ASSESSMENT OF ECOSYSTEM SERVICES IN PANCHASE PROTECTED FOREST, NEPAL

A THESIS SUBMITTED TO THE

CENTRAL DEPARTMENT OF ENVIRONMENTAL SCIENCE

INSTITUTE OF SCIENCE AND TECHNOLOGY

TRIBHUVAN UNIVERSITY

NEPAL

FOR THE AWARD OF

DOCTOR OF PHILOSOPHY

IN ENVIRONMENTAL SCIENCE

BY

ANANTA RAM BHANDARI

FEBRUARY 2020

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DECLARATION

Thesis entitled "**Assessment of Ecosystem Services in Panchase Protected Forest, Nepal**" which is being submitted to the Central Department of Environmental Science, Institute of Science and Technology (IoST), Tribhuvan University, Nepal for the award of the degree of Doctor of Philosophy (Ph.D.), is a research work carried out by me under the supervision of Dr. Udhab Raj Khadka, Central Department of Environmental Science, Tribhuvan University and co-supervised by Dr. Keshav Raj Kanel, Visiting Faculty, Kathmandu Forestry College (Tribhuvan University Affiliation), Kathmandu, Nepal.

This research is original and has not been submitted earlier in part or full in this or any other form to any university or institute, here or elsewhere, for the award of any degree.

Ananta Ram Bhandari

RECOMMENDATION

This is to recommend that **Mr. Ananta Ram Bhandari** has carried out research entitled "**Assessment of Ecosystem Services in Panchase Protected Forest, Nepal**" for the award of Doctor of Philosophy (Ph.D.) in **Environmental Science** under our supervision. To our knowledge, this work has not been submitted for any other degree.

Mr. Bhandari has fulfilled all the requirements laid down by the Institute of Science and Technology (IoST), Tribhuvan University, Kirtipur for the submission of the thesis for the award of Ph.D. degree.

Udhab Raj Khadka, PhD
Supervisor
(Associate Professor)
Central Department of Environmental Science
Tribhuvan University
Kirtipur, Kathmandu, Nepal

Keshav Raj Kanel, PhD
Co-Supervisor
(Visiting Faculty)
Kathmandu Forestry College
(Tribhuvan University Affiliation)
Kathmandu, Nepal

February 2020

Tel: 4-332147
4-332711

TRIBHUVAN UNIVERSITY

CENTRAL DEPARTMENT OF ENVIRONMENTAL SCIENCE

Kirtipur
Kathmandu, Nepal

Date: 28 February 2020

LETTER OF APPROVAL

On the recommendation of **Dr. Udhab Raj Khadka** and **Dr. Keshav Raj Kanel**, this Ph.D. thesis submitted by **Mr. Ananta Ram Bhandari**, entitled "**Assessment of Ecosystem Services in Panchase Protected Forest, Nepal**" is forwarded by Central Department Research Committee (CDRC) to the Dean, Institute of Science and Technology (IoST), Tribhuvan University (TU).

Rejina Maskey Byanju, PhD
Professor and Head,
Central Department of Environmental Science
Tribhuvan University
Kirtipur, Kathmandu, Nepal

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Ananta Ram Bhandari

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ABSTRACT

Ecosystem has both structural and functional components and through continuous interaction of these components, ecosystem delivers crucial materials and services to the functioning of ecosystem itself and to the human society as a whole. The present research has been carried out with the aim of assessing ecosystem services of Panchase Protected Forest by identifying ecosystem services, estimating their economic values, assessing distribution of benefits and framing financing mechanisms for sustainable management of forest ecosystems. Transect Walk Observations, Focus Group Discussions, Key Informant Interviews and Expert Consultations were used to identify ecosystem services, examine distribution of benefits and explore financing mechanisms. The economic value of ecosystem services was estimated using Total Economic Valuation framework considering both use values and non-use values. Panchase Protected Forest has been providing 17 types of ecosystem services including six provisioning, six regulating, two habitat and three cultural and amenity services. The provisioning services include food, medicines, raw materials, energy sources, ornamental resources and water. The regulating services include water flow regulation, erosion prevention, water purification, soil fertility maintenance, air quality regulation and climate regulation. The habitat services include life cycle maintenance and genetic resources maintenance, and the cultural and amenity services include recreation and tourism, cultural and religious, and cognitive resources. The total annual economic value of the ecosystem services provided by the forest is NPR 204.63 million (USD 2,046,312). However, economic contribution of forest ecosystem services has not been well reflected in National Accounting System. The beneficiaries of the ecosystem services of the protected forest range from local to sub-national, national and global levels. The present research has suggested 'payment for ecosystem services' and 'forest ecosystem trust fund' as appropriate financing mechanism for conservation and sustainable management of the Panchase Protected Forest. Moreover, this study has suggested to revise current National Accounting System recognizing values of ecosystem services in economic decisions.

Keywords: economic valuation, ecosystem financing, ecosystem services, protected forest, willingness to pay

TABLE OF CONTENT

Page No.

LIST OF ACRONYMS AND ABBREVIATIONS

AGB	Above Ground Biomass
ALTER-Net	A Long-Term Biodiversity, Ecosystem, Awareness Research Network
BGB	Below Ground Biomass
CBFM	Community Based Forest Management
CDES	Central Department of Environmental Science
CDRC	Central Department Research Committee
CO_2e	Carbon dioxide equivalent
CSUWN	Conservation and Sustainable Use of Wetlands in Nepal
CVM	Contingent Valuation Method
DNPWC	Department of National Parks and Wildlife Conservation
DoF	Department of Forests
ERPD	Emission Reduction Program Document
ESP	Ecosystem Services Partnership
FCPF	Forest Carbon Partnership Facility
FETF	Forest Ecosystem Trust Fund
FGD	Focus Group Discussion
GIZ	German International Development Cooperation
GoN	Government of Nepal
ICIMOD	International Center for Integrated Mountain Development
IoF	Institute of Forestry
IoST	Institute of Science and Technology
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KTWR	Koshi Tappu Wildlife Reserve
MEA	Millennium Ecosystem Assessment
MoFE	Ministry of Forests and Environment
MoFSC	Ministry of Forests and Soil Conservation
NatCap	Natural Capital Project
NBSAP	National Biodiversity Strategy and Action Plan

NCC	Natural Capital Coalition
NPR	Nepali Rupees
NTNC	National Trust for Nature Conservation
PES	Payment for Ecosystem Services
PF	Protected Forest
PPF	Panchase Protected Forest
PPFC	Panchase Protected Forest Council
REDD	Reducing Emission from Deforestation and Forest Degradation
SPSS	Statistical Package for the Social Sciences
TCM	Travel Cost Method
TEEB	The Economics of Ecosystems and Biodiversity
TESSA	Toolkit for Ecosystem Service Site-based Assessment
TEV	Total Economic Valuation
TU	Tribhuvan University
UKNEA	United Kingdom National Ecosystem Assessment
UNDP	United Nations Development Program
USD	United States Dollars
VDC	Village Development Committee
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WTP	Willingness to Pay
WWF	World Wide Fund for Nature

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

CHAPTER 1

1. INTRODUCTION

1.1 Introduction

Nepal is a mountainous country situated in the central part of the Himalayas between 26º22' and 30º27' North latitude and 80º04' and 88º12' East longitude. It outspreads from 70 meter to 8,848 meter above mean sea level covering an area of 14.72 million hectares. Nepal comprises five physiographic zones including High Himal, High Mountains, Middle Mountains (Mid-hills), Siwalik and Tarai (Government of Nepal [GoN]/Ministry of Forests and Soil Conservation [MoFSC], 2014; Figure 1). The diverse geographic conditions and altitudinal variations have resulted in rich diversity of species and ecosystems in Nepal comprising 11,971 species of flora, 11,861 species of fauna and 118 types of ecosystems (Dobremez, 1976; GoN/MoFSC, 2014).

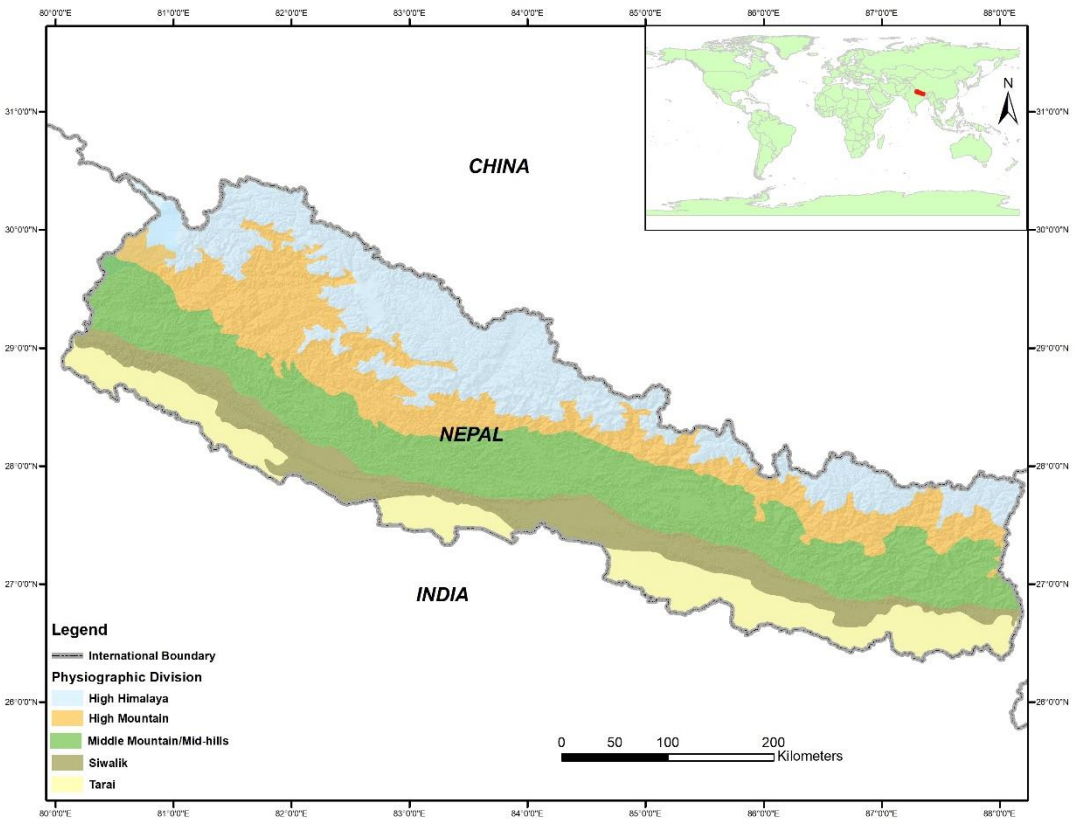

Figure 1: Physiographic zones of Nepal (GoN/MoFSC, 2014)

1.1.1 Ecosystems and Forests

Ecosystem is a community of living organisms interacting each other and with the physical environment as an interdependent system. The stock of natural ecosystems existing at a point of time is known as natural capital (Costanza et al., 1997). Natural capital provides a flow of benefits to people and the economy. Nepal is rich in natural capital comprising of various ecosystems. Dobremez (1976) has classified 118 natural ecosystems in Nepal (Table 1; Appendix I). Among them, Middle Mountain physiographic zone harbors 53 types of ecosystems followed by High Himal and High Mountains with 38 ecosystems, Siwalik with 14 ecosystems and Terai with 12 ecosystems (GoN/MoFSC, 2014). Out of 118 natural ecosystems of Nepal, 112 (94.92%) are forest ecosystems (GoN/MoFSC, 2014; Table 1). Forests cover 6.61 million hectares covering 44.7% of the total area of the country (Department of Forest Research and Survey [DFRS], 2015a).

Forest is a 'land spanning more than 0.5 hectares with trees higher than five meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ'* (Food and Agriculture Organization [FAO], 2015). Stainton (1972) has reported 35 forest types in Nepal (Table 2). The major forest types distributed in the Mid-hills (Middle Mountains) include sub-tropical evergreen forest, sub-tropical deciduous hill forest, *Schima-Castanopsis* forest, sub-tropical semi-evergreen hill forest, *Pinus roxburghii* forest, Quercus forest, *Castanposis* forest, Aesculus-Juglans-Acer forest, lower temperate mixed broadleaved forest and rhododendron forest (Table 2).

Table 1: Number of ecosystems by physiographic zones

Physiographic zone	Number of ecosystems	
	Total	Forest dominant
High Himal and High Mountains	38	37
Middle Mountains	53	52
Siwalik	14	13
Terai	12	10
Other	1	0
Total	118	112

Source: GoN/MoFSC (2014)

Table 2: Forest types of Nepal

SN	Forest type	SN	Forest type
1	Sal forest	19	Lower temperate mixed broadleaved forest
2	*Dalbergia-Acacia* forest	20	*Rhododendron* forest
3	*Terminalia* forest	21	*Betula utilis* forest
4	Tropical deciduous riverine forest	22	*Abies spectabilis* forest
5	Tropical evergreen forest	23	*Tsuga dumosa* forest
6	Sub-tropical evergreen forest	24	*Pinus excelsa* forest
7	Sub-tropical deciduous hill forest	25	*Abies pindrow* forest
8	*Schima-Castanopsis* forest	26	*Picea smithiana* forest
9	Sub-tropical semi-evergreen hill forest	27	*Cupressus* forest
10	*Pinus roxburghii* forest	28	*Cedrus* forest
11	*Quercus incana-Q lanuginosa forest*	29	*Larix* forest
12	*Quercus dilatata* forest	30	*Alnus* forest
13	*Quercus semecrpifolia* forest	31	*Populus ciliata* forest
14	*Quercus lamellosa* forest	32	*Hippophae* forest
15	*Castanopsis tribuloides-C. hystrix* forest	33	Moist alpine scrub
16	*Lithocarpus pachyphyla* forest	34	Dry alpine scrub
17	*Aesculus-Juglans-Acer* forest	35	*Juniper walichiana* forest
18	Upper temperate mixed broadleaved forest		

Source: Stainton (1972)

In Nepal, based on the ownership and management regimes, forests are broadly classified into two categories *viz.* private forests and national forests. Private forests are the forests that are grown in privately owned land, whereas national forests are the forests within the government or public lands (GoN/MoFSC, 2016). National forests are further classified into government managed forest and community managed forest (Figure 2). The government managed forest include forest within protected areas, block forests and forests distributed in various patches but not yet assigned as community-based forests. Protected forest is also a government managed forest, however, community engagement in management decisions is ensured through Protected Forest Council. The community managed forest includes community forest, collaborative forest, religious forest, leasehold forest (pro-poor and industrial) and forests within conservation areas/buffer zones. Besides, trees have also been grown in public lands and urban areas as public land forests and urban forests (GoN/MoFSC, 2016; Figure 2).

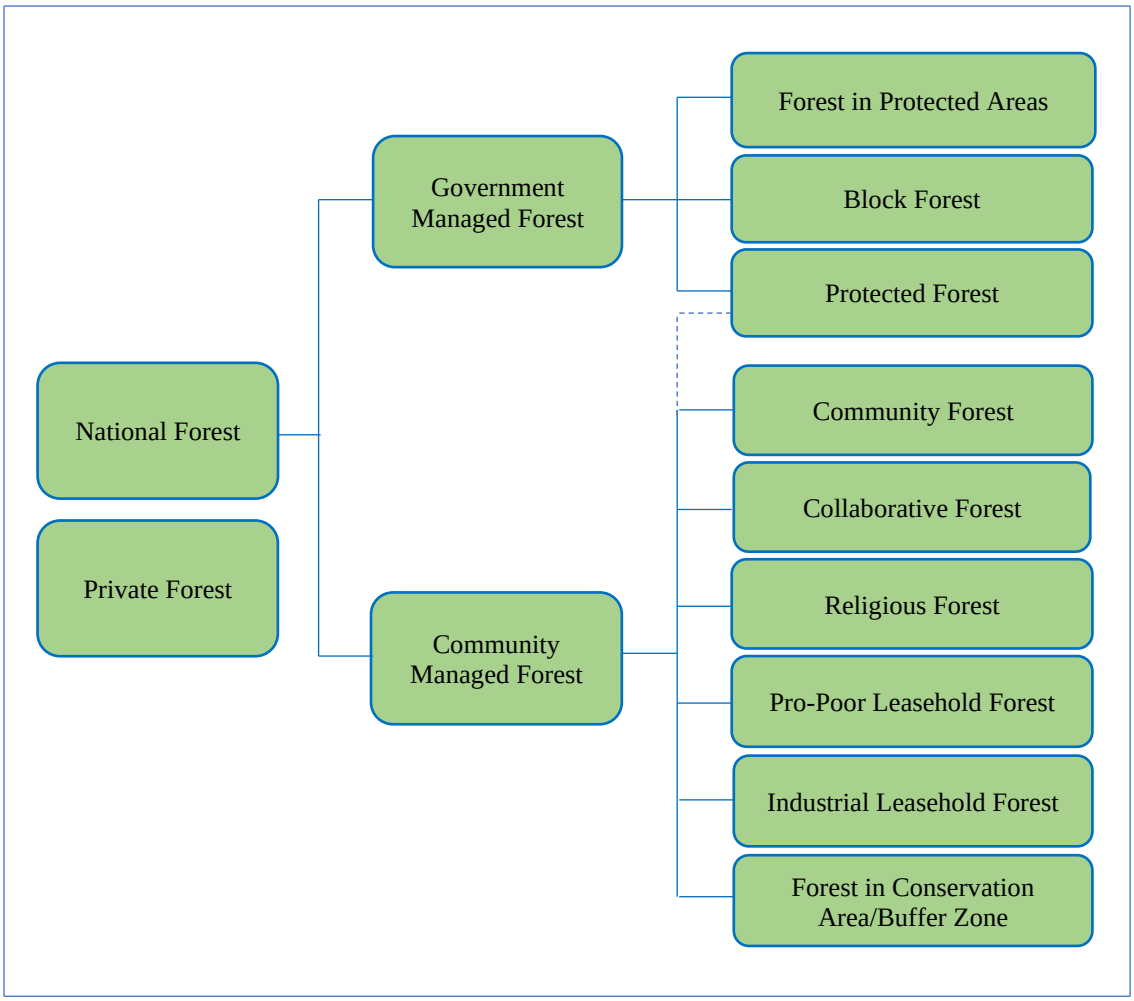

Figure 2: Forest management regimes in Nepal (Adapted from GoN/MoFSC, 2016)

With respect to conservation, Nepal has been involved in environment protection and biodiversity conservation by establishing networks of protected areas. A total of 20 protected areas have been established in Nepal covering 3.44 million hectares (23.3% of the total land of the country) (DNPWC, 2018; Appendix II). The protected areas are crucial for biodiversity and ecosystems conservation. Out of 118 natural ecosystems of Nepal (Dobremez, 1976), protected areas represent 80 ecosystems (GoN/MoFSC, 2014). However, many forests outside protected areas are also important in conserving biodiversity and ecosystems. Therefore, emphasizing the importance of biodiversity and ecosystems outside protected areas, Protected Forest Program has been initiated since 2012. As defined by Forest Act 1993, Protected Forest is a national forest of special environmental, scientific or cultural importance (GoN, 1993). It is a special category of forest which aims to balance human needs through conserving biodiversity, increasing ecosystem services and safeguarding environment (Shrestha et al., 2014). In

Nepal, 10 Protected Forests have been established covering an area of 190,809 hectares (Department of Forests [DoF], 2018; Table 3). Forests, representing 112 ecosystems out of 118 in Nepal, provide ecosystem services for human wellbeing.

Table 3: Protected forests of Nepal

Protected Forest	Year of declaration	Area (hectare)
Barandabhar	2012	10,466
Basanta	2012	69,001
Khata	2012	4,504
Laljhadi-Mohana	2012	29,642
Madane	2012	13,761
Panchase	2012	5,776
Kakrebihar	2013	175
Dhanusadham	2013	360
Resunga	2018	19,281
Thaple-Satyabati-Salimedaha	2018	37,843
Total		190,809

Source: DoF (2018)

1.1.2 Ecosystem Services

Ecosystem has both structural and functional components and through continuous interaction of these components, ecosystem delivers crucial materials and services to the functioning of ecosystem itself and to the human society as a whole. These materials and services delivered by ecosystem to the benefit of human are referred to as ecosystem services. It consists of flow of various materials and services from natural capital as a result of their structure and functions (Daily, 1997). Millennium Ecosystem Assessment (MEA, 2005) has defined ecosystem services as the benefits people obtain from ecosystem, which are ultimately the planet's life support systems (Global Environment Facility [GEF], 2011). In other words, ecosystem services are the direct and indirect contributions of ecosystems to the human wellbeing (The Economics of Ecosystem and Biodiversity [TEEB], 2010). Building on the ecosystem services concept, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) has highlighted ecosystem services as 'nature's contribution to people' which is defined as 'all the contributions, positive and negative, of living nature to the quality of life for people'.

In general, ecosystem services are broadly classified into provisioning, regulating, cultural, and habitat or supporting services, though they vary slightly with classification systems. According to MEA (2005), there are four broad categories of ecosystem services *viz.* provisioning, regulating, cultural and supporting services (Table 4). Later, TEEB (2010) has slightly modified the MEA classification of ecosystem services as provisioning, regulating, habitat, and cultural and amenity services (Table 4). The provisioning services and the regulating services are similar in both MEA and TEEB classifications. However, cultural services of MEA are elaborated as 'cultural and amenity services' in TEEB. In TEEB classification, most of the supporting services of MEA are included in the regulating services, whereas some of them are included in 'habitat services,' a new service type introduced in TEEB (Table 4).

