and Udayapur District, Nepal*. Kathmandu: ICIMOD.

Kroeger, T. & Casey, F. (2007). An assessment of market-based approaches to providing ecosystem services on agricultural lands. *Ecological Economics*, 64, 321-332.

Maharana, I., Rai, S. C. & Sharma, E. (2000a). Environmental economics of the Khangchendzonga National Park in the Sikkim Himalaya, India. *GeoJournal*, 50(4), 329-337.

Maharana, I., Rai, S. C. & Sharma, E. (2000b). Valuing ecotourism in a sacred lake of the Sikkim Himalaya, India. *Environmental conservation*, 27(03), 269-277.

Mahat, T. B. S., Griffin, D. M. & Shepherd, K. R. (1987). Human Impacts on some forests of the middle hills of Nepal Part 3. Forests in the subsistence economy of sindhu Palchok and Kabhre Palanchok. *Mountain research and Development*, 53-70.

MEA (2005). *Ecosystem and human well-being, Synthesis report*. Washington, DC: Island Press.

Metzger, M. J., Rounsevell, M. D. A., Acosta-Michlik, L., Leemans, R. & Schröter, D. (2006). The vulnerability of ecosystem services to land use change. *Agriculture, Ecosystems & Environment*, 114(1), 69-85.

MoFSC (2014). *Nepal Fifth National Report to Convention on Biological Diversity*. Kathmandu: Ministry of Forest and Soil Conservation.

MoFSC (2009). *Asia-Pacific Forestry Sector Outlook Study II Working Paper Series Working Paper No. APFSOS II/ WP/2009/05*. Kathmandu: Ministry of Forest and Soil Conservation.

MoFSC (2010). *Nepal's Readiness Preparation Proposal: REDD 2010-2013*. Kathmandu: Ministry of Forest and Soil Conservation.

Motel, P. C., Choumert, J., Minea, A. & Sterner, T. (2014). Explorations in the Environment-Development dilemma. *Environmental and Resource Economics*, 57(4), 479.

Müller, F., de Groot, R. & Willemen, L. (2010). Ecosystem services at the landscape scale: The need for integrative approaches. *Landscape Online*, 23, 1-11.

Nepal, S. (2012). Integrated Tourism Concepts to Contribute to Sustainable Mountain Development in Nepal. *Mountain Research and Development*, 32(4), 487-487.

Olson, D. M. & Dinerstein, E. (1998). The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. *Conservation Biology*, 12(3), 502-515.

Pant, K. P., Rasul, G., Chettri, N., Rai, K. R. & Sharma, E. (2012). *Value of forest ecosystem services: A quantitative estimation from the Kangchenjunga landscape in eastern Nepal*. ICIMOD Working Paper 2012/5. Kathmandu: ICIMOD

Paudyal, K., Baral, H., Burkhard, B., Bhandari, S. P. & Keenan, R. J. (2015). Participatory assessment and mapping of ecosystem services in a data-poor region: Case study of community-managed forests in central Nepal. *Ecosystem services*, 13, 81-92.

Peh, K.S. H., Balmford, A. P., Bradbury, R. B., Brown, C., Butchart, S. H. M., Hughes, F. M. R., Stattersfield, A. J., Thomas, D. H. L., Walpole, M., Bayliss, J., Gowing, D., Jones, J. P. G., Lewis, S. L.,Mulligan, M., Pandeya, B., Strateford, C.,Thompson, J. R.,Turner, K., Vira, B., Willcock, S. & Birch, J. C. (2013). TESSA: A toolkit for rapid assessment of ecosystem services at sites of biodiversity conservation importance. *Ecosystem Services*, 5, 51-57.

Perrings, C., Duraiappah, A., Larigauderie, A. & Mooney, H. (2011). The biodiversity and ecosystem services science-policy interface. *Science*, 331 (6021), 1139-1140.