Among these ecosystem services, provisioning services comprise of food, water, fiber, raw materials, ornamental resources, medicinal resources and genetic resources (MEA, 2005; TEEB, 2010; Table 4). Similarly, regulating services reduce the effect of stresses and shocks to the system and include erosion prevention, water purification and waste treatment, air quality regulation, climate regulation, natural hazard regulation, regulation of hydrological flow, soil fertility maintenance, pollination, pests and diseases control, and biological control (MEA, 2005; TEEB, 2010; Table 4). Likewise, cultural services include recreation and tourism, aesthetic values, spiritual and religious values, inspirations, social relations, sense of place, cultural heritage value and cognitive values (MEA, 2005; TEEB, 2010; Table 4). In cultural services, there are four types of cultural practices *viz.* playing and exercising, creating and expressing, producing and caring, and gathering and consuming (Fish et al., 2016). Similarly, supporting services comprise the ecosystem processes that underpin production of all these services including soil formation, photosynthesis, primary production, water cycling and nutrients cycling (MEA, 2005; Table 4). The new category of TEEB, the habitat services, include life cycle maintenance and gene pool protection (TEEB, 2010; Table 4). The 'nature's contribution to people' has been categorized as material, non-material, and regulation of environmental process (IPBES, 2019; Table 4)

Table 4: Classification of ecosystem services

Ecosystem Service	Classification Systems		
	MEA*	TEEB**	IPBES*** (Nature's contribution to people)
Provisioning	Food	Food	(Materials)
	Freshwater	Water	Food and feed
	Fiber	Raw materials	Energy
	Ornamental resources	Ornamental resources	Materials and assistance
	Genetic resources	Genetic resources	Medicinal, biochemical and genetic resources
	Biochemicals and natural medicines	Medicinal resources	
Regulating	Air quality regulation	Air quality regulation	(Regulating)
	Climate regulation	Climate regulation	Regulation of air quality
	Natural hazard regulation	Moderation of extreme events	Regulation of climate
	Water regulation	Regulation of water flows	Regulation of hazards and extreme events
	Water purification/waste treatment	Waste treatment (water purification)	Regulation of freshwater quantity, location and timing
	Erosion regulation	Erosion prevention	Regulation of freshwater and coastal water quality
	Pollination	Pollination	Regulation of ocean acidification
	Pest regulation/control	Biological control	Formation, protection and decontamination of soils and sediments
	Diseases regulation/control	Maintaining soil fertility	Pollination and dispersal of seeds and other propagules
			Regulation of detrimental organisms and biological processes
			Habitat creation and maintenance
			Maintenance of options

Source: *MEA (2005); **TEEB (2010); ***IPBES (2019)

Table 4: Contd…

Ecosystem Service	Classification Systems		
	MEA*	TEEB**	IPBES*** (Nature's contribution to people)
Cultural	Recreation and tourism	Recreation and tourism	(Non-material)
	Aesthetic values	Aesthetic and amenity	Physical and psychological experiences
	Cultural diversity	Inspiration for culture, art, design	Learning and inspiration
	Spiritual and religious values	Spiritual experience	Supporting identities
	Knowledge systems	Cognitive development	
	Educational values		
	Inspiration		
	Social relations		
	Sense of place		
	Cultural heritage value		
Supporting	Soil formation	Not applicable	NA
	Nutrient cycling		
	Primary production		
	Photosynthesis		
	Water cycling		
Habitat	Not applicable	Lifecycle maintenance	NA
		Gene pool protection	

Source: *MEA (2005); **TEEB (2010); ***IPBES (2019)

The ecosystem services provided by forests and other ecosystems have ecological and economic values. The MEA (2005) framework has emphasized ecological importance of the ecosystem services to policy and decision-making process. Furthermore, TEEB (2010) came into effect emphasizing collaborative efforts of ecology and economics in ecosystem valuation (Pandeya et al., 2016).

1.1.3 Ecosystem Values

Values of ecosystem services are derived from the services produced by the ecosystems. TEEB (2010) has classified these values of ecosystem services into use value and non-use value (Table 5). The use value is associated with 'private goods' for which market price usually exists. The use value has been classified into direct use value and indirect use value. Direct use value comprises benefits derived from the actual, direct use of ecosystem services either through extraction or without extraction. The direct use value received through extraction is consumptive use value (provisioning services e.g. timber), whereas the direct use value received without extraction is non-consumptive use value (cultural services e.g. recreation). Indirect use value refers to the benefits derived from an ecosystem's functions without having direct interaction (regulating services e.g. carbon sequestration).

The non-use value is associated with 'common goods' for which market price usually does not exist and that does not involve in direct or indirect use. The non-use value has been classified into option value, existence value, altruist value and bequest value (Table 5). Option value is the future use of known and unknown benefits and is related to the importance that people anticipate to the future availability of ecosystem services for personal benefit. Existence value is the satisfaction of knowing that ecosystems exist and is related to the satisfaction of individuals that ecosystems continue to exist. Altruist value is the satisfaction of knowing that people of the present generation have access to the benefits provided by ecosystems considering intra-generational equitable sharing of ecosystem's benefits. Bequest value is the satisfaction of knowing that future generation will also have access to the benefits from ecosystems considering the inter-generational equitable sharing of ecosystem's benefits (Table 5). In order to capture these values of ecosystem services for conservation and sustainable management of ecosystems, ecosystem financing is important.

Table 5: Different values of ecosystem services

Value		Description
Use value	Direct use value	Benefits derived from the actual, direct use of ecosystem services (consumptive or non-consumptive)
	Indirect use value	Benefits derived from an ecosystem's functions without direct interaction with it
Non-use value	Option value	Relates to the importance that people give to the future availability of ecosystem services for personal benefit (option value in a strict sense) (Quasi-option value sometimes dealt as use value)
	Existence value	Value related to the satisfaction that individuals derive from the mere knowledge that species and ecosystems continue to exist
	Altruist value	Value attached by individuals to the fact that other people of the present generation have access to the benefits provided by species and ecosystems (intra-generational equity concerns)
	Bequest value	Value attached by individuals to the fact that future generations will also have access to the benefits from species and ecosystems (inter-generational equity concerns)

Source: Adapted from TEEB (2010)

1.1.4 Ecosystem Financing

Ecosystem financing is the practice of raising and managing capital and using financial incentives to support ecosystem management sustainably. It includes private and public financial resources to be used to manage ecosystems, and investments that produce positive ecosystem outcomes. Most of the ecosystem financing sources are derived from public funds, although private sector funding is gradually increasing (Bladon et al., 2014). In Nepal, federal, state and local governments are the major sources of financing for ecosystem management. Nepal has developed system of 'National Accounts' as a framework for analyzing and evaluating the performance of national economy. The system of National Accounts in Nepal is based on the United Nations system of National Accounts (Central Bureau of Statistics [CBS], 2007). The current system of National Accounts has recognized forest products such as timber, fuelwood, grass, fodder, bedding materials, medicinal herbs and resin (CBS, 2007), considering only the consumptive use-value of provisioning services as contributors of gross

domestic products. However, the non-consumptive use value, indirect use value and non-use values have been ignored in the National Accounts system.

Payment for Ecosystem Services (PES) and 'Trust Funds' are potential financing mechanisms for sustainable management of natural resources. PES is a voluntary transaction mechanism between ecosystem service users and providers on agreed rules of natural resource management for generating offsite services (Wunder, 2015). Nowadays, PES is becoming an instrument to create additional funding for protected areas (Schirpke et al., 2017; Wunder, 2013) and providing socio-economic benefits at local level (Clements & Milner-Gulland, 2015). However, socio-economic benefits of PES are determined by a combination of factors such as type of ecosystem services, conditions of PES agreement and socio-economic context of local communities (Schirpke et al., 2018). The PES relies on the idea of monetary value of ecosystem services to internalize positive externalities of ecosystem management and to incentivize the producers to generate more of these services. On the other hand, the 'Trust Funds' are financial vehicles established for raising funds and creating financial incentives (Droesse, 2011). The 'Trust Funds' are legally independent grant-making institutions which provide sustainable financing for conservation and sustainable development (Spergel & Taieb, 2008). The 'Trust Funds' provide an innovative model for sustainable financing for watershed conservation (Kauffman, 2013) and long-term financing for conservation programs (Bhutan Trust Fund for Environmental Conservation [BTFEC], 2018). This approach combines planning for the ecological, financial, social, political, and institutional measures for durable and effective management of nature (World Wide Fund for Nature [WWF], 2015). The 'Trust Funds' not only lead to financial sustainability through diversification of financing mechanisms, but also help initiate and strengthen inter-sectoral collaboration (Bladon et al., 2014).

1.2 Rationale

In the present context of growing human population and increasing forest degradation and loss, ecosystem services are becoming scarcer over time period and thus becoming subject of growing public concerns. At global scale, MEA (2005) has estimated that approximately 60% of the ecosystem services are being degraded or used unsustainably. Likewise, TEEB (2010) has made aware of the growing evidences of ecosystem degradation approaching critical thresholds level. Moreover, IPBES (2019) has reported that ecosystems are declining faster than at any time in human history. Thus, conservation and sustainable management of natural ecosystems is of utmost important.

In this context, identification of ecosystem services and economic valuation is important in creating markets and developing incentive mechanisms for ecosystem conservation and management. However, current market system only shed information about the value of a small subset of ecosystem services that has been priced and incorporated in transaction mechanisms as commodities or services. Some of the ecosystem services have market prices, but many do not have, since they are not traded in the market because of higher transaction costs due to long geographic or temporal distances between the production and use of these services (Dasgupta et al., 2011). Moreover, markets fail to capture the real value of ecosystem services as many of them are 'common goods' and are often open access in character and non-rival in their consumption (TEEB, 2010). The neo-classical economics largely neglects the economic contribution of nature by restricting its scope of analysis to those ecosystem services that bear a price (Costanza et al., 1997). Hence, market failure often leads to degradation of natural environment and accelerated loss of ecosystems (TEEB, 2010). Ecosystem valuation plays an important role in creating markets through demonstration and appropriation of monetary values (TEEB, 2010) and in creating incentive mechanisms to conserve these ecosystems (Department for Environment, Food & Rural Affairs [DEFRA], 2007) maximizing the benefits (Bird Conservation Nepal [BCN] & DNPWC, 2012). Moreover, valuation of ecosystem services also helps in sensitizing policy makers for various policy choices and scenarios (Costanza et al., 2014).

Among the ecosystems, forest dominant ecosystems provide a number of ecosystem services and are important refugia for terrestrial biodiversity and as a source of ecosystem services essential for human wellbeing (MEA, 2005). In the context of Nepal, forests are crucial for ecosystem services, as out of total 118 natural ecosystems, 112 are forest dominant. However, ecosystem services provided by forests are neither adequately assessed nor the value of these ecosystem services are properly recognized in Nepal (Bhatta et al., 2014; Paudyal et al., 2015; Peh et al., 2016).

Ecosystem valuation is crucial to impart policy formulation for ecosystem financing. The current National Accounts system in Nepal only captures the value of provisioning services, whereas the values of regulating, cultural and habitat services provided by the forests are not recognized. Thus, the value of ecosystem services is not adequately integrated in development planning in Nepal (Oort et al., 2015). Recognition of only consumptive use value and exclusion of other use and non-use values of ecosystem services in the national account system has limitation in distributing adequate financial resources for ecosystem management. Therefore, ecosystem valuation is an important approach to reflect the value of ecosystems in economic decisions. Thus, ecosystem valuation is essential for making financially sustainable conservation efforts (Bastian, 2013).

In Nepal, there are limited research on ecosystem services in few protected areas and wetlands (Baral et al., 2016; Basnyat et al., 2012; Bhatta et al., 2015; Chaudhary et al., 2018; Conservation and Sustainable Use of Wetlands in Nepal [CSUWN], 2011; Khanal et al., 2014; Merriman et al., 2017; Oort et al., 2015; Peh et al., 2016; Sharma et al., 2015; Shrestha et al., 2007). Although, protected forests are important for biodiversity, ecosystems and ecological safeguards, research on ecosystem services of protected forest regime seems lacking. In Panchase Protected Forest as well, such information seems lacking. Moreover, the ecosystem services studies in Nepal (Basnyat et al., 2012; Bhatta, et al., 2014; Birch et al., 2014; Khanal, et al., 2014; Oort et al., 2015; Paudyal et al., 2015; Paudyal et al., 2017; Peh et al., 2016; Sharma et al., 2015) have observed that ecosystem services and their values are not adequately recognized in decision-making process of the country. Likewise, most of the studies (Basnyat et al., 2012; Bhatta et al., 2014; CSUWN, 2011; Khanal et al., 2014; Peh et al., 2016; Oort et al., 2015; Birch et al., 2014; Paudyal et al., 2017) have urged the need of ecosystem

financing for sustainable management of ecosystems. Therefore, the present study has been carried out in Panchase Protected Forest with the aim of assessing ecosystem services demonstrating their economic values and framing financing mechanisms for sustainable mechanism.

The present study intends to seek answers to the following questions:

1. Which ecosystem services protected forest has been providing?
2. What is the economic value of the ecosystem services provided by the forests?
3. How the benefits derived from ecosystem services is distributed among stakeholders?
4. What are the possible sustainable financing mechanisms to conserve the forests?

1.3 Objectives

1.3.1 General Objective

The general objective of this study is to assess ecosystem services of Panchase Protected Forest in the Mid-hills of Nepal.

1.3.2 Specific Objectives

Specific objectives of the study are to:

1. Identify ecosystem services of Panchase Protected Forest;
2. Estimate economic values of ecosystem services provided by Panchase Protected Forest;
3. Assess distribution of benefits derived from ecosystem services of Panchase Protected Forest; and
4. Explore sustainable financing mechanisms to conserve ecosystems in Panchase Protected Forest.

1.4 Conceptual Framework

The present research work has been designed following TEEB (2010) framework of ecosystem services (Figure 3). The tiered approach of analyzing and structuring ecosystem valuation consists of recognition, demonstration and appropriation whereas, maintaining and improving ecosystem services dealt with management. In this framework, recognition refers to the identification of the full range of ecosystem services provided by forest ecosystems and quantification of these ecosystem services. Demonstration refers to the estimation of economic value of ecosystem services using appropriate methods, demonstrating their values. Similarly, appropriation refers to capturing some or all of the demonstrated and measured values of ecosystem services to provide incentives for their sustainable provision. Appropriation refers to the introduction of financing mechanisms that incorporate the values of ecosystem services into decision-making and seek solutions to overcome their undervaluation using economically informed policy instruments. Likewise, management refers to the sustainable management of natural capitals to regulate ecosystem services and contribute towards human wellbeing.

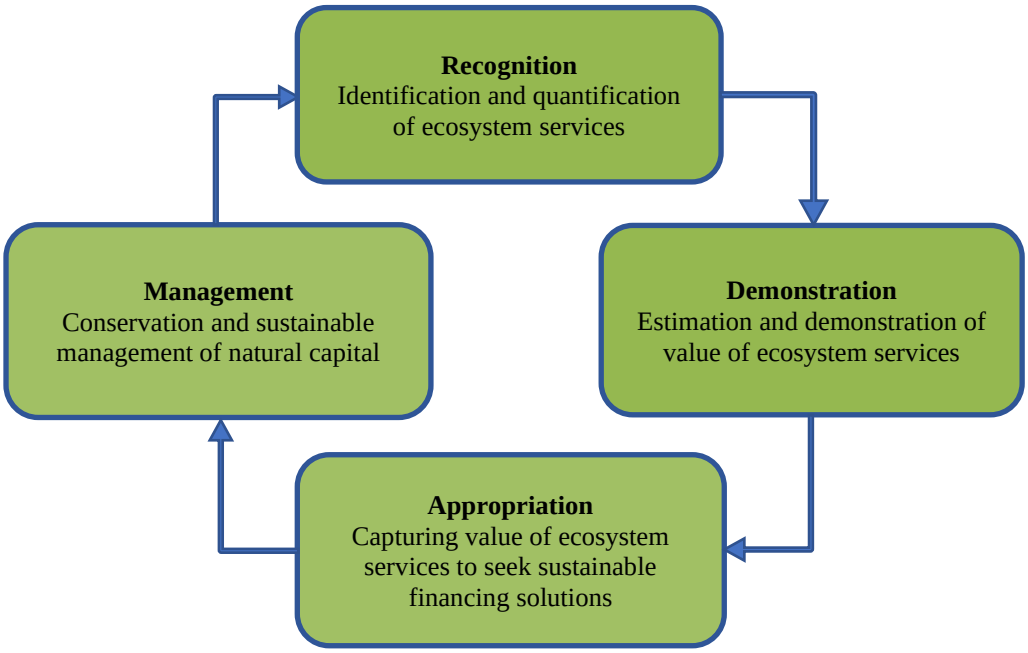

Figure 3: Conceptual framework of the study (Adapted from TEEB, 2010)

CHAPTER 2

2. LIRATURE REVIEW

2.1 Genesis of Ecosystem Services

Although, the term ‘ecosystem service’ is relatively new, initiatives of combining economics and biological science to manage human interactions with nature, has a long history (Polasky & Segerson, 2009). According to Polasky & Segerson (2009), Faustmann (1849) defined optimal rotation of forest stand by combining biological growth models and economic framework. Similarly, Leopold (1949), Carson (1962), and Krutilla and Fisher (1975) stated people-environment interactions (Polasky & Segerson, 2009). The term ‘nature’s service’ was first used in academic literature by Westman (1977) in a paper entitled ‘how much are nature’s service worth?’ and the term ‘ecosystem services’ was first used by Ehrlich and Ehrlich (1981). According to Costanza et al. (2017), the concept of ecosystem services became widespread after 1980s, as Odum (1989), Folke and Kaberger (1991), Braat (1992), De Groot (1992), Dasgupta et al. (1994), Costanza et al. (1997) and Daily (1997), among others, used it extensively. A further boost to the subject was given by the MEA (2005) by linking ecosystem services to human wellbeing. After the MEA (2005), ecosystem services science has made much progress in framing the concepts and approaches. Moreover, economic interface has been expanded into ecosystem services science after TEEB (2010). Furthermore, IPBES (2019) has aimed at strengthening science-policy interface for ecosystem services.

In the global context, the history of the development of ecosystem services science can be expressed in three stages (Figure 4). The stages include ‘origin and gestation of the modern ecosystem services’ until late 1980s, ‘ecosystem services in regular scientific agenda’ from late 1980s to late 1990s and ‘ecosystem services in decision making’ since early 2000s. In 1970s, ecosystem service literatures have started framing beneficial ecosystem functions to highlight societal dependence on ecosystems. In 1980s, market environmentalism was expanded. Similarly, ecosystem services science has been mainstreamed into the sustainability literatures from 1990s. Furthermore,

ecosystem service has become a part of policy agenda since 2000s (Gomez-Baggethen et al., 2010; Figure 4).

Ecosystem services agenda has been emphasized, during the course of time, through the establishment of global and regional initiatives on ecosystem service research, policy and practice. The major regional and global initiatives include Millennium Ecosystem Assessment (MEA), The Economics of Ecosystem and Biodiversity (TEEB), Ecosystem Services Partnership (ESP), United Kingdom National Ecosystem Assessment (UKNEA), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), A Long-Term Biodiversity, Ecosystem and Awareness Research Network (ALTER-Net), Wealth Accounting and Valuation of Ecosystem Services (WAVES), Natural Capital Project (NatCap), and Natural Capital Coalition (NCC) (Table 6).

In the national context, Nepal has been working in forest carbon services through Reducing Emissions from Deforestation and Forest Degradation (REDD) since 2008. REDD Forestry and Climate Change Cell (now named as REDD Implementation Centre), a separate entity to look after REDD program, was established in 2008 under the then Ministry of Forests and Soil Conservation. REDD Readiness Package was developed and implemented between 2011 and 2014 (Ministry of Forests and Environment [MoFE], 2018). Nepal has developed Emission Reduction Program Document (ERPD) for Terai Arc Landscape which has been approved by the Forest Carbon Partnership Facility in 2018. The ERPD covers 13 districts of the Terai Arc Landscape with the potential to recover up to USD 45 million by sequestrating 9.16 million tons of carbon-dioxide equivalent (CO_2e) over six-year period, from 2019 to 2024 (MoFE, 2018). Moreover, the ecosystem services agenda has been integrated into national policy documents such as National Biodiversity Strategy and Action Plan (NBSAP) 2014-2020, Forestry Sector Strategy 2016-2025, Nepal National REDD+ Strategy 2018, and Forest Policy 2019. Although the concept of ecosystem services is being increasingly integrated into environmental policy documents, the full breadth of ideas associated with ecosystem services does not appear to be well understood by key stakeholders in Nepal (Chaudhary & McGregor, 2018).