Poverty-Environment Initiative (2010). *Nepal Programme Framework*. Kathmandu: National Planning Commission, Ministry of Local Development, UNDP Nepal, UNDP/UNEP PEI.

Rasul, G., Chettri, N. & Sharma, E. (2011). *Framework for valuing ecosystem services in the Himalayas*. Kathmandu: ICIMOD.

Raymond, C. M., Bryan, B. A. MacDonald, D. H., Cast, A., Strathearn, S., Grandgirard, A. & Kalivas, T. (2009). Mapping community values for natural capital and ecosystem services. *Ecological Economics*, 68, 1301-1315.

RBG (2014). *Flora of Nepal. Edinburg: Royal Botanical Garden*. URL: http://www.floraofnepal.org/page/StaticRoot (accessed 15th August 2015).

Sánchez-Azofeifa, G. A., Pfaff, A., Robalino, J. A. & Boomhower, J. P. (2007). Costa Rica's payment for environmental services program: Intention, implementation and impact. *Conservation Biology*, 21, 1165-1173.

Secretariat of the Convention on Biological Diversity (2010). *Global Biodiversity Outlook 3*. Montréal, 94 pages.

Secretariat of the Convention on Biological Diversity (2014). *Global Biodiversity Outlook 4*. Montréal, 155 pages.

Seto, K. C., Güneralp, B. & Hutyra, L. R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences*, 109(40), 16083-16088.

Shah, K. B. & Tiwari, S. (2004). *Herpetofauna of Nepal. A Conservation Companion*. Kathmandu: IUCN Nepal.

Sharma, B., Rasul, G. & Chettri, N. (2015). The Economic Value of Wetland Ecosystem Services: Evidence from Koshi Tappu Wildlife Reserve, Nepal. *Ecosystem Services*, 12, 84-93.

Shrestha, T. K. (2008). *Ichthyology of Nepal: a study of fishes of the Himalayan waters*. Kathmandu: Himalayan Ecosphere

Shrestha, A. B., Devkota, L. P. (2010). *Climate change in the Eastern Himalayas: Observed trends and model projections; Climate change impact and vulnerability in the Eastern Himalayas - Technical Report 1*. Kathmandu: ICIMOD

Smith, C. (2010). *Lepidoptera of Nepal*. Kathmandu: Himalayan Nature.

Steffen, W. (2009). Interdisciplinary research for managing ecosystem services. *Proceedings of the National Academy of Sciences*, 106(5), 1301-1302.

Suich, H., Howe, C. & Mace, G. (2015). Ecosystem services and poverty alleviation: A review of the empirical links. *Ecosystem Services*, 12, 137-147.

TEEB (2008). The economics of ecosystems and biodiversity (TEEB), an interim report. Brussels: European Commission. www.teebweb.org/LinkClick.aspx?fileticket=u2fMSQoWJf0%3d&tabid (retrieved 15 March 2014)

TEEB (2009). TEEB for policy makers - Summary: responding to the value of nature. Bonn: TEEB. www.teebweb.org/Portals/25/Documents/TEEB%20for%20National%20Policy%20Makers/TEEB%20for%20Policy%20exec%20English.pdf (retrieved 16 March 2014)

TEEB (2010). *The economics of ecosystems and biodiversity: Ecological and economic foundations. In: UK National Ecosystem Assessment (2010) Progress and steps towards delivery*. Cambridge: UNEP-WCMC. Earthscan, London (UK).

Thapa, I., Butchart, S. H. M., Gurung, H.,Stattersfield, A. J., Thomas, D. H. L. & Birch, J. C. (2014). Using information on ecosystem services in Nepal to inform biodiversity conservation and local to national decision-making. Oryx, 1-9.

Thapa, S. (2014). A checklist of mammals of Nepal. *Journal of Threatened Taxa*, 6(8), 6061-6072.

Turner, R. K., Paavola, J., Cooper, P., Farber, S., Jessamy, V. & Georgiou, S. (2003). Valuing nature: lessons learned and future research directions. *Ecological economics*, 46(3), 493- 510.