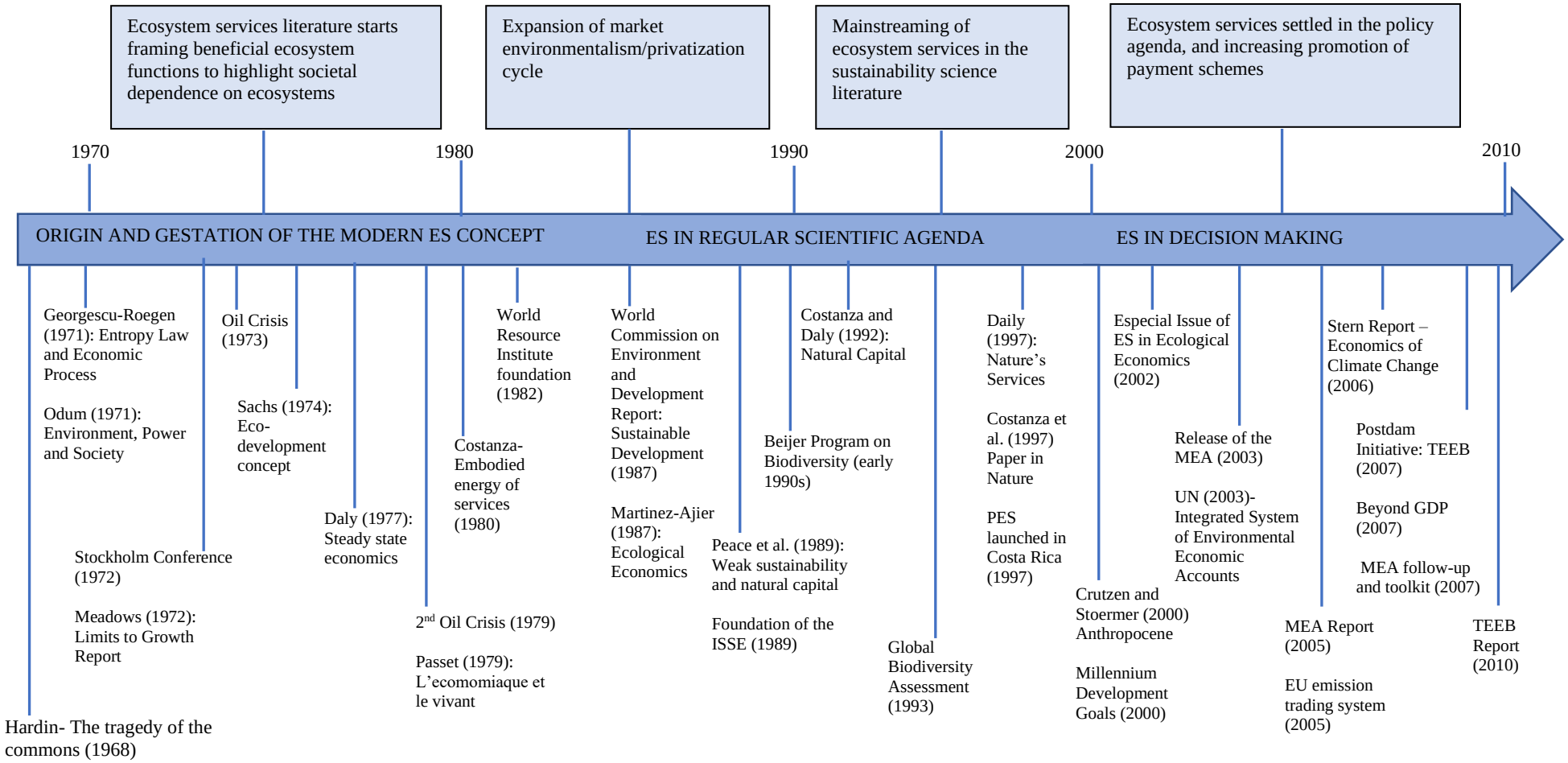

Figure 4: Stages of the modern history of ecosystem services (Adapted from Gomez-Baggerthun et al., 2010)

Table 6: Initiatives on ecosystem service research, policy and practice

Initiatives	Description
Millennium Ecosystem Assessment (MEA)	MEA is a multilateral initiative aimed at detailing global and sub-global assessments of ecosystem services. The MEA was a 4-year, 1,300 scientist study commissioned by the United Nations. The report has analyzed the state of the world's ecosystems and provided recommendations for policy makers. It has determined that human actions have depleted the world's natural capital to the point that the ability of majority of the globe's ecosystems to sustain future generations can no longer be taken for granted (MEA, 2005).
The Economics of Ecosystems and Biodiversity (TEEB)	TEEB is an initiative to draw attention to the global economic benefits of biodiversity and ecosystem services, to highlight the growing costs of biodiversity loss and ecosystem degradation. The TEEB became able to bring together expertise from the fields of science, economics and policy to enable practical actions moving forward. TEEB has been hosted by United Nations Environment Program (TEEB, 2010). TEEB synthesis report has been produced in 2010.
Ecosystem Services Partnership (ESP)	ESP is a worldwide network to enhance the science, policy and practice of ecosystem services for conservation and sustainable development. ESP was created in 2008 and has grown to become a bigger international member-based network focused on facilitating ecosystem services professionals from science, policy and practice worldwide (https://www.es-partnership.org accessed on 11/07/2018).
United Kingdom National Ecosystem Assessment (UKNEA)	UKNEA is an initiative established to analyze United Kingdom's natural environment in terms of the benefits it provides to society and continuing economic prosperity. It was commenced in 2009 and produced report in 2011 as an inclusive process involving many government agencies, academia, non-governmental organizations and private sector institutions (https://uknea.unep-wcmc.org accessed on 23/12/2019).
Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)	IPBES is an inter-governmental body which assesses the state of biodiversity and ecosystem services and provides information for decision making process. Established in 2012, IPBES has expanded its membership in 126 countries. IPBES has been placed under the auspices of four United Nations entities *viz.* United Nations Environment Program, United Nations Educational, Scientific and Cultural Organization, Food and Agriculture Organization, and United Nations Development Program (https://www.ipbes.net accessed on 23/12/2019).

Table 6: Contd…

Initiatives	Description
A Long-Term Biodiversity, Ecosystem and Awareness Research Network (ALTER-Net)	ALTER-Net is a network of various institutions from 17 European countries. It integrates research capacities across Europe assessing changes in biodiversity, analyzing the effect of those changes on ecosystem services and informing policymakers and the public at a European scale. Originally, it was funded by the European Union's Framework VI program to stimulate a collaborative approach, ALTER-Net is now operating independently, contributing to the integration of Europe's research capacity on biodiversity (http://alter-net.info accessed on 23/12/2019).
Wealth Accounting and Valuation of Ecosystem Services (WAVES)	WAVES is a World Bank led global partnership that aims to promote sustainable development by ensuring natural resources mainstreamed in development planning and national economic accounts (https://www.wavespartnership.org accessed on 23/12/2019).
Natural Capital Project (NatCap)	NatCap is a partnership between the Stanford University, University of Minnesota, The Nature Conservancy and the World Wildlife Fund with the goal of integrating the value of ecosystem services into decision making. The NatCap has developed open-sources tools such as the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) which models the ecosystem services values and uses (https://naturalcapitalproject.stanford.edu accessed on 11/07/2018).
Natural Capital Coalition (NCC)	NCC is a global multi-stakeholder organization established in 2014 with the aim of supporting the business community to incorporate ecosystem services and their values into their operations. NCC has published a Natural Capital Protocol, a framework designed to support business managers decision related to their impact on environment. (https://naturalcapitalcoalition.org accessed on 23/12/2019).
Forest Carbon Partnership Facility (FCPF)	FCPF is a global partnership of governments, businesses, civil society and indigenous peoples focused on reducing emissions from deforestation and forest degradation, forest carbon stock conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (https://www.forestcarbonpartnership.org accessed on 11/07/2018).

2.2 Ecosystem Services Studies in Nepal

Globally, ecosystem services agenda has been moving forward from scientific research agenda to decision making tools (Gomez-Baggethun et al., 2010). However, in the Nepalese context, it is still in the preliminary stage of study and practice. In the present research, previous studies conducted in the ecosystem services in Nepal have been reviewed under three themes *viz.* identification of ecosystem services, valuation of ecosystem services and financing mechanism for ecosystem management.

2.2.1 Identification of Ecosystem Services

Every ecosystem provides materials and services for human wellbeing. Identification of such services provided by the ecosystems is important for conservation, management and sustainable use. In Nepal, few studies (Basnyat et al., 2012; Bhatta et al., 2015; Birch et al., 2014; CSUWN, 2011; Khanal et al., 2014; Oort et al., 2015; Paudyal et al., 2015; Paudyal et al., 2017) have been conducted to identify ecosystem services of few wetlands (Phewa Lake Area, Ghodaghodi Lake Area, Beeshazar and Associated Lake Area), protected areas (Bardia National Park), watersheds and river basins (Jhiggu Khola watershed, Koshi River Basin) and community forests.

With respect to wetlands, CSUWN (2011) has identified ecosystem services provided by Phewa Lake Area, in the Central Mid-hills. The study has identified food, fishes, gravel, sands, and water (to be used for washing, bathing, irrigation and hydropower) as provisioning services of Phewa Lake Area. The study has estimated annual fish harvesting from Phewa Lake to be 33,519 kg. Similarly, the study has identified tourism and recreation, boating and paragliding as cultural services of Phewa Lake Area. According to the study, 203,527 foreigners and 200,000 Nepali tourists visited Pokhara in fiscal year 2008/09. Moreover, water purification and waste treatment have been identified as regulating services provided by Phewa Lake Area. The study has concluded that Phewa Lake is under pressure mainly from siltation and eutrophication which may lead to reducing the ecosystem services provided by the Lake Area.

Likewise, CSUWN (2011) has identified ecosystem services provided by Ghodaghodi Lake Area, in the Western Terai region of Nepal. The study has identified food, water

(to be used for bathing and washing and for livestock), medicine and ornamental resources as provisioning services of Ghodaghodi Lake Area. The study has estimated annual fish harvesting from Ghodaghodi Lake Area to be 10,409 kg. Similarly, the study has identified religious activities, bird watching and hiking as cultural services of Ghodaghodi Lake Area. Moreover, carbon sequestration, flood protection, water purification and waste management as regulating services provided by Ghodaghodi Lake Area.

Similarly, Khanal et al. (2014) have identified ecosystem services provided by Beeshazar and Associated Lake Area in the buffer zone of Chitwan National Park in the Central Terai region of Nepal. The study has identified fishes, edible fruits, timber, fodder, vegetables and medicinal plants as provisioning services, and climate regulation, water regulation and erosion control as regulating services. Moreover, the study has identified recreational, spiritual and education as cultural services, and nursery and refugia as supporting services provided by Beeshazar and Associated Lake Area.

With respect to watersheds and river basins, Oort et al. (2015) have assessed local perceptions of ecosystem use and values of ecosystem services in Jhiggu Khola watershed in the Central Mid-hills of Nepal. The authors have identified agricultural products (crops, livestock), forest products (fuelwood, fodder, timber, leaf litter, medicinal plants) and water (drinking water, water for irrigation) as provisioning services. Similarly, regulating services identified by the study include soil regulation, water quality maintenance, landslide control, erosion control and sediment control, and supporting services include biodiversity. The authors have highlighted the importance of PES mechanism to conserve ecosystems by linking upstream communities and downstream beneficiaries of the watershed.

With respect to protected areas, Basnyat et al. (2012) have identified ecosystem services provided by Bardia National Park, in the Western Terai region of Nepal. The ecosystem services identified by the study from the Bardia National Park include provisioning services such as firewood, fodder and thatching grass, regulating services such as carbon sequestration, soil conservation, biodiversity conservation and nutrient cycling, and recreational services such as tourism.

With respect to forests, Bhatta et al. (2015) have identified provisioning services of forest ecosystems in the upstream of Koshi River basin, in the Eastern Mid-hills of Nepal. The identified ecosystem services include timber, fuelwood, leaf litter, medicinal plants, grass, fodder and raw materials for Nepali handmade paper. The authors have found that despite having high potential of forest ecosystem services, the availability of provisioning services, particularly fuelwood, fodder and leaf litter is declining because of a strict regulation on forest products extraction. The authors have reported that, due to impact of climate change, invasive species such as *Lantana camara* and *Eupatorium species* are colonizing the forests preventing regeneration of timber species resulting in changing densities and composition of vegetation.

Similarly, Birch et al. (2014) have conducted a rapid assessment of ecosystem services in Phulchoki Forest of Lalitpur district in the Central Mid-hills of Nepal. The study has mentioned timber, non-timber forest products, water provision, carbon storage and nature-based recreation as the major ecosystem services provided by the forests. The study has suggested PES as a means of paying local people for the global ecosystem services that the forest is providing.

Likewise, Paudyal et al. (2015) have identified ecosystem services provided by the selected community managed forests in Dolakha district in the Central Mid-hills of Nepal. The provisioning services identified include food, forage, timber, fuelwood, genetic resources, medicines and freshwater. Similarly, the regulating services include air regulation, carbon sequestration, groundwater recharge, natural hazard reduction, water purification and disease regulation. Moreover, habitat services identified by the study include soil protection and biodiversity preservation, and cultural services include spiritual and religious, aesthetic value and recreation and ecotourism. The study has found that the practice of community forestry has increased forest cover resulting in the perceived increased in ecosystem services provided by the community forests.

Moreover, Paudyal et al. (2017) have conducted a study on the ecosystem services and benefits of community-based forestry in Nepal. The study has identified timber, fuelwood, herbs and medicines, water provision, habitat and biodiversity, cultural and education, and forest health and stock as ecosystem services provided by the forests.

The study has concluded that the benefits of ecosystem services from community forestry are distributed to wide range of beneficiaries from local and global levels. The study has recommended the need of improved understanding of ecosystem services to shift the management of community-based forestry from narrow focus on timber and local subsistence products to more holistic set of objectives considering ecosystem services.

2.2.2 Economic Valuation of Ecosystem Services

Economic valuation demonstrates the value of ecosystem services in monetary terms which is important in creating markets, providing information for policy decisions and developing ecosystem financing mechanisms. In Nepal, ecosystem valuation studies (Baral et al., 2016; Basnyat et al., 2012; CSUWN, 2011; KC et al., 2013; Merriman et al., 2017; Peh et al., 2016; Sharma et al., 2015; Shrestha et al., 2007) have been conducted in few protected areas such as Koshi Tappu Wildlife Reserve, Bardia National Park and Shivapuri-Nagarjun National Park (Basnyat et al., 2012; KC et al., 2013; Merriman et al., 2017; Peh et al., 2016; Sharma et al., 2015; Shrestha et al., 2007) and wetlands such as Phewa Lake Area, Ghodaghodi Lake Area and Jagadishpur Reservoir (CSUWN, 2011; Baral et al., 2016).

With respect to protected areas, Shrestha et al. (2007) have estimated economic value of Koshi Tappu Wildlife Reserve (KTWR) to be USD 1.6 million per year. They have applied contingent valuation method estimating the local people's 'willingness to accept'. The authors have suggested to increase local people's economic opportunities and their engagement in management decisions to protect ecosystems of the KTWR. Likewise, Sharma et al. (2015) have estimated annual economic value of KTWR to be USD 16 million. The authors have applied combination of direct market price method and value transfer method to estimate economic value of provisioning services and regulating and cultural services. Highlighting the importance of the economic benefits generated from the ecosystem services of the KTWR for the wellbeing of the local people, the authors have emphasized the need of increasing management investment to control degradation of ecosystems. Similarly, Merriman et al. (2017) have estimated annual economic value of KTWR to be USD 0.35 million. The authors have applied Toolkit for Ecosystem Service Site-based Assessments (TESSA) to estimate the value

of ecosystem services. For economic valuation, the authors have considered provisioning services (fodder, thatch grass, fish, fuelwood, rice), cultural services (nature-based recreation) and regulating services (climate regulation). These studies show a large variation in the economic value of KTWR. It may be due to the variation in methods applied and the ecosystem services considered for valuation. Thus, selection of method is crucial for valuation so that values of ecosystem services are well captured.

Similarly, Basnyat et al. (2012) have estimated economic value of ecosystem services provided by Bardia National Park to be NPR 379 million per year. The study has adopted total economic valuation approach applying revealed price method (for direct use value), contingent valuation method (for non-use value) and benefit transfer method (for direct use, indirect use and non-use values). Recognizing the gap between economic value and government investment, the authors have suggested market-based mechanism for financing biodiversity conservation and sustainable management of natural resources.

Likewise, Peh et al. (2016) have estimated economic value of Shivapuri-Nagarjun National Park to be USD 11 million per year. The authors have applied Toolkit for Ecosystem Service Site-based Assessments (TESSA) to assess the ecosystem services and has selected climate regulation, water (water production and prevention of water sedimentation), nature-based recreation and tourism, and wood products (timber and fuelwood) for economic valuation. The authors have concluded that protected areas in Nepal, although declared specially for biodiversity conservation, have high economic and social importance. The study has identified PES mechanism as an incentive based fiscal instrument, particularly for watershed services where upstream communities, who contribute to protect watershed, should be paid by downstream beneficiaries through the mechanism.

Similarly, KC et al. (2013) have estimated the economic value of cultural ecosystem services provided by Bagmara Community Forest, in the buffer zone of Chitwan National Park, to be USD 3.8 million per year. The authors have applied contingent valuation method, through users' and visitors' Willingness to Pay (WTP), to estimate cultural services. The socio-economic variables considered by the study include gender, family size, landholding, occupation, distance to residence of the users. Out of these

variables, the authors have found significant positive correlation of WTP with family size and occupation. Moreover, Bhandari et al. (2016) have assessed the relationship between people's WTP for ecosystem services and various socio-economic attributes (sex, age, education, occupation and family income) in the Chure region of Western Nepal. The authors have observed significant positive correlation between WTP and family income. Furthermore, Chaudhary et al. (2018) have assessed access and benefits of ecosystem services and various socio-economic variables (gender, caste, income, land, livestock, education, food sufficiency, occupation) in Maipokhari, Ilam, the Ramsar Site of Eastern Nepal. The authors have observed caste, income and gender are the determinants for access to and benefits from ecosystem services.

With respect to wetlands, the then Ministry of Forests and Soil Conservation (MoFSC) through the project entitled 'Conservation and Sustainable Use of Wetlands in Nepal (CSUWN)' has developed an 'economic valuation tool for wetlands'. The project has applied the tool for economic valuation of Phewa Lake Area. The study has considered provisioning services (food, fishes, gravel, sands, water for washing, bathing, irrigation, hydropower), cultural and amenity services (tourism and recreation, boating, visiting, and paragliding) and regulating services (water purification and waste treatment) to estimate economic value. The study has estimated annual economic value of Phewa Lake Area to be USD 43.6 million using market price method and value transfer method. Likewise, CSUWN (2011) has estimated economic value of Ghodaghodi Lake Area applying the 'economic valuation tool for wetlands'. In order to estimate economic value, the study has considered provisioning services (food, materials, medicine, ornamental resources and water for bathing, washing, livestock wallowing and agriculture use), cultural and amenity services (spiritual, religious, bird watching, hiking) and regulating services (carbon sequestration, flood protection, water purification, waste management). The study has estimated annual economic value of Ghodaghodi Lake Area to be USD 0.88 million using market price method and value transfer method. The study has suggested 'payment for ecosystem services' mechanism for financing conservation of the Lake Area.

Likewise, Baral et al. (2016) have estimated economic value of ecosystem services provided by Jagadishpur Reservoir to be NPR 94.5 million per year. The authors have adopted revealed-price method for direct use values, benefit transfer methods for

indirect use values and contingent valuation method for non-use values. The study has considered fish, tortoise and edible food for estimating consumptive use value, tourism for estimating non-consumptive use value, and existence value and option value for estimating non-use value.

2.2.3 Financing Mechanisms for Ecosystem Management

Ecosystem services-based financing mechanisms are crucial for sustainable management of natural capital as they capture the value of ecosystem services to seek financing solutions. In the present research, widely used financing mechanisms such as 'Trust Funds' and 'Payment for Ecosystem Services (PES)' practiced for biodiversity conservation and natural resources management have been reviewed.

Studies on 'Trust Fund' seems lacking in Nepal. However, Kauffman (2013) has reported 'Water Trust Funds' in Ecuador as successful model for sustainable financing for watershed conservation. Moreover, BTFEC (2018) has reported 'Bhutan Trust Fund for Environmental Conservation' in Bhutan as an innovative mechanism to finance conservation programs for the long term. Bladon et al. (2014) have assessed 12 conservation related 'Trust Funds' including 'Mexican Fund for the Conservation of Nature' (Mexico), 'Bangladesh Tropical Forest Conservation Foundation' (Bangladesh), 'Phoenix Islands Protected Area Conservation Trust' (Kiribati), 'Banc d'Arguin Coastal and Marine Biodiversity Trust Fund' (Mauritania), 'Sangha Tri-National Foundation' (Cameroon, Central African Republic and Republic of Congo), 'Mesoamerican Reef Fund' (Mexico, Belize, Guatemala and Honduras), 'Caribbean Biodiversity Fund' (Caribbean Region), 'Bhutan Trust Fund for Environmental Conservation' (Bhutan), 'Yasuni-Ishpingo-Tambococha-Tiputini' (Ecuador), 'Fund for the Protection of Water' (Ecuador), 'Protected Areas Conservation Trust Fund' (Belize) and 'Fund for Environmental Action and Childhood' (Colombia). The authors have found that 'Trust Fund' ties up financial resources over the long term as it is the pool of funds potentially available to conservation at the scale required. Moreover, the authors have concluded that 'Trust Funds' as independent entities, can also have flexibility and efficiency more akin to private sector corporations than government agencies. The authors have recommended that capable implementing organization,

basic legal and financial frameworks, government support, and a group of stakeholders with a common vision are crucial to create a 'Trust Fund'.

With respect to PES, some studies (Bhatta et al., 2014; Bhatta et al., 2017; Khanal & Paudel, 2012; Khatri, 2009) have been carried out in Nepal. The PES has been initiated for some water supply schemes (Dhulikhel water supply in Kavre, Bara water supply in Bara, Pithuwa-Jutpani water supply in Chitwan), irrigation systems (Haldekhal irrigation in Kanchanpur) and watershed management (Kulekhani watershed in Makawanpur, Sardukhola watershed in Sunsari, Phewa watershed in Kaski). However, the PES schemes are very localized and small-scale. Khatri (2009) has concluded that PES in Kulekhani has provided a mechanism for transferring hydroelectricity revenue to support community development as a payment for watershed services. However, the author has observed that the PES scheme has failed to provide incentives to resource managers *viz.* community forest user groups who are the principle beneficiaries of ecosystem services. In this PES scheme, Nepal Electricity Authority, the service receiver, provides incentives to District Development Committee and undermine the role of community forest user groups. The study has highlighted the importance of institutional mechanism for the effectiveness of PES scheme.