Uddin, K., Shrestha, H.L., Murthy, MSR., Bajracharya, B., Shrestha, B., Gilani, H., Pradhan, S. & Dangol, B. (2015). Development of 2010 national land cover database for the Nepal, *Journal of environment management,* 148, 82-90

van Oort, B., Bhatta, L. D., Baral, H., Rai, R. K., Dhakal, M., Rucevska, I. & Adhikari, R. (2015). Assessing community values to support mapping of ecosystem services in the Koshi river basin, Nepal. *Ecosystem Services*, 13, 70-80.

Watson, R. T. (2012, November). The science-policy interface: The role of scientific assessments—UK National Ecosystem Assessment. *Proceedings of the Royal Society A*, 468(2147), 3265-3281.

World Bank (2006). *Where is the wealth of nations*. The World Bank.

World Bank (2008). *Nepal, Country Environmental Analysis*. The World Bank.

Xiaoli, B. I. & Jianping, G. E. (2004). Evaluating Ecosystem Service Valuation in China Based on the IGBP Land Cover Datasets. *Journal of Mountain Research*, 1, 009.

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

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

Annex 1– Bird Species recorded from Rauta ward # 5 and 9

SN	Common name	Scientific name	Number
1	Ashy Drongo	*Dicrurus leucophaeus*	15
2	Asian Palm Swift	*Cypsiurus balasiensis*	14
3	Bar-winged flycatcher Shrike	*Hemipus picatus*	37
4	Black crested Bulbul	*Pycnonotus melanicterus*	4
5	Black Drongo	*Dicrurus macrocercus*	35
6	Black-backed Forktail	*Enicurus immaculatus*	4
7	Black-chinned Babbler	*Stachyris pyrrhops*	12
8	Black-hooded Oriole	*Oriolus xanthornus*	5
9	Black-lored Tit	*Parus xanthogenys*	12
10	Black-shoulder Kite	*Elanus caeruleus*	1
11	Black-winged Cuckooshrike	*Coracina melaschistos*	2
12	Blue-bearded Bee-eater	*Nyctyornis athertoni*	2
13	Blue-capped rock-Thrush	*Monticola cinclorhynchus*	2
14	Blue-throated Barbet	*Megalaima asiatica*	1
15	Blue-whistling Thrush	*Myophonus caeruleus*	3
16	Blyth's Reed Warbler	*Acrocephalus dumetorum*	2
17	Bronzed Drongo	*Dicrurus aeneus*	3
18	Brown Shrike	*Lanius cristatus*	1
19	Cattle egret	*Bubulcus ibis*	13
20	Chestnut bellied Nuthatch	*Sitta castanea*	5
21	Chestnut-tailed Starling	*Sturnus malabaricus*	3
22	Common Buzzard	*Buteo buteo*	2
23	Common Chiffchaff	*Phylloscopus collybita*	8
24	Common Iora	*Aegithina tiphia*	16
25	Common Kestrel	*Falco tinnunculus*	2
26	Common Kingfisher	*Alcedo atthis*	3
27	Common Myna	*Acridotheres tristis*	23
28	Common Rosefinch	*Carpodacus erythrinus*	1
29	Common Stonechat	*Saxicola torquata*	13
30	Common Tailorbird	*Orthotomus sutorius*	26
31	Coppersmith Barbet	*Megalaima haemacephala*	4
32	Crested Treeswift	*Hemiprocne coronata*	3
33	Crimson Sunbird	*Aethopyga siparaja*	9
34	Dusky Warbler	*Phylloscopus fuscatus*	3
35	Eurasian Collared Dove	*Streptopelia decaocto*	6
36	Fulvous-breasted Woodpecker	*Dendrocopos macei*	2
37	Golden-fronted Leafbird	*Chloropsis aurifrons*	3
38	Greater Coucal	*Centropus sinensis*	2
39	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	2