Bhatta et al. (2014) have evaluated the successes and challenges of 10 PES-like schemes including Kulekhani hydropower (Makwanpur district of Central Nepal), Dhulikhel water supply (Kavrepalanchok district of Central Nepal), protected area buffer zones (throughout the country), Haldekhal irrigation scheme (Kanchanpur district of Western Nepal), Mohana Kailali forest corridor conservation (Kailali district of Western Nepal), REDD pilots in three selected watersheds (Chitwan, Dhading and Gorkha districts of Central and Western Nepal), Rupa Lake conservation (Kaski district of Western Nepal), Shivapuri-Nagarjun National Park (Kathmandu district of Central Nepal), water supply of Central Terai (Simara underground water, Bara district; Bara water supply, Bara district; Pithuwa-Jutpani water supply, Chitwan district), and Shardu Khola watershed management (Sunsari district of Eastern Nepal). The authors have found that there is a promising potential to establish and implement PES in ecosystem services at a larger scale, but concrete legislative and institutional mechanism are essential for making the schemes successful. Moreover, the authors have observed that Nepal has improved its ecosystem and landscape conservation through community-based natural resource

management such as community forestry, conservation areas and protected area buffer zones. However, the study has claimed that there is a limited focus on ecosystem services value in these management approaches, particularly with respect to the non-use values of ecosystem services. Bhatta et al. (2017) have recommended that input-based PES scheme is appropriate in the areas, where community relies on natural resources. The study has suggested to involve multi-stakeholders while setting PES institutions, so that service providers and receivers, and ecosystem managers will not be betrayed by the other party and PES can sustain for long time.

Furthermore, Paudyal et al. (2018) have conducted a case study to determine key elements of PES for community managed forests in the Phewa watershed of Central Nepal. The elements assessed include policy and institutional elements (PES governance, local institutions, property rights and tenure arrangement, government policy), social/human capital (pro-poor participation, livelihoods, pro-poor benefits, social value and preferences, capacity building, community characteristics, facilitating organizations), financial elements (payment structure, transaction costs, opportunity cost), and technical elements (access to information, bundling of ecosystem services, boundary of scheme, quantification and valuation, scale). Out of them, nine elements such as policy and institutional (government policy, governance, local institutions, property rights and tenure), social (livelihoods, pro-poor participation) and financial (payment structure, transaction cost, opportunity cost) were considered highly relevant while designing PES scheme for community-based forest management.

In Nepal, the policy and legal instruments relevant to financing mechanisms for ecosystem management include Forest Act 1993, National Biodiversity Strategy and Action Plan 2014-2020, Forestry Sector Strategy 2016-2025 and Forest Policy 2019. The National Biodiversity Strategy and Action Plan (2014-2020) has proposed to engage public and private sector for biodiversity funding (GoN/MoFSC, 2014). Forest Sector Strategy 2016 has envisioned a separate financing mechanism for forestry sector development (GoN/MoFSC, 2016). Moving a step further, Forest Policy 2019 has envisioned to establish a 'Forest Development Fund' for forestry sector finance (GoN/MoFE, 2019) which has been provisioned in the recent (2019) amendment of Forest Act 1993. This creates an enabling condition to develop and implement 'Trust Fund' mechanism for sustainable management of forest ecosystems.

The review of preceding works has reflected that there are limited studies on ecosystem services in Nepal. The ecosystem services studies have been carried out in few protected areas such as Koshi Tappu Wildlife Reserve (Merriman et al., 2017; Sharma et al., 2015; Shrestha et al., 2007), Shivapuri-Nagarjun National Park (Peh et al., 2016) and Bardia National Park (Basnyat et al., 2012), wetlands such as Phewa Lake Area (CSUWN, 2011), Ghodaghodi Lake Area (CSUWN, 2011), Beeshazar and Associated Lake Area (Khanal, et al., 2014), Jagadispur Reservoir (Baral et al., 2016) and Maipokhari Ramsar Site (Chaudhary et al., 2018), and watersheds such as Jhiggu Khola watershed (Oort et al., 2015) and Koshi River Basin (Bhatta et al., 2015). However, researches on the valuation of ecosystem services of protected forest regime in the country seems lacking. The ecosystem services researches (Basnyat et al., 2012; Bhatta, et al., 2014; Birch et al., 2014; Khanal, et al., 2014; Oort et al., 2015; Paudyal et al., 2015; Paudyal et al., 2017; Peh et al., 2016; Sharma et al., 2015) have observed that ecosystem services and their values are not adequately recognized in decision-making process of the country. Moreover, most of the studies (Basnyat et al., 2012; Bhatta et al., 2014; Birch et al., 2014; CSUWN, 2011; Khanal et al., 2014; Peh et al., 2016; Oort et al., 2015; Paudyal et al., 2017) have urged the need of ecosystem financing for sustainable management of ecosystems. Furthermore, current policy and legal instruments of Nepal (Forest Act 1993, National Biodiversity Strategy and Action Plan 2014-2020, Forestry Sector Strategy 2016-2025 and Forest Policy 2019) has created enabling conditions for creating financing mechanisms such as ‘payment for ecosystem services’ and ‘trust fund’.

CHAPTER 3

3. MATERIALS AND METHODS

3.1 Study Area

Panchase Protected Forest (PPF) lies in the central part of Nepal between 28˚10'55" and 28˚15'56" North latitude and 83˚48'03" and 83˚49'53" East longitude. It outspreads from 900 meter to 2,517 meter above mean sea level covering an area of 5,775.7 hectares in the Mid-hills physiographic zone (DoF, 2017; Figure 5; Figure 6). The Panchase Protected Forest lies at the juncture of Kaski, Syangja and Parbat districts of Gandaki State spreading into nine Village Development Committees (VDC) (Figure 7; Table 7).

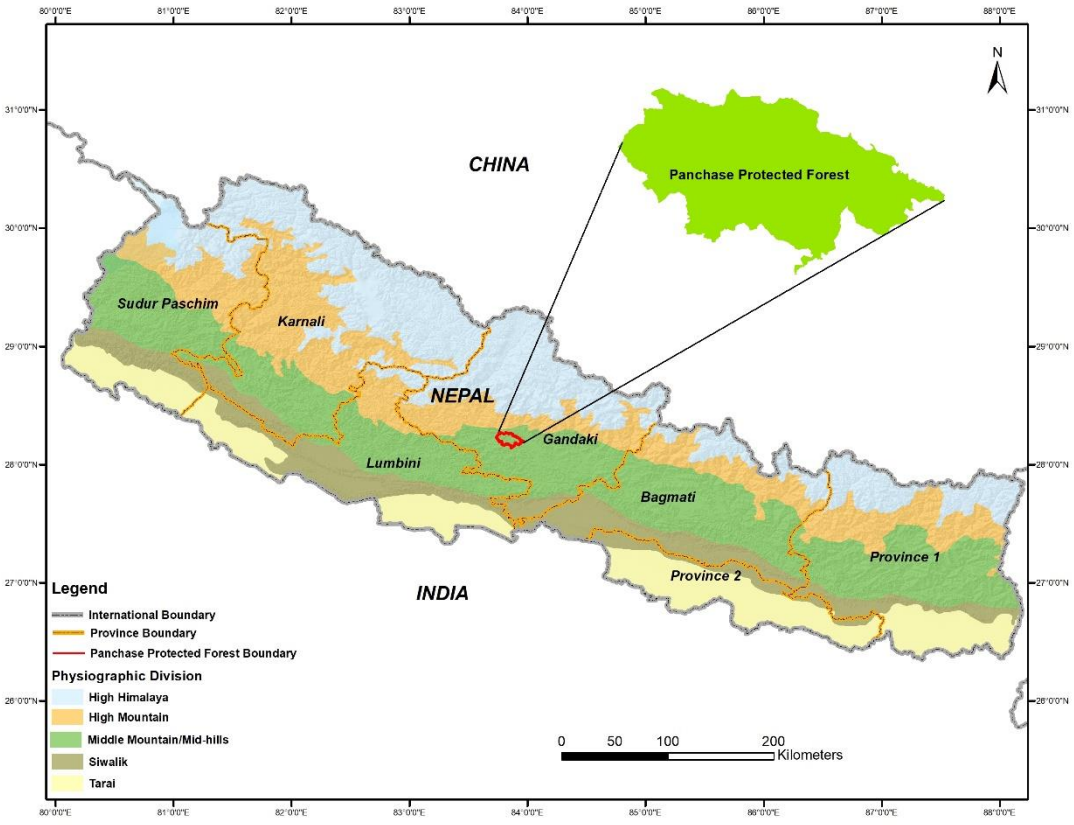

Figure 5: Location of Panchase Protected Forest in Mid-hills physiographic zones

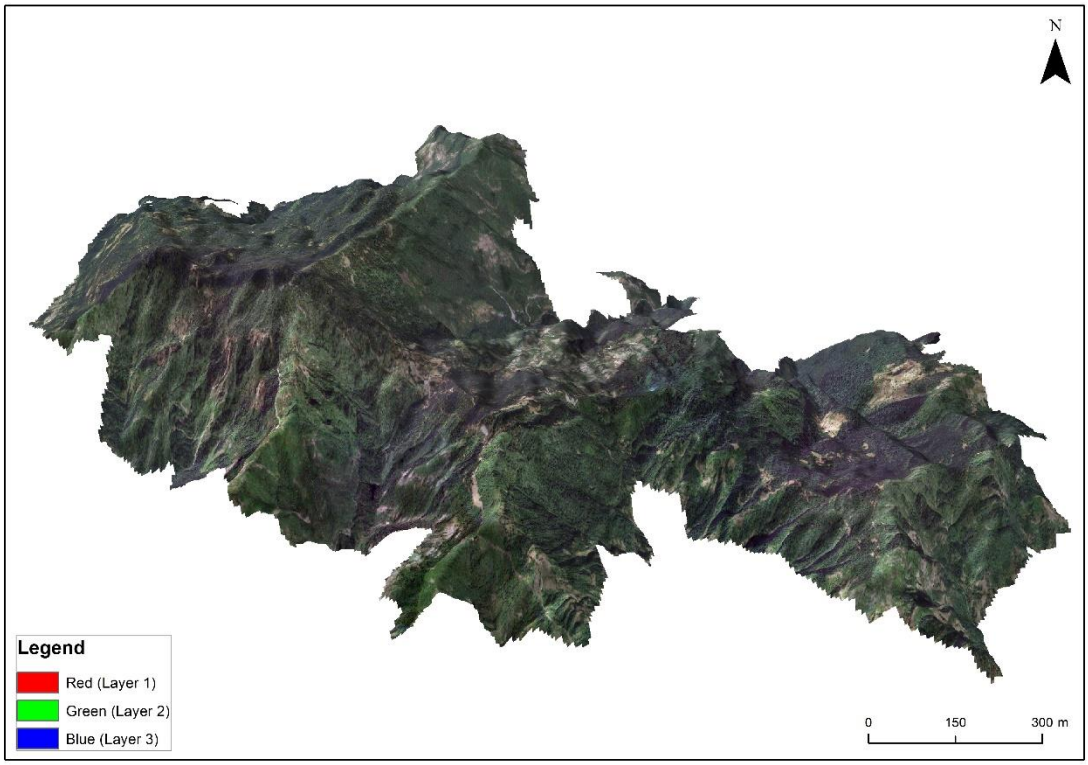

Figure 6: Three-dimensional map of Panchase Protected Forest

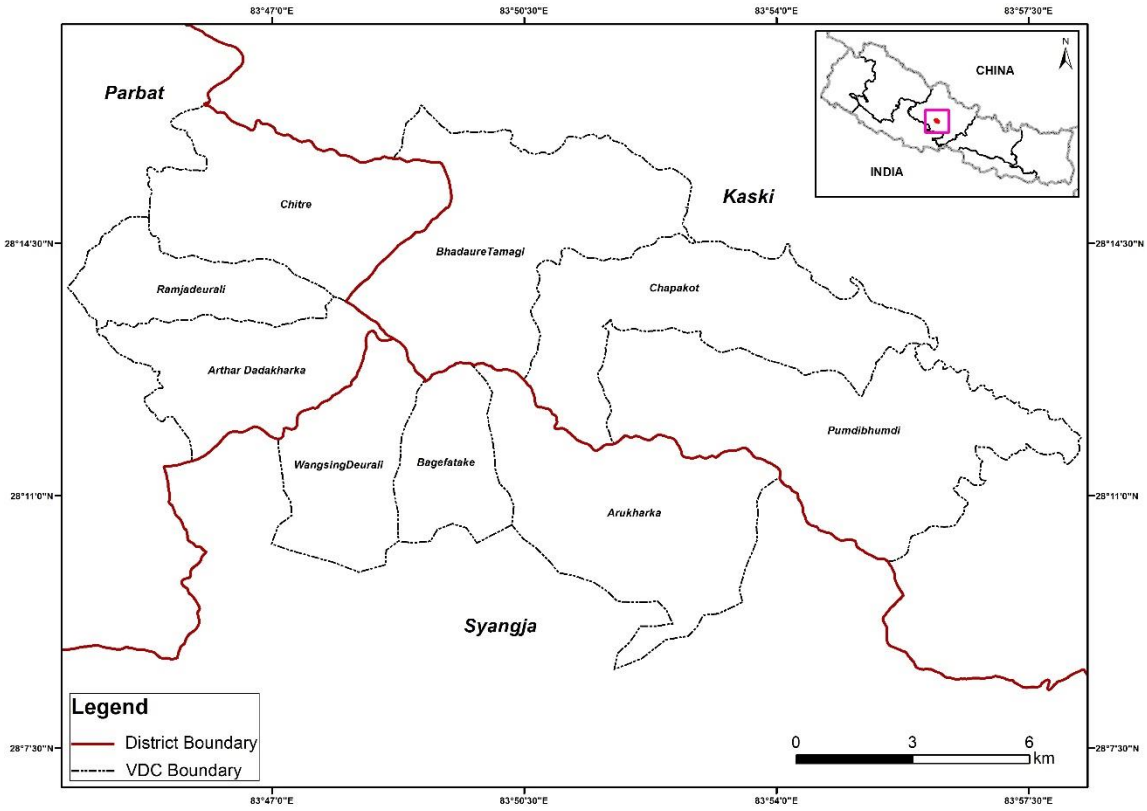

Figure 7: Administrative units in Panchase Protected Forest before restructuring

In the current political restructuring of Nepal, the VDC structure has been altered into municipal structure. Based on the new structure, the Panchase Protected Forest lies within four rural municipalities, one municipality and one metropolitan city (Figure 8; Table 7). Since the restructuring process completed in 2017 after the research design and field works, this study has adapted the then political structures.

Table 7: Administrative units in Panchase Protected Forest before and after restructuring

District	Before restructuring (VDC)*	After restructuring (Municipality)
Kaski	Bhadaure Tamagi	Annapurna Rural Municipality
		Pokhara Lekhnath Metropolitan City
	Chapakot	Pokhara Lekhnath Metropolitan City
	Pumdibhumdi	Pokhara Lekhnath Metropolitan City
Parbat	Arther Dadakharka	Kushma Municipality
	Chitre	Modi Rural Municipality
	Ramja Deurali	Modi Rural Municipality
Syangja	Aarukharka	Phedikhola Rural Municipality
	Bangefadke	Phedikhola Rural Municipality
	Bansing Deurali	Aandhikhola Rural Municipality

* Adapted in the present study

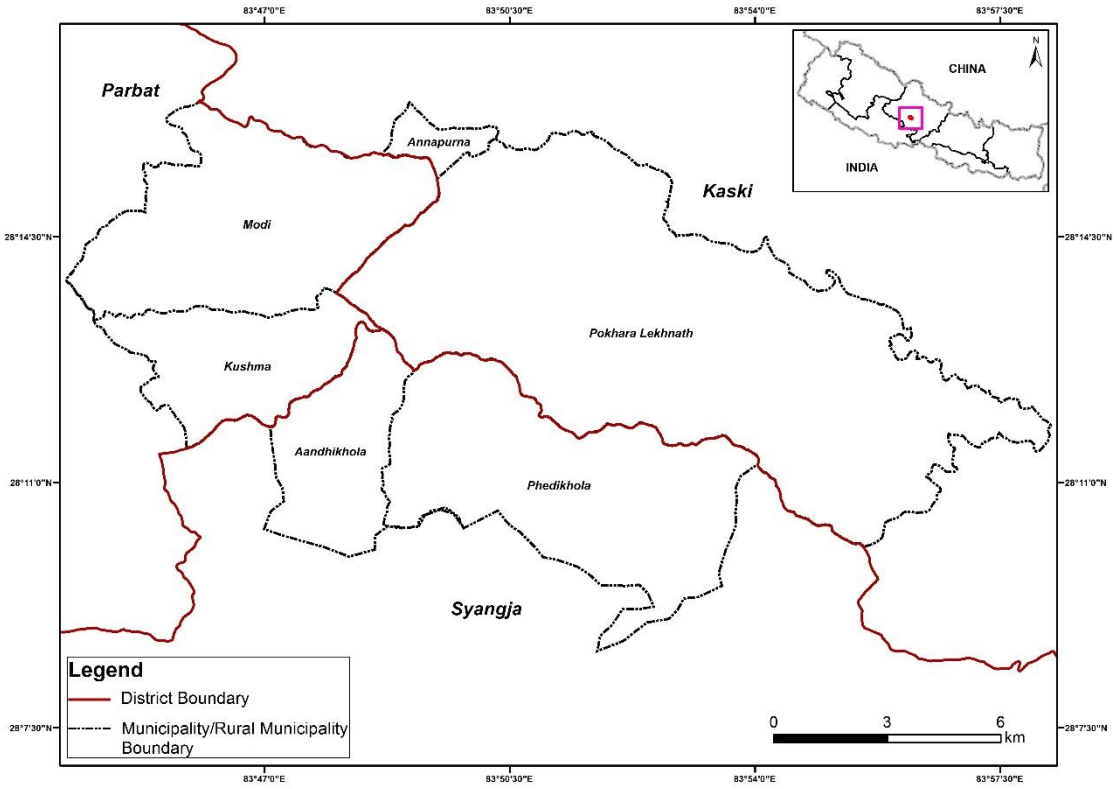

Figure 8: Administrative units in Panchase Protected Forest after restructuring

3.1.1 Forests

Out of 35 forest types of Nepal, Panchase Protected Forest represents five forest types *viz.* Alder Forest, Chirpine-Broad Leaved Forest, Oak Laurel Forest, Lower Temperate Oak Forest, and *Schima-Castanopsis* Forest (DoF, 2017; Table 8). Among the forest types, Panchase Protected Forest is dominated by *Schima-Castanopsis* forest, a representative forest type of the Mid-hills physiographic zone of Nepal. Out of the total 5,775.7 ha area of PPF, *Schima-Castanopsis* forest covers 3,413.5 ha (59.10%), followed by Lower Temperate Oak forest covering 886.6 ha (15.35%), Chirpine-Broadleaved forest accounting 834.6 ha (14.45%), East Himalayan Oak Laurel forest accounting 507.0 ha (8.78%) and Alder forest covering 134.0 ha (2.32%) (Table 8).

Table 8: Forest types in Panchase Protected Forest

Forest Type	Area (ha)	Area (%)
Alder Forest	134.0	02.32
Chir Pine-Broad Leaved Forest	834.6	14.45
East Himalayan Oak Laurel Forest	507.0	08.78
Lower Temperate Oak Forest	886.6	15.35
Schima-Castanopsis Forest	3,413.5	59.10
Total	5,775.7	100.00

Source: DoF (2017)

Panchase Protected Forest is an important forest for biodiversity and natural ecosystems. It harbors 589 species of plants, 262 species of birds and 24 species of mammals (DoF, 2012; Kunwar & Upadhya, 2013). Panchase Protected Forest is also culturally important where thousands of pilgrims visit the religious temples and their surroundings within the protected forest. Considering the environmental and cultural significance, Government of Nepal declared the forest of the Panchase region as Protected Forest in February 2012 (DoF, 2012). Panchase Protected Forest has been divided into 'Core area', the innermost region and 'Fringe area', the surrounding of the 'Core area' for the purpose of conservation and management (Figure 9). The 'Core area' has been proposed for protection and conservation, whereas the 'Fringe area' has been proposed for sustainable use and management. In the 'Fringe area', 108 'community forests' with an area of 4,215.42 hectares (73% of the total area of the Panchase Protected Forest) have been handed over to the local communities for

protection, management and sustainable use (DoF, 2017; Appendix III). The adjacent settlements around the 'Fringe area' have been delineated as an 'Impact zone' of Panchase Protected Forest (Figure 9).