SN	Common name	Scientific name	Number
40	Greenish Warbler	*Phylloscopus trochiloides*	34
41	Grey Wagtail	*Motacilla cinerea*	2
42	Grey-backed Shrike	*Lanius tephronotus*	2
43	Grey-bellied Tesia	*Tesia cyaniventer*	1
44	Grey-breasted Prinia	*Prinia hodgsonii*	58
45	Grey-capped Pygmy Woodpecker	*Dendrocopos canicapilus*	1
46	Grey-headed Canary Flycatcher	*Culicicapa ceylonesis*	28
47	Grey-throated Babbler	*Stachyris nigriceps*	1
48	Himalayan Bulbul	*Pycnonotus leucogenys*	43
49	Himalayan Griffon	*Gyps himalayensis*	9
50	Hodgson's Redstart	*Phoenicurus hodgsoni*	2
51	House Sparrow	*Passer domesticus*	24
52	Hume's Warbler	*Phylloscopus humei*	19
53	Indian Pond Heron	*Ardeola grayii*	17
54	Indian Roller	*Coracias benghalensis*	3
55	Jungle Babbler	*Turdoides striatus*	30
56	Large-billed Crow	*Corvus macrorhynchos*	13
57	Large-tailed Nightjar	*Caprimulgus macrurus*	1
58	Lesser Adjutant	*Leptoptilos javanicus*	3
59	Lesser Yellownape	*Picus clorolophus*	2
60	Olive backed Pipit	*Anthus hodgsoni*	5
61	Orange-bellied Leafbird	*Chloropsis hardwickii*	2
62	Oriental Turtle Dove	*Streptopelia orientalis*	1
63	Oriental-magpie Robin	*Copsychus saularis*	3
64	Oriental-white eye	*Zosterops palpebrosus*	15
65	Pied Bushchat	*Saxicola caprata*	4
66	Plain Martin	*Riparia paludicola*	18
67	Plumbeous Water Redstart	*Rhyacornis fuliginosus*	15
68	Plum-headed Parakeet	*Psittacula cyanocephala*	20
69	Red throated Flycatcher	*Ficedula parva*	7
70	Red Wattled Lapwing	*Vanellus indicus*	7
71	Red-billed Blue Magpie	*Urocissa erythroryncha*	5
72	Red-vented Bulbul	*Pycnonotus cafer*	92
73	Red-whiskered Bulbul	*Pycnonotus jocosus*	6
74	Rufous Tree-pie	*Dendrocitta vgabunda*	13
75	Rufous-capped Babbler	*Stachyris ruficeps*	2
76	Scaly breasted Munia	*Lonchura punctulata*	11
77	Scarlet Minivet	*Pericrocotus flammeus*	12
78	Shikra	*Accipiter badius*	1
79	Snowy-browed Flycatcher	*Ficedula hyperythra*	1
80	Spangled Drongo	*Dicrurus hottentotus*	16
81	Spotted Dove	*Streptopelia chinensis*	22
82	Spotted Owlet	*Athene brama*	2
83	Spot-winged Starling	*Saroglossa spiloptera*	4
84	Striped Tit Babbler	*Macronous gularis*	4

SN	Common name	Scientific name	Number
85	Thick Billed Warbler	*Acrocephalus aedon*	3
86	Tickell's Leaf Warbler	*Phylloscopus affinis*	8
87	Velvet Fronted Nuthatch	*Sitta frontalis*	2
88	Verditer Flycatcher	*Eumyias thalassina*	10
89	White Wagtail	*Motacilla alba*	10
90	White-breasted Waterhen	*Amaurornis phoenicurus*	12
91	White-browed Wagtail	*Motacilla maderaspatensis*	4
92	White-capped Water Redstart	*Chaimarrornis leucocephalus*	16
93	White-throated Kingfisher	*Halcyon smyrnensis*	7

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