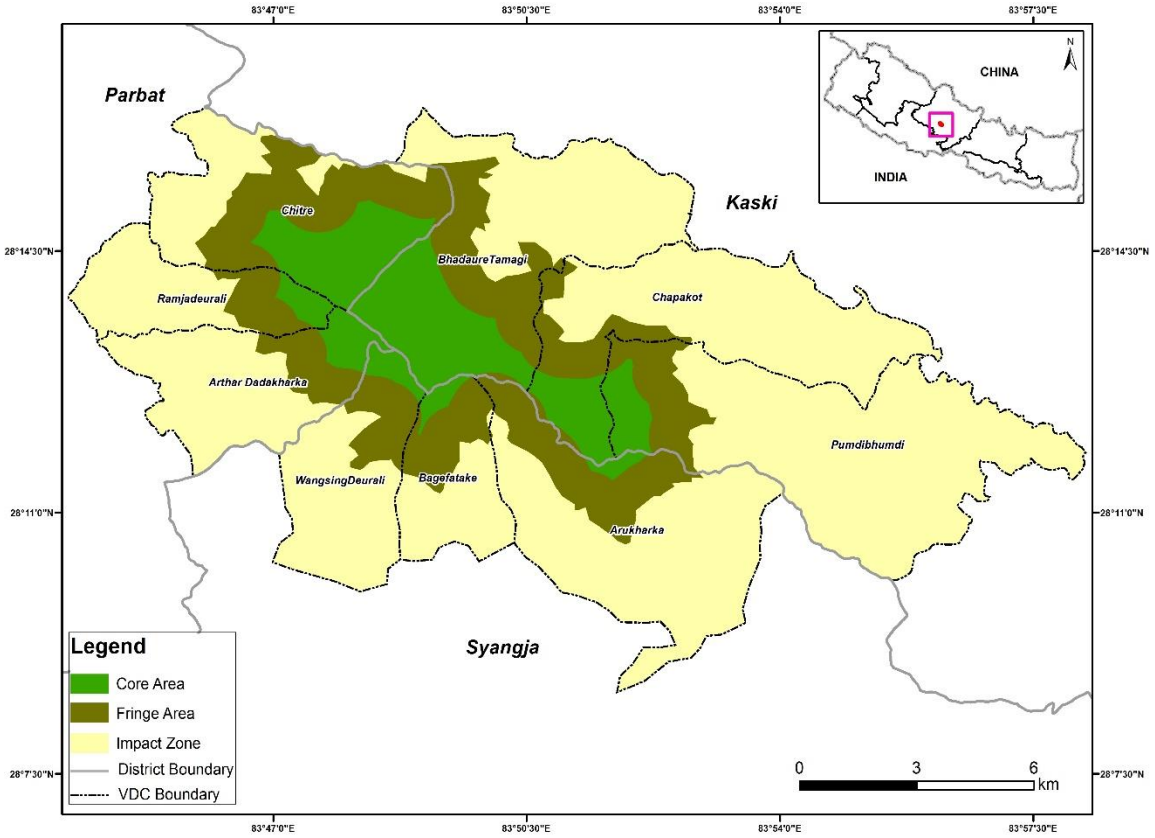

Figure 9: Management zones of Panchase Protected Forest

3.1.2 Socio-economic Characteristics

The 'Impact zone' of the Panchase Protected Forest covers settlements within the then nine Village Development Committees (VDC)- three VDCs from each Kaski, Parbat and Syangja districts. According to CBS (2011), there are 7,039 households with total 27,482 populations in the 'Impact zone' of the Panchase Protected Forest (Table 9). Out of the nine VDCs, Pumdi Bhumdi VDC of Kaski district has the largest population (7,391 persons) followed by Bansing Deurali VDC of Syangja district (3,546 persons) and Bangefadke VDC of Syangja district hosts the lowest population (1,102 persons). The average family size in the 'Impact zone' of the Panchase Protected Forest is 3.90 (Table 9). The biggest family size is in Bansing Deurali VDC with 4.10 persons followed by Pumdi Bhumdi VDC with 4.02 persons and the smallest family

size is in Arther Dadakharka VDC with 3.72 persons (Table 9). Moreover, the 'Impact zone' of the Panchase Protected Forest is dominated by women population of 15,383 followed by men population of 12,099 with a male: female ratio of 0.8 (Table 10). Furthermore, by age group, the population with the age between 10 and 14 years have the highest population with 3,468 persons followed by age group between 15 and 19 years with 3,449 persons (Table 11). The average years of schooling (year of education in school and university) of the people within the 'Impact zone' of the Panchase Protected Forest is 6.12 years having 6.18 years for male and 6.06 years for female (Table 10).

Table 9: Population and family size in the 'Impact zone' of Panchase Protected Forest

District	VDC	No of household	Human population	Family size
Kaski	Bhadaure Tamagi	875	3,272	3.73
	Chapakot	680	2,637	3.88
	Pumdi Bhumdi	1,837	7,391	4.02
Parbat	Arthar Dadakharka	703	2,618	3.72
	Chitre	435	1,740	4.00
	Ramja Deurali	486	1,779	3.66
Syangja	Arukharka	878	3,397	3.87
	Bangefadke	281	1,102	3.92
	Bansing Deurali	864	3,546	4.10
Total		7,039	27,482	3.90

Source: CBS (2011)

Table 10: Population and schooling years by gender in the 'Impact zone' of Panchase Protected Forest

		Population			Years of schooling		
District	VDC	Male	Female	Total	Male	Female	Total
Kaski	Bhadaure Tamagi	1,483	1,789	3,272	6.37	5.92	6.15
	Chapakot	1,151	1,486	2,637	6.37	6.16	6.26
	Pumdi Bhumdi	3,358	4,033	7,391	6.76	6.32	6.54
Parbat	Arthar Dadakharka	1,121	1,497	2,618	5.54	5.70	5.62
	Chitre	767	973	1,740	5.85	5.78	5.81
	Ramja Deurali	783	996	1,779	6.76	6.58	6.67
Syangja	Arukharka	1,462	1,935	3,397	6.51	6.43	6.47
	Bangefadke	461	641	1,102	5.73	6.05	5.89
	Bansing Deurali	1,513	2,033	3,546	5.72	5.57	5.64
Total		12,099	15,383	27,482	6.18	6.06	6.12

Source: CBS (2011)

Table 11: Population by age group in the 'Impact zone' of Panchase Protected Forest

Age Group	Kaski			Parbat			Syangja			Total
	Bhadaure Tamagi	Chapakot	Pumdi Bhumdi	Arthar Dadakharka	Ramja Deurali	Chitre	Arukharka	Bangefadke	Bansing Deurali	
00-04	291	207	532	178	114	186	268	88	330	2,194
05-09	322	245	686	237	151	152	327	114	416	2,650
10-14	407	368	923	340	199	223	422	133	453	3,468
15-19	366	351	997	328	255	213	428	123	388	3,449
20-24	245	223	631	195	136	131	292	61	239	2,153
25-29	215	169	522	142	64	93	179	91	228	1,703
30-34	180	134	405	118	78	83	166	70	180	1,414
35-39	201	133	427	137	72	86	187	48	158	1,449
40-44	188	176	559	175	128	111	242	64	200	1,843
45-49	105	85	284	79	68	57	92	39	117	926
50-54	173	103	345	132	91	70	168	50	152	1,284
55-59	155	118	276	130	104	82	157	55	193	1,270
60-64	119	101	238	137	95	93	141	55	175	1,154
65-69	105	70	200	109	71	63	130	43	114	905
70-74	85	66	144	79	67	40	101	28	89	699
75-79	58	47	118	55	38	29	43	21	61	470
80-84	36	29	64	33	28	21	35	13	34	293
85-89	14	11	28	11	14	2	10	3	8	101
90-94	4	1	9	3	5	4	9	1	9	45
95-100	3	0	3	0	1	1	0	2	2	12
Total	3,272	2,637	7,391	2,618	1,779	1,740	3,397	1,102	3,546	27,482

Source: CBS (2011)

3.1.3 Protected Forest Management Institution

In order to protect and manage Panchase Protected Forest, an institution *viz.* 'Protected Forest Council' has been established (Figure 10). The Panchase Protected Forest Council (PPFC) is composed of a chairperson, a member secretary and nine executive members. The chairperson and the executive members of the council are elected from the district units of PPFC. However, the member secretary is nominated by the Government of Nepal among the officials from the Department of Forests. The district unit of the PPFC is formed by the representatives of Community Forests, Religious Forests, District Federation of Community Forestry Users, and Civil Society Organizations from the 'Impact zone' of the protected forest. The district unit of PPFC is composed of a chairperson and eight members. Representatives of municipality and sub-division forest office are the defacto members of the district unit of PPFC. The PPFC has a secretariat with 16 staff members including a member secretary, two forest officers, two forest rangers, one technical assistant, one administrative assistant, one forest technician, three community mobilizers, three forest guards and two office assistants.

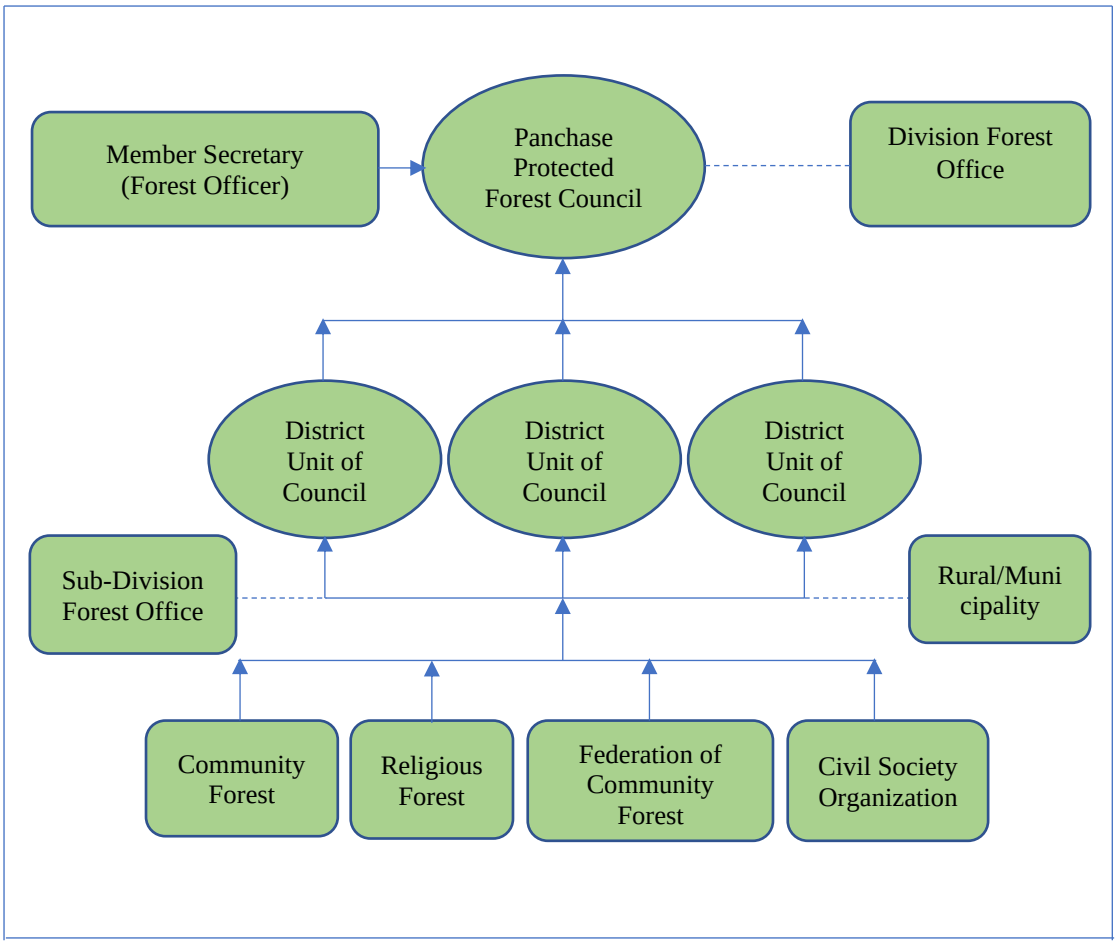

Figure 10: Organogram of Panchase Protected Forest Council (Adapted from DoF, 2017)

3.2 Methods

In order to achieve the purpose of the present study, multiple methods have been used (Figure 11). The ecosystem services provided by Panchase Protected Forests were identified through transect walk observations, Focus Group Discussions (FGD), Key Informant Interviews (KII) and Expert Consultations (EC). Similarly, the economic values of ecosystem services provided by the protected forest were estimated by adopting the Total Economic Valuation (TEV) framework. Both use values (consumptive use, non-consumptive use and indirect use) and non-use values (option value, existence value, altruist value and bequest value) of ecosystem services were considered for the economic valuation. For estimating consumptive use values and indirect use values, Market Price Method (MPM) was applied whereas, for estimating non-consumptive use value, Travel Cost Method (TCM) was applied. Likewise, for

estimating non-use values, Contingent Valuation Method (CVM) was applied. The distribution of benefits of the ecosystem services was assessed through FGD, KII and EC (Figure 11). Moreover, to identify financing mechanisms for sustainable management of ecosystems, FGD, KII and EC were applied (Figure 11). The present study has also used secondary sources of information with due acknowledgements.

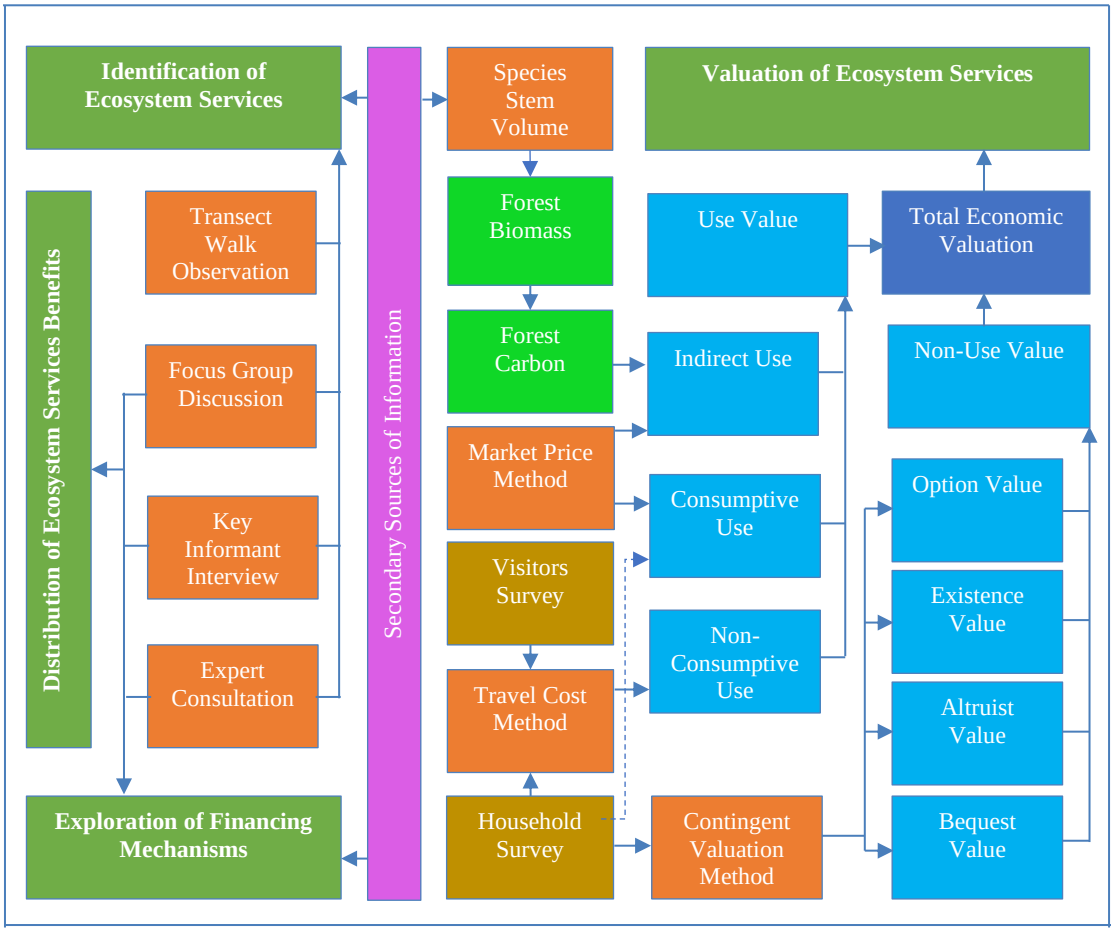

Figure 11: Methodological framework

3.2.1 Identification of Ecosystem Services

In order to identify provisioning services, cultural services and habitat services provided by Panchase Protected Forests, transect walk observations was performed. Transect walk was made along the trekking routes of Panchase Protected Forest with the participation of local people in March 2015. The routes followed during the transect walk include Bhadaure-Panchase, Sidane-Bhanjyang, Pumdibhumdi-Bhanjyang, Bangefadke-Panchase, Arther-Bhanjyang and Chitre-Panchase (Figure 12). During the

transect walk observation, a checklist (Appendix IV) was used to capture information from field observations.

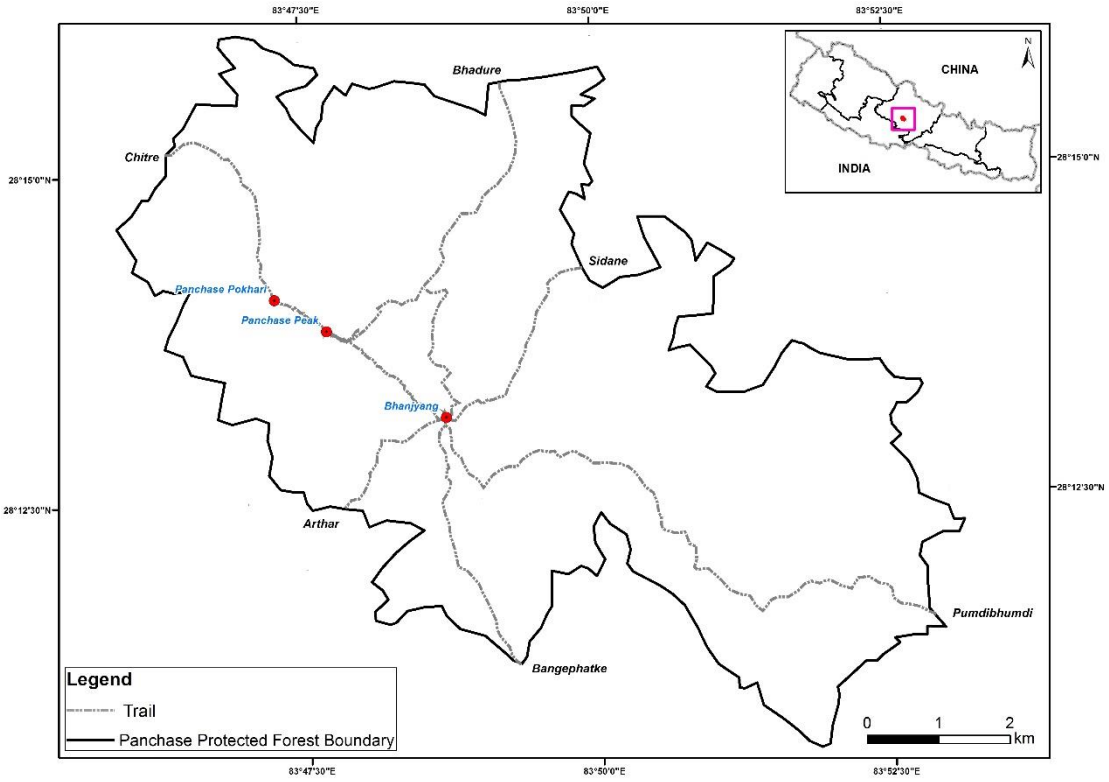

Figure 12: Trekking routes in Panchase Protected Forest used for transect walk

Moreover, to identify ecosystem services and their availability in Panchase Protected Forests, Focus Group Discussion (FGD) was applied. FGD is a useful technique to gather data when the researcher is interested to exhume more deeply into an area of interest (Baker, 1998) avoiding any cultural and social issues among the participants (Corbetta, 2003). In the present study, three FGDs were conducted in three Village Development Committees (VDC), one from each Kaski, Parbat and Syangja districts. Among the VDCs, Bhadaure Tamangi, Chitre and Bangefadke were selected respectively from Kaski, Parbat and Syangja districts, for the FGDs. A checklist (Appendix IV) was used for conducting the FGDs. In total, 39 representatives of the local community participated in the FGDs conducted in March 2015.

Likewise, to identify regulating services and cultural services, 'Key Informants' were interviewed. Cultural and religious sites and events, natural heritages, recreation sites, trekking routes and strategic locations for visitors were identified through the

interviews. Panchase Protected Forest Council members, community forest user group members and hoteliers were selected as the key informants. In total, 10 Key Informants (Appendix V) were interviewed from the 'Impact zone' of the Panchase Protected Forest, in March 2015 and April 2017. To collect the required information systematically, a checklist (Appendix IV) was used for conducting the interview. Moreover, to identify regulating services, nine experts (Appendix V) from various academic and professional organizations such as the Institute of Forestry of Tribhuvan University, the Division Forest Office, the Panchase Protected Forest Office, the Ministry of Forests and Environment, the World Wide Fund for Nature (WWF) and the International Center for Integrated Mountain Development (ICIMOD) were consulted.

3.2.2 Economic Valuation of Ecosystem Services

The economic values of ecosystem services provided by the protected forest were estimated by adopting Total Economic Valuation (TEV) framework (TEEB, 2010; Figure 13). The TEV is the sum of the economic values of all services that the ecosystem generates (TEEB, 2010). The TEV framework is a widely used monetary valuation of ecosystem services as the flow of benefits from nature to humans (Pandeya et al., 2016). For the application of TEV, the use values were further classified into direct use values (consumptive and non-consumptive) and indirect use values (Figure 13). Similarly, non-use values were further classified into option value, existence value, altruist value and bequest value (Figure 13).

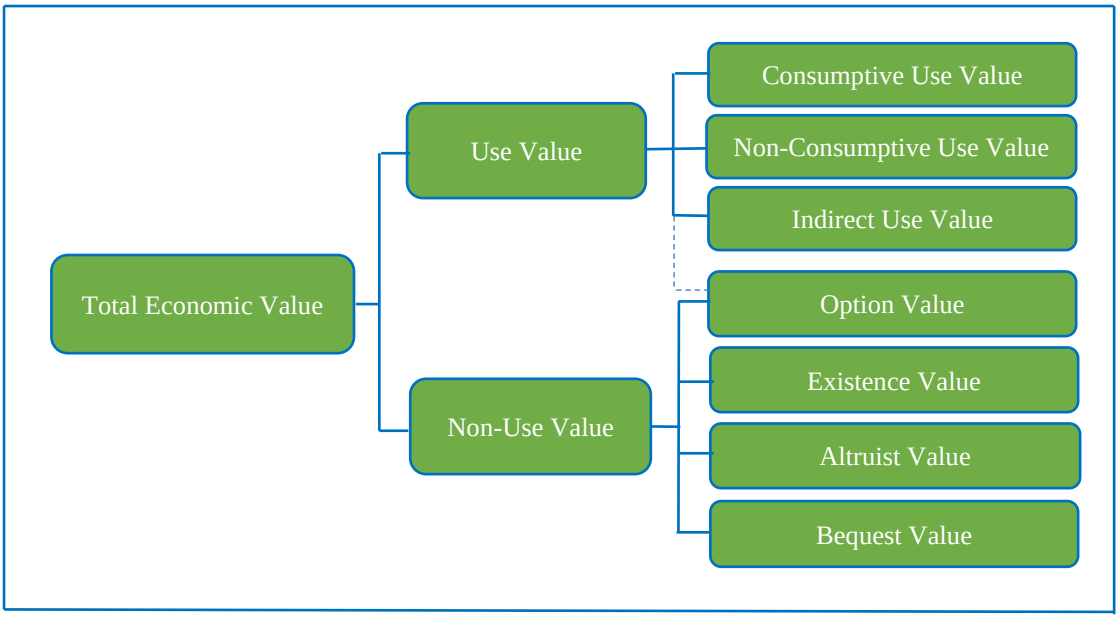

Figure 13: Total Economic Valuation framework (Adapted from TEEB, 2010)

In order to calculate the total economic value, all use and non-use values were summed following the TEV approach (TEEB, 2010).

$$V_{TE} = V_{CU} + V_{NCU} + V_{IU} + V_{NU}$$

Where,

V_{TE} = total economic value

V_{CU} = consumptive use value

V_{NCU} = non-consumptive use value

V_{IU} = indirect use value

V_{NU} = non-use value

3.2.2.1 Consumptive Use Value

In the present study, the consumptive use value of ecosystem services was calculated applying market price method. In well-functioning competitive markets, preferences and marginal costs of production are reflected in a market price and these can be taken as accurate information to value the commodities (TEEB, 2010). The market price-based approaches are the most often used methods to obtain the value of provisioning services, as the commodities produced by provisioning services are often bought and

sold on markets (TEEB, 2010). The Consumptive Use Value of Panchase Protected Forest was calculated using following formula.

$$V_{CU} = (Q_T \times P_T) + (Q_F \times P_F) + (H_W \times P_W)$$

Where,

V_{CU} = consumptive use value

Q_T = quantity of timber extracted from the forest

P_T = unit price of timber

Q_F = quantity of fuelwood extracted from the forest

P_F = unit price of fuelwood

H_W = number of households using water from the forest

P_W = unit price of water to be paid by household

The quantity of provisioning services such as timber and fuelwood extracted from the protected forest were quantified through a questionnaire survey (Chapter 3.2.3, Appendix VI). Annual extraction of provisioning services per household was averaged and multiplied by the number of total households within the 'Impact zone' of the Panchase Protected Forest. To calculate the economic value, the quantity of the provisioning services was multiplied by the price of the services (NPR 7,769.23 m^{-3} for timber and NPR 6,000 ton^{-1} for fuelwood) at local market. Similarly, for drinking water valuation, average annual tariff to be paid by a household to water supply committee (NPR 300 $year^{-1}$) was used.

3.2.2.2 Non-Consumptive Use Value

Non-consumptive use value of ecosystem services was calculated by applying Travel Cost Method (TCM). The TCM is a well-known method that uses the costs that visitors bear during travelling recreational site (Haque et al., 2011). It is a survey technique where questionnaire is prepared and administered to estimate the recreation value (Das, 2013). In the present study, two types of non-consumptive use values *viz.* religious value and recreational value were considered to determine the total value of cultural and amenity services of the protected forest. The non-consumptive use value was calculated using following formula (adapted from Haque et al., 2011).

$$V_{NCU} = N_F\{E_T + (N_D \times E_L)\} + N_P\{E_T + (N_D \times OC)\}$$

Where,

V_{NCU} = non-consumptive use value

N_F = number of foreign visitors

E_T = transportation expenses per trip

N_D = number of days spent in the protected forest

E_L = living expenses (per day)

N_P = number of pilgrims

OC = opportunity cost

Religious value was estimated based on the number of pilgrims visit to the Panchase Protected Forest for religious or cultural motives. The number of days spent in the protected forest as a pilgrim and transportation costs were captured through questionnaire survey (Chapter 3.2.3; Appendix VI) conducted in April-May 2017. The number of days was converted into the monetary value using the average wage rate of the study area (NPR 500) as an opportunity cost of time. Opportunity cost of time and transportation cost were taken into account to calculate religious value of an individual pilgrim. The total annual religious value was calculated multiplying the value of individual pilgrim by total number of pilgrims in a year.

Recreational value, which is associated with the tourists visit to the Panchase Protected Forest for recreation, was estimated by a visitors' survey using semi-structured questionnaires (Appendix VII). In total, 24 foreign visitors were surveyed, in April 2017, in Bhanjyang, the most strategic place along the trekking route to Panchase peak. Since there was no formal visitors' record keeping system in the study area, consultations were made with the hoteliers in Bhanjyang and Panchase peak to estimate total number of visitors. Due to lack of information on domestic visitors, only foreign visitors were considered to estimate recreational value. Cost of accommodation and food, and transportation costs were taken into account to calculate individual recreation value. Then the individual value of sampled visitors was totaled and averaged to calculate the average recreational value of an individual visitor. The total annual recreational value was calculated multiplying average recreational value of individual visitor by the total number of visitors in a year.

3.2.2.3 Indirect Use Value

Indirect use value of ecosystem services provided by the Panchase Protected Forest was calculated by estimating the value of carbon sequestration by the protected forest. Carbon estimation was made using forest inventory data of 2012 and 2017 available in the five-year management plans of Panchase Protected Forest (DoF, 2012; DoF, 2017). Species wise stem volume presented in the management plans was used to calculate biomass of the forest. Stem volume was converted into stem biomass by multiplying stem volume by wood density (HMGN, 1988).

$$B_F = V_{St} \times D_W$$

Where,

B_F = forest biomass

V_{St} = stem volume

D_W = wood density

Biomass of branches and leaves was calculated applying species specific branch-stem ratio and leaf-stem ratio in accordance with the Master Plan for Forestry Sector, Nepal (HMGN, 1988). DFRS (2015a) and Sharma and Pukkala (1990) have also used the similar methods to calculate biomass of the forests of Nepal. Above ground biomass of the protected forest was calculated by adding stem biomass, branch biomass and foliage biomass.

$$B_{AG} = B_{St} + B_{Br} + B_{Fo}$$

Where,

B_{AG} = above ground biomass

B_{St} = stem biomass

B_{Br} = branch biomass

B_{Fo} = foliage biomass

Below ground biomass was calculated with an averaged root-to-shoot biomass ratio of 0.25 (Intergovernmental Panel on Climate Change [IPCC], 2006). The total biomass was calculated by summing above ground biomass and below ground biomass.

$$B_T = B_{AG} + B_{BG}$$

Where,

B_T = total biomass

B_{AG} = above ground biomass

B_{BG} = below ground biomass

The biomass was converted into carbon by multiplying 0.47 (IPCC, 2006) and the total carbon was converted into carbon dioxide equivalent (CO_2e) by multiplying the carbon by the conversion factor of 3.7 (IPCC, 2006).

$$CO_{2e} = B_T \times C_{factor} \times CO_{2\ factor}$$

Where,

CO_2e = carbon dioxide equivalent

B_T = total biomass

C_{factor} = carbon factor (0.47)

$CO_{2\ factor}$ = carbon dioxide factor (3.7)

The World Bank has agreed with the Government of Nepal to purchase forest carbon from the Terai Arc Landscape of Nepal, through the emission reduction program, at the rate of USD 5 per ton of CO_2e (MoFE, 2018). To calculate the economic value of carbon sequestration, total tons of CO_2e sequestrated by the Panchase Protected Forests was multiplied by the rate of USD 5.

3.2.2.4 Non-Use Value

Non-use value of ecosystem services provided by the Panchase Protected Forest was calculated by applying Contingent Valuation Method (CVM). The CVM is a survey based stated preference method most frequently used to estimate the non-use values of ecosystem services by creating a hypothetical market (Haque et al., 2011; Spangenberg & Settele, 2010; TEEB, 2010). The CVM survey uses questionnaire to ask people to express their preferences in terms of Willingness to Pay (WTP) to conserve the ecosystems services (CSUWN, 2011). Economic value is often defined in strict economic terms as aggregate WTP for the ecosystem services (Costanza et al., 2017).

The CVM survey was conducted, in April-May 2017, developing a structured questionnaire (Chapter 3.2.3; Appendix VI), among the people living in the 'Impact zone' of the Panchase Protected Forest. The non-use value of the protected forest was calculated using following formula through WTP expressed for all option value, existence value, altruist value and bequest value.

$$V_{NU} = V_O + V_E + V_A + V_B$$

Where,

V_{NU} = non-use value

V_O = option value

V_E = existence value

V_A = altruist value

V_B = bequest value

In order to estimate WTP, labor contribution was used as a payment vehicle as it is more realistic in a subsistence economy, where most of the economic transactions are non-monetized (Rai & Scarborough, 2012). In this process, respondents were asked to measure their annual WTP in terms of their labor contribution. The WTP for option value, existence value, altruist value and bequest value were separately asked, and summed-up to calculate the total WTP of a respondent. Before asking the questions, the respondents were made aware of the four types of non-use values *viz.* option value, existence value, altruist value and bequest value. The labor contribution was converted into the monetary value using the average daily wage rate of the study area (NPR 500) as an opportunity cost of unskilled labor. The WTP of all respondent households was then totaled and divided by the total number of sampled households to calculate the average WTP of a household. The average value was multiplied by the total number of households within the study area to calculate the total WTP.

In order to understand the relationship between WTP and various socio-economic variables, a multiple regression equation was developed. The socio-economic variables chosen in the present study include gender, education, family size, landholding, livestock holding, family income, distance to forest, and position on forest management executive committee (Table 12). As multiple linear model is a commonly used regression model (Greene, 1993) that expresses relationship between dependent and

independent variables (Gujarati, 2003), a multiple linear regression equation was used in the present study. Baral et al. (2008) have also used similar model to estimate the value of ecotourism in Annapurna Conservation Area. The equation of the multiple linear regression model is expressed as;

$$Yi = \beta + \sum \beta ij\ Xij + ei$$

Where,

Y = dependent variable (WTP)

β = regression coefficient

X = independent variables (socioeconomic variables)

e = error

The regression model is described as the following equation, which analyzes the relationship between WTP and socioeconomic variables. Expected sign and hypothesis has been set for each socioeconomic variable (Table 12).

$$WTP = \beta_0 + \beta_1\ GENDER + \beta_2\ EDUCATION + \beta_3\ FAMILYSIZE + \beta_4\ LANDHOLDING + \beta_5\ LIVESTOCK + \beta_6\ FAMILYINCOME + \beta_7\ DISTANCEFOREST + \beta_8\ POSITIONFOREST + error$$

Table 12: Socio-economic variables and their description

Variables	Expected sign	Description	Assumption/hypothesis
Gender (GENDER)	+	Sex of respondent (male = 1, female = 0)	WTP of men is higher than of women
Education (EDUCATION)	+	Education of respondent (number of schooling years)	The higher the education the higher the WTP
Family size (FAMILYSIZE)	+	Number of people in respondent's family	The higher the size of the family, the higher the WTP
Landholdings (LANDHOLDING)	+	Land area owned by respondent's family	The larger the landholdings of the family, the higher the WTP
Livestock (LIVESTOCK)	+	Number of livestock unit owned by respondent's family	The larger the livestock holding of the family, the higher the WTP
Family income (INCOME)	+	Annual family income of respondent	The higher the family income, the higher the WTP
Distance to forest (DISTANCEFOREST)	-	Distance to forest from respondent's home	The longer the distance to forest, the lower the WTP
Position in forest management executive committee (POSITIONFOREST)	+	Position of respondent in forest management executive committee (position holder =1, other =0)	WTP of position holder is higher than of non-position holder

Normality and collinearity of the socio-economic variables were checked through 'normal probability plot' and 'scatter plots'. Multicollinearity effect between the socio-economic variables was examined through 'condition index'. F-statistics and coefficient of determinants (R^2) value was used to check the suitability of the model. The data were analyzed using Statistical Package for the Social Sciences (SPSS, IBM Version 23).

3.2.3 Sampling and Questionnaire Survey

In order to collect required data for CVM and TCM, and to determine quantity of provisioning services provided by the forest, questionnaire survey was applied in the 'Impact zone' of Panchase Protected Forest. Sample size was determined following Krejcie and Morgan (1970).

$$n = \frac{N\,Z^2P(1-P)}{Nd^2 + Z^2P(1-P)}$$

Where,

n = sample size

Z = Z-value (1.96 for 95% confidence level)

P = population proportion (0.5 for the maximum sample size)

d = degree of accuracy (maximum acceptable error: 0.05)

N = population size (total number of households)

Out of the total 7,039 households in the 'Impact zone' of the Panchase Protected Forest, 364 (5%) households were selected at a confidence level of 95% with a marginal error of 5% for the questionnaire survey. The sample size was distributed proportionally in all nine Village Development Committees of the 'Impact zone' of the protected forest (Table 13). After determining the sample size in each Village Development Committee, simple random sampling method was adopted to select the household to be sampled. A survey (in-person interview) was conducted within the sampled household in April-May 2017 using structured questionnaire (Appendix VI). Before finalizing, the questionnaire was pre-tested in March 2015. Household heads were chosen as the respondents for this questionnaire survey.

Table 13. Sample size distribution

District	Village Development Committee	Total Households	Sample size
Kaski	Bhadaure Tamagi	875	45
	Chapakot	680	35
	Pumdi Bhumdi	1,837	95
Parbat	Arthar Dadakharka	703	36
	Chitre	435	22
	Ramja Deurali	486	25
Syangja	Arukharka	878	45
	Bangefadke	281	15
	Bansing Deurali	864	45
Total		7,039	364

3.2.4 Distribution of Benefits from Ecosystem Services

In order to assess the distribution of benefits derived from the ecosystem services, focus group discussions, consultations with the experts and key informant interviews were adopted. The beneficiaries of ecosystem services were categorized into local, sub-national, national and global levels (Table 14). Local level beneficiaries include people from the 'Impact zone' of Panchase Protected Forest. The villages within the 'Impact zone' of the protected forest include Bhadaure Tamagi, Chapakot and Pumdi Bhumdi, of Kaski district; Arther-Dandakharka, Chitre and Ramjhadeurali of Parbat district; and Arukharka, Bangefadke and Bansing Deurali of Syangja district. Sub-national level beneficiaries include people from Syangja, Parbat and Kaski districts beyond the 'Impact zone'. People of the downstream urban areas such as Pokhara, Kusma, Baglung and Putalibazar have also been considered as sub-national level beneficiaries. National level beneficiaries are the stakeholders beyond sub-national level beneficiaries within Nepal and global level beneficiaries include people from international community and visitors.

Table 14: Beneficiary categories of ecosystem services provided by PPF

Level	Geographic coverage
Local	Beneficiaries from 'Impact zone' of Panchase Protected Forest
Sub-national	Beneficiaries from Kaski, Parbat and Syangja districts beyond 'Impact zone'
National	Beneficiaries beyond local and sub-national level but from Nepal
Global	International community and visitors

3.2.5 Financing Mechanisms for Ecosystem Management

In order to identify ecosystem-based financing mechanisms, existing institutions in the region were mapped, and legal and policy instruments were reviewed. Institutions of this region were mapped employing FGDs. In order to understand the policy and legal provisions of the ecosystem financing, documents such as Forest Act 1993, National Biodiversity Strategy and Action Plan 2014-2020, Forestry Sector Strategy 2016-2025 and Forest Policy 2019 were reviewed. Moreover, consultation was made with the 10 key informants (Appendix V) in the Panchase Protected Forest region and with nine

experts (Appendix V) from various academic and professional organizations such as the Institute of Forestry of Tribhuvan University, the Division Forest Office (Kaski, Parbat, Syangja), the Panchase Protected Forest Office, the Ministry of Forests and Environment, WWF and ICIMOD. A checklist (appendix IV) was followed for conducting FGDs and expert consultations.

CHAPTER 4

4. RESULTS AND DISCUSSION

The benefits obtained from the Panchase Protected Forest has been described with respect to the various ecosystem services, their economic values and possible financing mechanisms for the sustainability of the ecosystems and their services.

4.1 Ecosystem Services

Ecosystem services provided by Panchase Protected Forest have been discussed under the categories of provisioning, regulating, habitat, and cultural and amenity services following TEEB (2010) classification.

4.1.1 Provisioning Services

Panchase Protected Forest has been providing six types of provisioning services including food, medicines, raw materials, energy sources, ornamental resources and water (Table 15).

Table 15: Provisioning services provided by Panchase Protected Forest

Services	No of species	Name of the species used
Food	35	*Asparagus racemosus, Bambusa nepalensis, Bauhinia variegata, Berberis aristata, Castanopsis indica, Choerospondias axillaris, Cinnamomum glaucescens, C. tamala, Dendrocalamus strictus, Dioscorea bulbifera, D. deltoidei, Diplazium esculentum, Diploknema butyracea, Emblica officinalis, Ficus auriculata, F. carica, F. glaberrima, F. lacor, F. neriifolia, F. roxburghii, F. semicordata, Hydnum repandum, Juglans regia, Morus alba, Myrica esculenta, Nephrolepis auriculata, N. cordifolia, Picrasma javanica, Rhus chinensis, Rubus ellipticus, Streblus asper, Termitomyces eurhizus, Tinospora sinensis, Urtica dioica* and *Viburnum mullaha*

Table 15: Contd…

Services	No of species	Name of the species used
Medicines	40	*Aconitum bisma, Acorus calamus, Aloe vera, Amomum aromaticum, Artimisia indica, Asparagus racemosus, Bauhinia variegata, Berberis aristata, Bergenia ciliata, Brassaiopsis hainla, Centella asiatica, Cinnamomum glaucescens, Cuscuta reflexa, Dactylorhiza hatagirea, Emblica officinalis, Eurya acuminata, Justicia adhatoda, Litsea monopetala, Lycopodium clavutum, Lyonia ovalifolia, Myrica esculenta, Osyris wightiana, Paris polyphylla, Persea duthiei, Rhododendron arboreum, Rhus chinensis, Rubia manjith, Rubus ellipticus, Sapium insigne, Semecarpus anacardium, Swertia chirayita, Taxus wallichiana, Terminaia chebula, T. bellirica, Tribulus terrestris, Urtica dioica, Viscum album, Vitex negundo, Woodfordia fruticosa and Zanthoxylum armatum*
Raw materials	22	*Abies spectabilis, Alnus nepalensis, Arundinaria species, Bambusa nepalensis, Castanopsis indica, C. tribuloides, Daphne bholuwa, Daphniphyllum himalense, Dendrocalamus strictus, Edgeworthia gardneri, Girardinia diversifolia, Juglans regia, Michelia champaca, Pinus roxburghii, P. wallichiana, Quercus glauca, Q. lamelossa, Q. semicarpifolia, Rhododendron arboreum, R. arbatum, Schima wallichii and Taxus wallichiana*
Energy sources	17	*Abies spectabilis, Alnus nepalensis, Castanopsis indica, C. tribuloides, Daphniphyllum himalense, Engelhardia spicata, Eurya cerasifolia, Lyonia ovalifolia, Pinus roxburghii, P. wallichiana, Quercus glauca, Q. lamelossa, Q. semicarpifolia, Rhododendron arboreum, R. barbatum, Schima wallichii* and *Symplocos racemosa*
Ornamental resources	119	*Lycopodium clavutum*, 5 species of Rhododendrons and 113 species of orchids
Water		Lakes, spring sources and 29 streams

Food

Panchase Protected Forest has been providing food for local people through various species of plants. A total of 35 plant species were found to be used as food (Table 15) in the form of leaves, shoots, fruits, and seeds. The common plant species used as food include *Bauhinia variegata, Berberis aristata, Castanopsis indica, Choerospondias axillaris, Dioscorea deltoides, Diploknema butyracea, Emblica officinalis, Ficus*

semicordata, Morus alba, Myrica esculenta, Rubus ellipticus and *Urtica dioica* (Bhandari et al., 2018a). Though, the protected forest is rich in wild foods, there seems no specific information available in terms of yields, distribution and seasonality of the products (GoN/DoF/UNDP, 2014). The present study doesn't include animals and their parts as provisioning services (food) because wild animals are protected and are not allowed to harvest.

Medicines

Panchase Protected Forest has been found as a good source of medicinal plants. A total of 40 medicinal plants from the protected forest have traditionally been using for medicine (Table 15). The common plant species used in the medicines include *Acorus calamus, Aloe vera, Artimisia indica, Asparagus racemosus, Berberis aristata, Emblica officinalis, Justicia adhatoda, Paris polyphylla, Rubia manjith, Swertia chirayita, Terminalia bellirica, T. chebula* and *Zanthoxylum armatum* (Bhandari et al., 2018a). Medicinal plants such as *Asparagus racemosus, Paris polyphylla* and *Swertia chirayita* are the most valuable species in this area due to their high market price (Chikanbanjar, 2015). However, detailed data on the status and consumption of the medicinal plants seems lacking. This study doesn't include animals and their parts as provisioning services (medicine) because wild animals are protected and are not allowed to harvest.

Raw Materials

The present study has found that timber is one of the most common raw materials extracted from the Panchase Protected Forest. This study has estimated that 1,954.88 m^3 of timber are extracted from the protected forest annually with an average extraction of 0.28 m^3 per household (Table 16). A total of 16 tree species have been found to be used as timber (Table 15). The common tree species used as timber include *Abies spectabilis, Alnus nepalensis, Castanopsis indica, Daphniphyllum himalense, Juglans regia, Pinus roxburghii, P. wallichiana, Quercus glauca, Q. lamellosa, Q. semicarpifolia, Rhododendron arboreum, R. barbatum and Schima wallichi* (Bhandari et al., 2018a). Similarly, *Arundinaria species, Bambusa nepalensis* and *Dendrocalamus strictus* were found to be widely used as construction materials as well as for making baskets and handicrafts. Moreover, *Daphne bholuwa* and *Edgeworthia gardneri* were found to be used for making Nepali-handmade paper, whereas *Girardinia diversifolia* was found to be used as fiber for making nets. Construction materials such as sand,

gravel and stones have also been extracted from the river streams within the protected forest mostly for local use. The streams and rivers are potential for mining sands and gravels that also contribute to the reduction of siltation in Phewa Lake downstream (Kanel, 2015; GoN/DoF/UNDP, 2014). However, no systematic data were available on the quantity of the sands, gravels and stones.

Table 16: Timber and fuelwood extracted from Panchase Protected Forest

Ecosystem services	Unit	Quantity of timber (annual)	
		Average (per household)	Total
Timber	m^3	0.28	1,954.88
Fuelwood	ton	1.21	8,537.39

Energy Sources

The present study has observed that fuelwood is the major source of energy in this region for cooking and heating. Left-over biomass from tree species is used as fuelwood. This study has estimated that 8,537 tons of fuelwood is extracted from the protected forest annually with an average extraction of 1.21 tons per household (Table 16). A total of 17 tree species from Panchase Protected Forest have been used as fuelwood (Table 15). The major tree species used as fuelwood in the study area include *Alnus nepalensis, Castanopsis indica, Daphniphyllum himalense, Engelhardia spicata, Eurya cerasifolia, Lyonia ovalifolia, Rhododendron arboreum, Schima wallichi* and *Symplocos racemosa* (Bhandari et al., 2018a). High consumption of these species has been attributed to their high burning efficiency (Chikanbanjar, 2015). The present study has found increased availability of fuelwood after implementing community-based forest management, which contradicts to the findings of Oort et al. (2015) who has reported a decreased availability of fuelwood because of strict regulation of forest product extraction in Koshi River Basin of Eastern Nepal. Charcoal has been still in use by occupational castes for local use in this region albeit it is in the decreasing trend. The species mainly used to produce charcoal include *Castanopsis indica* and *Schima wallichii.* However, all the tree species used for fuelwood and timber have also been found to be used in making charcoal in this region.

Ornamental Resources

Panchase Protected Forest has been observed as a source of ornamental plants in this region. The commonly used ornamental plants include *Lycopodium clavatum, Rhododendron species* and orchid (Table 15). In total, 113 species of orchids, including two endemic species, have been reported from Panchase Protected Forest (DoF, 2012). The local people has been using these ornamental plants in decorating their homes, gardens and gates, whereas the hotel entrepreneurs have been using in decorating their hotels, yards and gardens.

Water

The present study has observed that the Panchase Protected Forest is a source of drinking water and water for irrigation in this region. In total, 29 streams have been originated from Panchase Protected forest contributing as the tributaries of Harpankhola, Phusrekhola, Adhikhola and Modikhola, the major streams in this region (Figure 14; Table 17). The local communities rely on these streams and spring sources for drinking water and irrigation. The present study has observed that all 7,039 households in the 'Impact zone' and many downstream households have been using the streams originated from the Panchase Protected Forest for drinking water. Moreover, about 550 hectares of land in the 'Impact zone' have been irrigated by the streams and rivers originated from the protected forests (GoN/DoF/UNDP, 2014).

Table 17: Rivers and their tributaries originated from Panchase Protected Forest

District	River	Tributary rivers (streams)	
		No.	Name
Kaski	Harpankhola	9	Chharchharekhola, Chharchhareparikhola, Tajekhola, Sidhanekhola, Krelokhola, Naulekhola, Hadikhola, Kuprekhola, Marsekhola
	Phusrekhola	3	Bhangerekhola, Dhabakhola, Tuisekhola,
Syangja	Aadhikhola	11	Kunekhola, Bukekhola, Nilirahakhola, Lunikhola, Ranguwakhola, Kanchhakhola, Nunthekkhola, Budhakhola, Adherikhola, Thotnekhola, Kalchekhola
Parbat	Modikhola	6	Sadhekhola, Lwakarkhola, Soprekhola, Jarekhola, Kupichhaharakhola, Lidikhola
Total		29	

Data source: DoS/HMGN (1997)

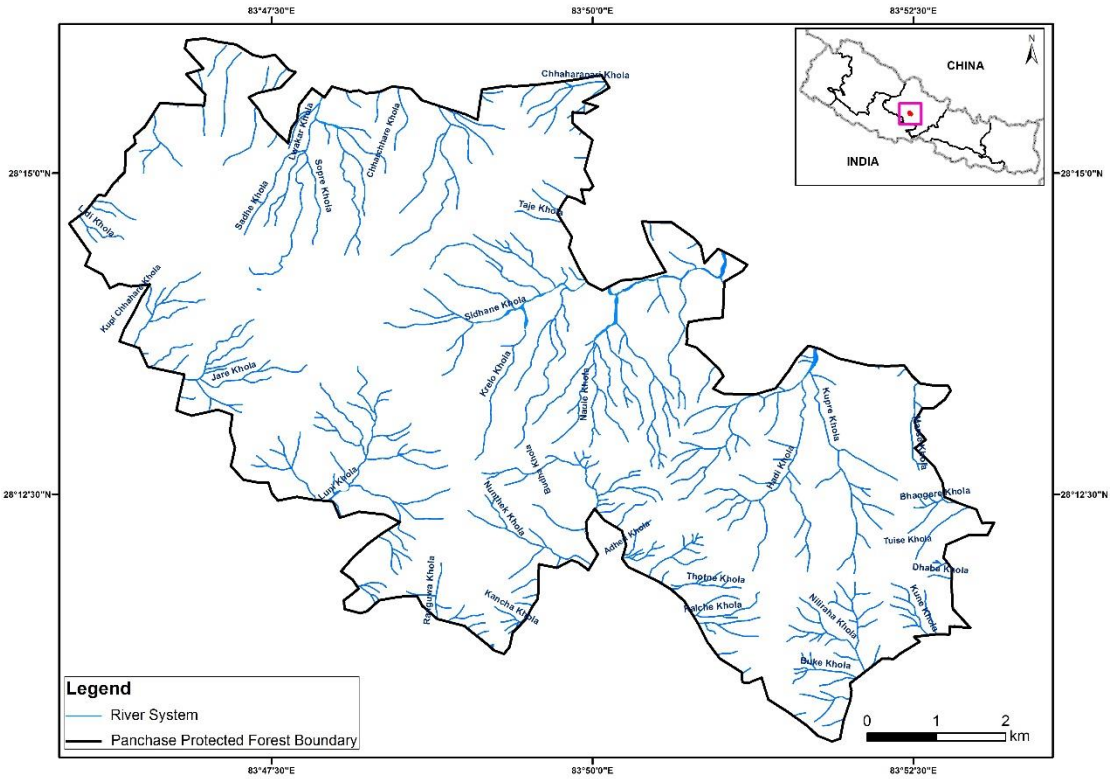

Figure 14: River systems of Panchase Protected Forest (Data source: DoS/HMGN, 1997)

In Panchase Protected Forest, there seems lack of preceding studies on ecosystem services for comparison with the present work. However, few studies have been carried out in other forests and ecosystems of Nepal. For example, Khanal et al. (2014) have reported 31 species of medicinal plants, 17 species of fruits, 15 species of fodder and 12 species of timber in Beeshajari Lake Area, in the buffer zone of Chitwan National Park in the Central Terai of Nepal. The present study shows, more plant species have been used in Panchase Protected Forest compared to Beeshajari Lake Area. It may because of the diversity of plants due to physiographic variation, high dependency of local people on forest resources and limited alternative options available for livelihoods in Panchase Protected Forest.

4.1.2 Regulating Services

Panchase Protected Forest has been providing six types of regulating services including water flow regulation, erosion prevention, water purification, soil fertility maintenance, air quality regulation and climate regulation (Table 18).

Table 18: Regulating services provided by Panchase Protected Forest

Service	Description
Water flow regulation	Headwater source for streams/rivers; regulates runoff, surface flow and base flow, control floods; groundwater recharge
Erosion prevention	Soil retention due to vegetation cover and intercepting rain, stabilize stream banks by sediment retention
Water purification	Maintains soil porosity, filter toxic and other substances
Soil fertility maintenance	Decomposition of leaf litters, branches, roots and stems; regulates nutrient cycling; soil formation process
Air quality regulation	Acts as sink by capturing dusts
Climate regulation	Sequestrates carbon, regulates micro-climate, temperature and precipitation

The Panchase Protected Forest is a headwater source for rivers such as Harpankhola, Phusrekhola, Aandhikhola and Modikhola. The Harpankhola is the major sources of water for Phewa Lake in the downstream of the protected forest. Being a part of the Ramsar site 'Pokhara Valley Lake Cluster', the Phewa Lake is ecologically and economically important at local, national and global scale. Likewise, Aandhikhola and Modikhola are tributaries of Kaligandaki River, and Phusrekhola is a tributary of Seti River in the downstream. Both Kaligandaki River and Seti River are tributaries of Gandaki River, one of the four major river systems of Nepal. Moreover, Panchase Lake, located just beneath the peak of the Panchase Mountain,and numbers of spring sources originated from the protected forests are contributing to recharge water in the downstream. Since the quantitative data on the contribution to water recharge by the Panchase Lake and the spring sources seems lacking, further assessment is needed.

Likewise, Panchase Protected Forest contributes in regulating surface-flow and preventing erosion. The vegetation cover within the protected forest intercepts rains through canopy and branches and absorbs water through root systems. The root systems also contribute to keep soil porous. Water is then stored in porous soils and then slowly released into surface water and ground water. Through this process, the Panchase Protected Forest maintains base-flow and recharges groundwater resulting in continuous flow of streams originated from this region (GoN/DoF/UNDP, 2014). Moreover, through decomposition of leaf litters, branches, roots and stems, the protected forest has been contributing to improve soil quality. Kalu et al. (2015) have reported soil quality of Panchase Protected Forest better than the pasturelands and the cultivated lands in the adjacent areas of the protected forest.

Furthermore, the Panchase Protected Forest has been contributing to improve air quality of the region by capturing dusts particles, and carbon dioxide from the atmosphere and releasing oxygen during photosynthesis process. Moreover, climate regulation is one of the important services provided by Panchase Protected Forest by sequestrating atmospheric carbon. The present study has estimated that Panchase Protected Forest has been sequestrating 24,948.56 tons (4.32 tons ha^{-1}) of carbon annually (Chapter 4.2.1.3).

4.1.3 Habitat Services

Panchase Protected Forest has been providing two types of habitat services including life cycle maintenance and genetic resources maintenance (Table 19). The protected forest is a habitat for 589 species of plants, 262 species of birds and 24 species of mammals (DoF, 2012; Kunwar & Upadhya, 2013). Among the plants, five species of rhododendrons, 107 species of medicinal plants, 113 species of orchids (including two endemic species), 98 species of ferns and 56 species of fungi have been recorded in the Panchase Protected Forest (DoF, 2012; Kunwar & Upadhya, 2013). The enriched habitat of the protected forest is contributing to protect gene pool. Panchase Protected forest is also a habitat for various endemic floral species such as *Asparagus racemosus, Arisaema tortosum, Berberis aristata, Cissampelos pareira, Cleistocalyx operculatus, Emblica officinalis, Ficus neriifolia,* and *Reinwardtia indica* (GoN/DoF/UNDP, 2014).

Table 19: Habitat services provided by Panchase Protected Forest

Service	Description
Life cycle maintenance	589 species of plants, 262 species of birds and 24 species of mammals
Genetic resource maintenance	Endemic floral species: *Asparagus racemosus, Arisaema tortosum, Berberis aristata, Cissampelos pareira, Cleistocalyx operculatus, Emblica officinalis, Ficus neriifolia,* and *Reinwardtia indica*

4.1.4 Cultural and Amenity Services

Panchase Protected Forest has been providing three types of cultural and amenity services including recreation and tourism, cultural and religious, and cognitive services (Table 20).

Table 20: Cultural and amenity services provided by Panchase Protected Forest

Service	Description
Recreation and tourism	Landscape, natural heritages
Cultural and religious	Panchase Lake, Siddhababa, Panchadham, cultural festivals (*Balachaturdasi)*, cultural heritages
Cognitive	Educational: students and researchers

Recreation and tourism

The Panchase Protected Forest has been providing landscape panorama and natural heritage, and thus it is an attractive destination for domestic and foreign visitors. The present study has estimated that 3,600 foreign visitors visit the Panchase Protected Forest annually (Table 21, Bhandari et al., 2018b). Foreign visitors visit the Panchase Protected Forest mostly during autumn (September-November) and spring (March-May). There is a huge potential of tourism in Panchase Protected Forest as it is very close to Pokhara city, one of the major tourist hubs of Nepal (CSUWN, 2011). The magnificent views of Mount Dhaulagiri, Mount Manaslu, Mount Machhchhapuchhre and Mount Annapurna can be seen from the Panchase Protected Forest. It is becoming a destination connected by roads from Pokhara (Kaski) and Kushma (Parbat) linking the villages of the "Impact zone' of the protected forest. The trekking routes in Panchase Protected Forest are: 1) Bhadaure-Bhanjyang-Panchase; 2) Sidane-Bhanjyang-Panchase; 3) Pumdibhumdi-Bhanjyang-Panchase; 4) Arthar-Bhanjyang-Panchase; and

5) Bangefadke-Bhanjyang-Panchase; and 6) Chitre-Panchase (Figure 12). Bhanjyang has been observed as the main junction from where tourist climb up to the top of the Panchase hill. In the 'Impact zone' of the protected forest, homestay tourism has been promoted over time, which are mainly used by domestic visitors.

Table 21: Number of visitors in Panchase Protected Forest

Ecosystem services	No of visitors			
	Domestic (Local)	Domestic (Sub/National)	Foreigner	Total
Religious	19,005	6,335	-	25,340
Recreational	-	-	3,600	3,600

Religious

The present study has revealed that Panchase Protected Forest is rich in religious and cultural heritages. The Siddhababa Temple at the top of the hill and Panchase Lake, just beneath the peak, are the most popular religious and cultural destinations. In this region, *Balachaturdasi* (the 14th day of the dark-half of the lunar calendar in the month of late November or early December) has been observed as the most famous festival celebrated every year. On that auspicious day, the worshippers sow '*Satbij*' (seven types of cereal's seeds) along the path as they travel. The seeds are sown with the belief of securing a better place in heaven for the soul of deceased relatives. These rituals are also carried out to appease the restless souls of departed ones who were not properly cremated. The present study has estimated 25,340 pilgrims visit the Panchase Protected Forest annually during this festival (Table 21; Bhandari et al., 2018b). Out of them, 19,005 (75%) are from the 'Impact zone' and 6,335 (25%) are from other parts of the country. According to the local people, majority of the pilgrims are Hindus.

Cognitive

In the recent years, Panchase Protected Forest has been growing as a cognitive site. According to the local people, school and university students and researchers from different parts of the country visit to observe and learn various dimensions of nature and people, and their interrelationships. The Central Department of Environmental Science of Tribhuvan University has accomplished 14 master's dissertations and eight case studies conducted in the Panchase Protected Forest (CDES-TU, 2015). Moreover, six master's and nine bachelor's dissertations have been conducted in various

dimensions of Panchase Protected Forests by the students of Institute of Forestry of the Tribhuban University (IoF Library, 2018; Appendix VIII).

Inferences on ecosystem services

Summarizing the results, with respect to the ecosystem services, the present study has revealed that the Panchase Protected Forest has been providing 17 types of ecosystem services with six provisioning, six regulating, two habitat and three cultural and amenity services. The provisioning services provided by the protected forest include food, medicines, raw materials, energy sources, ornamental resources and water. Likewise, the regulating services include water flow regulation, erosion prevention, water purification, soil fertility maintenance, air quality regulation and climate regulation. Moreover, the habitat services provided by the protected forest include life cycle maintenance and genetic resources maintenance, and the cultural and amenity services include recreation and tourism, cultural and religious, and cognitive resources (Table 22).

Table 22: Ecosystem services provided by Panchase Protected Forest

Category of services	No of services	Type of ecosystem services
Provisioning	6	Food, medicines, raw materials, energy sources, ornamental resources, water
Regulating	6	Water flow regulation, erosion prevention, water purification, soil fertility maintenance, air quality regulation, climate regulation
Habitat	2	Life cycle maintenance, genetic resource maintenance
Cultural and amenity	3	Recreation and tourism, cultural and religious, cognitive
Total	17	

From Panchase Protected Forest, 35 species of plants have been found to be used as food, 40 species as medicines, 22 species as raw materials, 17 species as energy sources and 119 species as ornamental resources. Likewise, the Panchase Protected Forest has been annually providing 1,954.88 m^3 of timber and 8,537.39 tons of fuelwood for the local communities. Moreover, 29 streams originated from the Panchase Protected Forest are the source of drinking water for 7,039 households. Additionally, the streams are the source of water for downstream rivers and lakes. The protected forest has been

sequestrating 29,948.56 tons of atmospheric carbon (equivalent to 92,309 tons of CO_2) per annum. Likewise, the Panchase Protected Forest has been providing habitat for 875 species (589 species of plants, 262 species of birds and 24 species of mammals) maintaining their genetic resources and life cycle. Moreover, the forest has been providing recreation for 3,600 foreign visitors and 25,340 pilgrims per annum.

4.2 Economic Valuation of Ecosystem Services

In order to estimate the total economic value of provisioning, regulating, habitat, and cultural and amenity services provided by the Panchase Protected Forest, both use value and non-use value of ecosystem services have been considered in accordance with TEEB (2010).

4.2.1 Use Value

The use value of ecosystem services considered in this study includes both direct use value and indirect use value. The direct use value includes consumptive and non-consumptive use. In order to estimate the economic value of consumptive use, provisioning services such as timber, fuelwood and drinking water have been considered. Non-timber forest products have been omitted because of lacking data of their collection and sale. Likewise, to estimate the economic value of non-consumptive use, cultural and amenity services have been considered. Furthermore, to estimate the economic value of indirect use, carbon sequestration value has been considered.

4.2.1.1 Consumptive Use Value

The present study has found the annual economic value of the consumptive use of the ecosystem services of the Panchase Protected Forest to be NPR 68.52 million (USD 685,212) (Figure 15; Table 23). This is the combined value of timber, fuelwood and drinking water, which was found respectively to be NPR 15.19 million (USD 151,880), NPR 51.22 million (USD 512,238) and NPR 2.11 million (USD 21,094) (Figure 15; Table 23). The economic value of timber and fuelwood is based on the extracted quantity (1,954.88 m^3 of timber and 8,537 tons of fuelwood) and the price in the local market (NPR 7,769.23 m^{-3} for timber and NPR 6,000 ton^{-1} for fuelwood) (Table 23).

Regarding the economic value of drinking water, the total households (7,039), who consume drinking water from spring sources and streams originated from the protected forest, were multiplied by the average annual payment rate of a household for drinking water (NPR 300) in the region (Table 23). As this study has considered the drinking water services only within the 'Impact zone' of the protected forest and has excluded downstream settlements from the calculation, it underestimates the economic value.

Table 23: Consumptive use value of Panchase Protected Forest

Services	Unit	Quantity	Unit Cost (NPR)	Amount	
				NPR (million)	USD*
Timber	m^3	1,954.88	7,769.23	15.19	151,880
Fuelwood	ton	8,537	6,000	51.22	512,238
Water	household**	7,039	300	2.11	21,094
Total				68.52	685,212

* 1 USD = NPR 100 (as of January 2018), **household as consumption unit

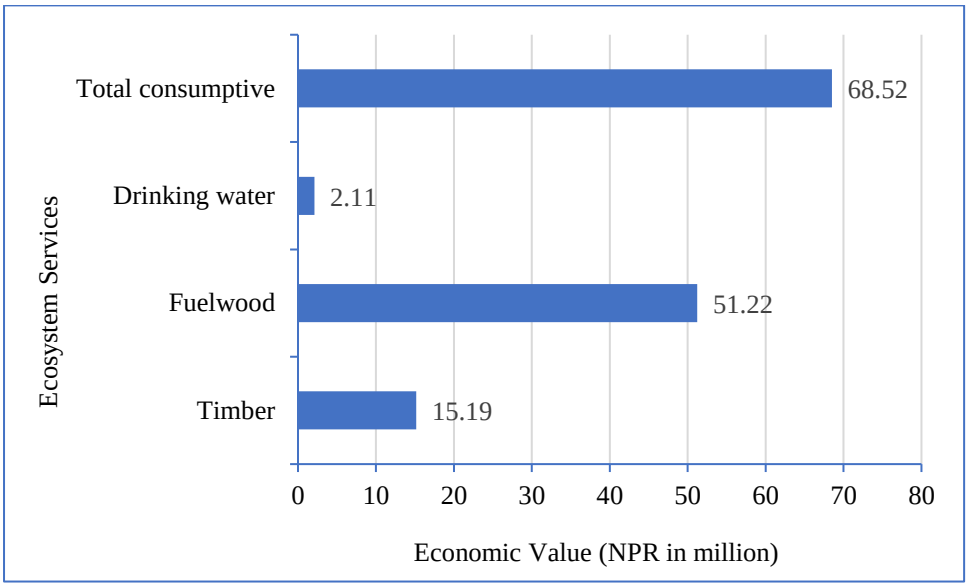

Figure 15: Consumptive use value of Panchase Protected Forest

4.2.1.2 Non-Consumptive Use Value

The present study has estimated the annual economic value of non-consumptive use of the ecosystem services of the Panchase Protected Forest to be NPR 37.84 million (USD 378,395) (Figure 16; Table 24). This non-consumptive use value is the combined

economic value of religious and recreational use of the cultural ecosystem services of the Panchase Protected Forests. The economic value of religious and recreational use was found to be NPR 23.44 million (USD 234,395) and NPR 14.40 million (USD 144,000), respectively (Table 24).

With respect to religious value, this study has found that 25,340 pilgrims, 19,005 from the 'Impact zone' and 6,335 from other areas of the country, visit Panchase Protected Forest annually (Table 21). In average, a pilgrim from the 'Impact zone' spend 1.5 days, whereas a pilgrim from other areas spend 2.5 days, including travel time. It was observed that the pilgrims from the 'Impact zone' usually walk instead of using vehicles. The economic value of religious use was calculated based on the opportunity cost of time (NPR 500 day^{-1}, the average wage rate in this region) and the transportation costs (NPR 200 $person^{-1}$, estimated by the survey during this study).

With respect to recreational value, this study has found that every year 3,600 foreign visitors visit Panchase Protected Forest (Table 21). The average duration of stay of a foreign visitor in the protected forest was reported to be two days. The cost for accommodation and food for a tourist in the protected forest was found to be NPR 1,500 day^{-1}. Moreover, transportation cost for a visitor was found to be NPR 1,000 (from Pokhara to Panchase round trip). As domestic visitors have not been included in the present assessment and only foreign visitors have been considered, it underestimates the recreational value. The recreational value can be further increased by promoting tourism and improving tourism infrastructures such as trails, resting places, vantage points and visitor's information centers. If entry fee is provisioned, which is not in practice now, it helps to increase the recreational value of the protected forest.

Table 24: Non-consumptive use value of Panchase Protected Forest

Non-consumptive value	No of visitors	Average cost (NPR)	Economic value (NPR in million)	Conversion Factor*	Economic value (USD)
Religious	25,340	925	23.44	100	234,395
Recreational	3,600	4,000	14.40	100	144,000
Total			37.84		378,395

* 1 USD = NPR 100 (as of January 2018)

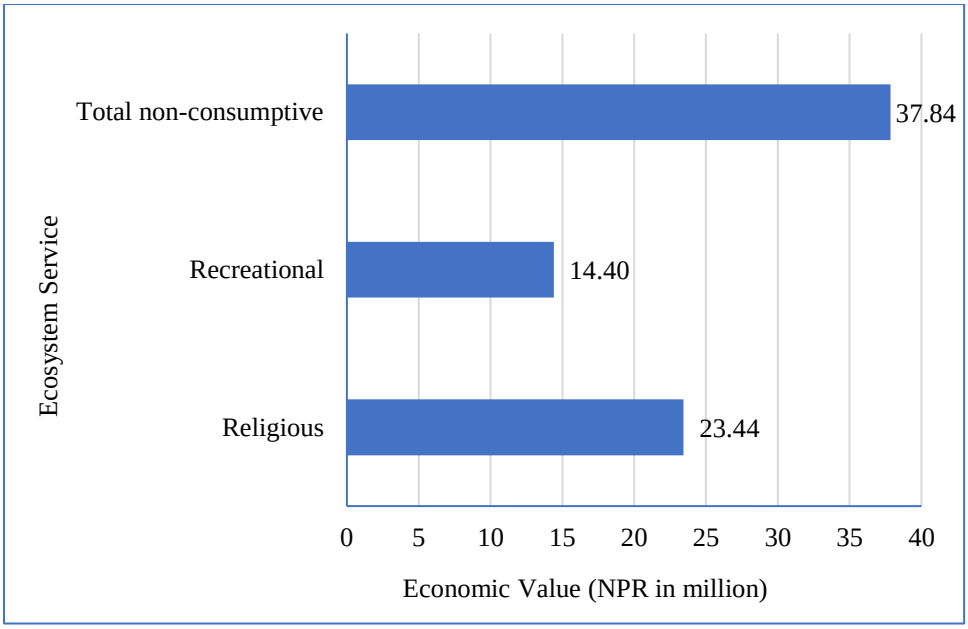

Figure 16: Non-consumptive use value of Panchase Protected Forest

The findings of the present study imply that the protected forest is important from the cultural and amenity services point of view. The higher religious value (NPR 23.44 million) than the recreational value (NPR 14.40 million) indicates that the Panchase Protected Forest is an important destination for religious and spiritual purpose. The economic value of non-consumptive use of cultural ecosystem services of Panchase Protected Forest (USD 378,395) estimated by this study seems lower than the Bagmara Community Forest in the buffer zone of Chitwan National Park (USD 3.8 million) estimated by KC et al. (2013). It may be due to the higher number of visitors in Bagmara Community Forest as it is located in the entry point of Chitwan National Park, one of the most popular tourist destinations of Nepal.

4.2.1.3 Indirect Use Value

The present study has considered carbon sequestration to estimate economic value of indirect use of ecosystem services.

Biomass

According to DoF (2012), the stem volume of Panchase Protected Forest was 57.84 m^3ha^{-1} in 2012 (Table 25). Similarly, DoF (2017) has reported the stem volume of Panchase Protected Forest to be 84.62 m^3ha^{-1} (Table 26). The stem volume of Panchase

Protected Forest was found to be less than the national average of 164.76 m^3ha^{-1} (DFRS, 2015a) and Middle Mountains average of 131.03 m^3ha^{-1} (DFRS, 2015b). The difference might be due to variation in species composition. However, the stem volume was increased from 57.84 m^3ha^{-1} in 2012 to 84.62 m^3ha^{-1} in 2017. It may be due to the implementation of management plan with active participation of local communities for conservation and management of the Panchase Protected Forest.

Analyzing the forest inventory data, this study reveals that 387,265.67 tons (67,050.51 kg ha^{-1}) of biomass was stored in the Panchase Protected Forest in 2012 (Table 25). Out of total, Above Ground Biomass (AGB) was found to be 309,812.53 tons (53,640.41 kg ha^{-1}) with contribution from stem, branch and foliage biomass of 201,619 tons (34,907.99 kg ha^{-1}), 96,760.11 tons (16,752.88 kg ha^{-1}) and 11,433.29 tons (1,979.54 kg ha^{-1}), respectively (Table 25). Similarly, Below Ground Biomass (BGB) was found to be 77,453 tons (13,410.51 kg ha^{-1}) (Table 25).

Moreover, the forest inventory data of second management plan (2017-2021) reveals that 652,675.90 tons (113,003.19 kg ha^{-1}) of biomass was stored in the Panchase Protected Forest in 2017 (Table 26). The stem, branch and leaf biomass of the Panchase Protected Forest was found to be 314,044.17 tons (54,373.07 kg ha^{-1}), 185,411.33 tons (32,101.79 kg ha^{-1}) and 22,685.22 tons (3,927.68 kg ha^{-1}), respectively (Table 26). Similarly, AGB and BGB was found to be 522,140.72 tons (90,402.55 kg ha^{-1}) and 130,535.19 tons (22,600.64 kg ha^{-1}), respectively (Table 26).

These findings show that average biomass of the Panchase Protected Forest is lower than the national average (194.51 tons ha^{-1}) reported by DFRS (2015a) as well as the Middle Mountains average (150.88 tons ha^{-1}) reported by DFRS (2015b), but higher than the mixed forest of Mid-hills of Central Nepal (64.62 tons ha^{-1}) reported by Aryal et al. (2013).

The results reveal that 387,265.67 tons of biomass was used to be stored in Panchase Protected Forest in 2012 and in 2017, it increased to 652,675.91 tons (Table 27; Figure 17). Similarly, average stock of biomass was found to be 67.05 tons ha^{-1} in 2012 (Table 25) and 113 tons ha^{-1} in 2017 (Table 26). Total gain of biomass in Panchase Protected

Forest during the five-year period (2012-2017) was 0.26 million tons with an average gain of 45.95 tons ha^{-1} (Table 28). In Panchase Protected Forest, the results depict that there is annual total gain of biomass equivalent to 53,082.05 tons accounting annual average gain of 9.19 tons ha^{-1} (Table 28).

Carbon

The analysis shows that 182,014.86 tons of carbon was used to be stocked in Panchase Protected Forest in 2012 and it increased to 306,757.68 tons in 2017 (Table 28). Average carbon storages in 2017 was estimated to be 53.11 tons ha^{-1} which is lower than the national average (108.88 tons ha^{-1}) (DFRS, 2015a) and the Middle Mountains average (138.11 tons ha^{-1}) (DFRS, 2015b). A total of 124,742.82 tons of additional carbon absorbed in Panchase Protected Forest during five-year period (2012-2017) with an average gain of 21.60 tons ha^{-1} (Table 28). The gain may be due to increased efforts of conserving forest after declaration as protected forest in 2012 and implementation of the management plan by the District Forest Offices of the Government of Nepal in collaboration with local communities. KC et al. (2017) has also found increased biomass from 126.3 tons ha^{-1} to 170.4 tons ha^{-1} between 2011 and 2014 in a managed community forests in the Mid-hills of Nepal.

This biomass growth suggests that annually 24,948.56 tons of carbon was sequestrated by Panchase Protected Forest which is equivalent to 92,309.68 tons of carbon dioxide (CO_2e) (Table 28). Average annual carbon sequestration of the Panchase Protected Forest was found to be 4.32 tons ha^{-1} (15.98 tons of CO_2e ha^{-1}) (Table 28).

Table 25: Average biomass of Panchase Protected Forest in 2012

Species	Stem volume[+] (m^3ha^{-1})	Wood density[*] (air-dry) (kg m^{-3})	Oven-dry: air-dry ratio[*]	Wood density (oven-dry) (kg m^{-3})	Stem biomass (kg ha^{-1}) (oven-dry)	Branch : stem ratio[*]	Branch biomass (kg ha^{-1})	Folia ge: stem ratio[*]	Foliage biomass (kg ha^{-1})	Above ground biomass (kg ha^{-1})	BGB: AGB ratio[**]	Below ground biomass (kg ha^{-1})	Total biomass (kg ha^{-1})
Alnus nepalensis	5.16	390	0.91	354.90	1,831.28	1.226	2,245.15	0.089	162.98	4,239.42	0.25	1,059.86	5,299.28
Castanopsis indica	3.53	740	0.91	673.40	2,377.10	0.915	2,175.05	0.048	114.10	4,666.25	0.25	1,166.56	5,832.81
Daphniphyllum himalense	31.53	674	0.91	613.34	19,338.61	0.400	7,735.44	0.040	773.54	27,847.60	0.25	6,961.90	34,809.50
Pinus roxburghii	2.54	750	0.91	682.50	1,733.55	0.256	443.79	0.046	79.74	2,257.08	0.25	564.27	2,821.35
Quercus spp.	1.92	860	0.91	782.60	1,502.59	0.960	1,442.49	0.215	323.06	3,268.14	0.25	817.03	4,085.17
Rhododendron arboreum	2.12	640	0.91	582.40	1,234.69	0.910	1,123.57	0.225	277.80	2,636.06	0.25	659.01	3,295.07
Schima wallichii	8.71	689	0.91	626.99	5,461.08	0.186	1,015.76	0.035	191.14	6,667.98	0.25	1,667.00	8,334.98
Other species[@]	2.33	674	0.91	613.34	1,429.08	0.400	571.63	0.040	57.16	2,057.88	0.25	514.47	2,572.35
Total	57.84				34,907.99		16,752.88		1,979.54	53,640.41		13,410.10	67,050.51

[+] DoF (2012); [*] HMGN (1988); [**] IPCC (2006)

[@] All species except mentioned in the table

Table 26: Average biomass of Panchase Protected Forest in 2017

Species	Stem volume[+] (m^3ha^{-1})	Wood density[*] (air-dry) (kg m^{-3})	Oven-dry: air dry ratio[*]	Wood density (oven-dry) (kg m^{-3})	Stem biomass (kg ha^{-1}) (oven-dry)	Branch : stem ratio[*]	Branch biomass (kg ha^{-1})	Foliage: stem ratio[*]	Foliage biomass (kg ha^{-1})	Above ground biomass (kg ha^{-1})	BGB: AGB ratio[**]	Below ground biomass (kg ha^{-1})	Total biomass (kg ha^{-1})
Alnus nepalensis	4.86	390	0.91	354.90	1,724.81	1.226	2,114.62	0.089	153.51	3,992.94	0.25	998.24	4,991.18
Castanopsis indica	21.53	740	0.91	673.40	14,498.30	0.915	13,265.95	0.048	695.92	28,460.17	0.25	7,115.04	35,575.21
Daphniphyllum himalense	13.33	674	0.91	613.34	8,175.82	0.400	3,270.33	0.040	327.03	11,773.18	0.25	2,943.30	14,716.48
Pinus roxburghii	11.47	750	0.91	682.50	7,828.28	0.256	2,004.04	0.046	360.10	10,192.41	0.25	2,548.10	12,740.52
Quercus spp.	8.92	860	0.91	782.60	6,980.79	0.960	6,701.56	0.215	1500.87	15,183.22	0.25	3,795.81	18,979.03
Rhododendron arboreum	3.12	640	0.91	582.40	1,817.09	0.910	1,653.55	0.225	408.84	3,879.48	0.25	969.87	4,849.35
Schima wallichii	16.75	689	0.91	626.99	10,502.08	0.186	1,953.39	0.035	367.57	12,823.04	0.25	3,205.76	16,028.80
Other species[@]	4.64	674	0.91	613.34	2,845.90	0.400	1,138.36	0.040	113.84	4,098.09	0.25	1,024.52	5,122.62
Total	84.62				54,373.1		32,101.79		3,927.68	90,402.6		22,600.64	113,003.19

[+] DoF (2017); [*] HMGN (1988); [**] IPCC (2006)

[@] All species except mentioned in the table

Table 27: Total biomass in Panchase Protected Forest in 2012 and 2017

Species	Biomass in 2012 (ton)			Biomass in 2017 (ton)		
	AGB	BGB	Total	AGB	BGB	Total
Alnus nepalensis	24,485.75	6,125.70	30,607.20	23,062.14	5,765.56	28,827.71
Castanopsis indica	26,951.00	6,742.40	33,688.76	164,378.26	41,094.55	205,472.81
Daphniphyllum himalense	160,840.22	40,237.90	201,050.26	67,998.71	16,999.71	84,998.42
Pinus roxburghii	13,036.28	3,261.33	16,295.37	58,868.67	14,717.14	73,585.80
Quercus spp.	18,875.89	4,722.21	23,594.85	87,694.18	21,923.57	109,617.75
Rhododendron arboreum	15,225.17	3,808.90	19,031.46	22,406.83	5,601.71	28,008.54
Schima wallichii	38,512.45	9,634.81	48,140.58	74,062.42	18,515.60	92,578.02
Other species	11,885.76	2,973.50	14,857.19	23,669.52	5,917.35	29,586.87
Total	309,812.53	77,506.76	387,265.67	522,140.72	130,535.19	652,675.91

Table 28: Carbon stock and gain in Panchase Protected Forest

Stock and gain	Biomass (ton)		Carbon Factor*	Carbon (ton)		CO_2 Factor*	CO_2e (ton)	
	Average	Total		Average	Total		Average	Total
Stock in 2012	67.05	387,265.67	0.47	31.51	182,014.86	3.70	116.60	673,455.00
Stock in 2017	113.00	652,675.92	0.47	53.11	306,757.68	3.70	196.51	1,135,003.42
Gain in five years (2012 to 2017)	45.95	265,410.25	0.47	21.60	124,742.82	3.70	79.91	461,548.42
Annual gain	9.19	53,082.05	0.47	4.32	24,948.56	3.70	15.98	92,309.68

* IPCC (2006)

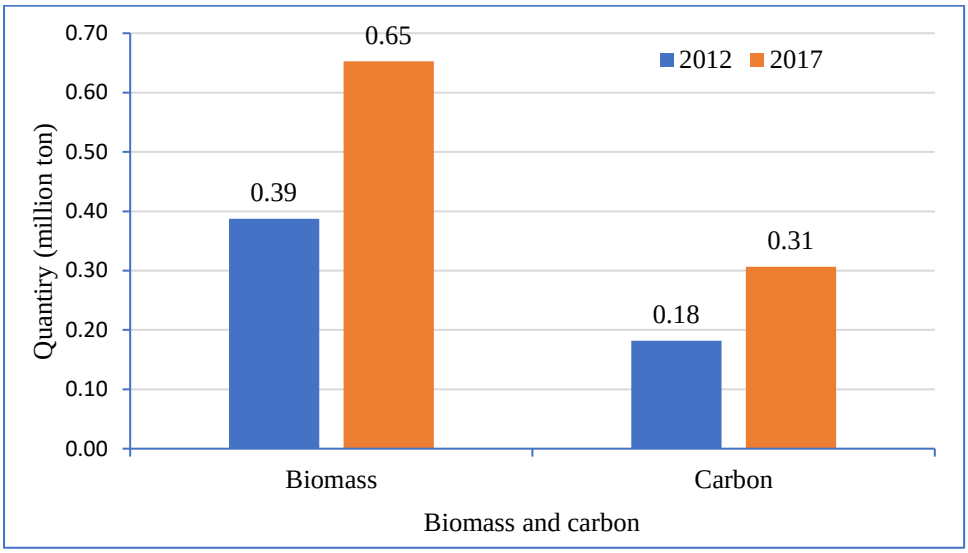

Figure 17: Biomass and carbon storage in Panchase Protected Forest

The results of the present study reveal that the annual economic value of the indirect use of the ecosystem services (carbon sequestration) of the Panchase Protected Forest to be NPR 46.15 million (USD 461,548) with average annual economic value of NPR 7,990 (USD 79.90) ha^{-1} (Table 29).

Table 29: Value of carbon sequestration in Panchase Protected Forest

Forest Area	Annual sequestration (ton CO_2e)	CO_2e rate (USD ton^{-1})*	Economic value (USD)	Conversion rate**	Economic value (NPR)
Average	15.98	5	79.90	100	7,990
Total	92,309.68	5	461,548	100	46,154,840

* MoFE (2018); ** 1 USD = NPR 100 (as of January 2018)

4.2.2 Non-Use Value

The present study has estimated annual economic value of non-use value of ecosystem services of the Panchase Protected Forest to be NPR 52.12 million (USD 521,157) (Figure 18; Table 30; Bhandari et al., 2018c). This non-use value is the sum of option value, existence value, altruist value and bequest value. The economic value of option, existence, altruist and bequest values were found to be NPR 16.00 million (USD 160,021), 9.62 million (USD 96,206), NPR 9.41 million (USD 94,079) and NPR 17.09 million (USD 170,850), respectively (Table 30).

Table 30: Non-use value of Panchase Protected Forest

Non-use value of ecosystem services	Economic value	
	NPR (million)	USD*
Option value	16.00	160,021
Existence value	9.62	96,206
Altruist value	9.41	94,079
Bequest value	17.09	170,850
Total	52.12	521,157

*1 USD = NPR 100 (as of January 2018)

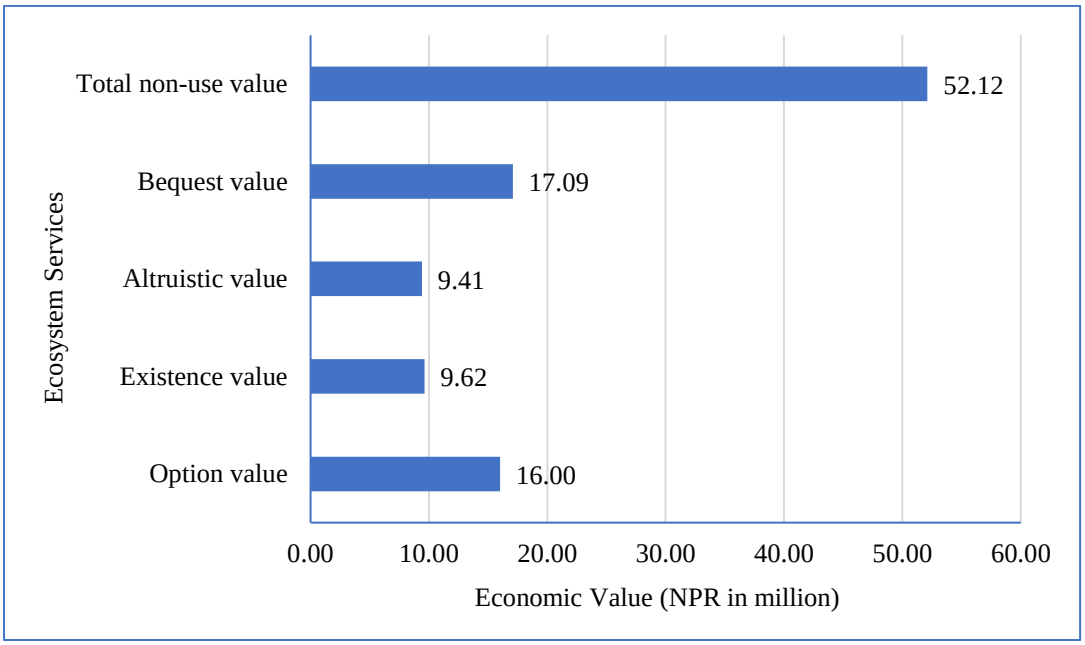

Figure 18: Non-use value of Panchase Protected Forest

4.2.3 Total Economic Value

The total economic value of Panchase Protected Forest has been found to be NPR 204.63 million (USD 2,046,312) per year (Figure 19). In the total economic value, use value has higher contribution with NPR 152.52 million (USD 1,525,155) compared to non-use value, which contributes NPR 52.12 million (USD 521,157) (Figure 19; Table 31). In the total use value, consumptive use value has the highest contribution worth NPR 68.52 million (USD 685,212) followed by indirect use value worth NPR 46.15 million (USD 461,548) and non-consumptive use value worth NPR 37.84 million (USD

378,395). Similarly, with respect to the total non-use value, bequest value has highest contribution equivalent to NPR 17.09 million (USD 170,850) followed by option value worth NPR 16.00 million (USD 160,021), existence value worth NPR 9.62 million (USD 96,206), and altruist value worth NPR 9.41 million (USD 94,079) (Figure 19).

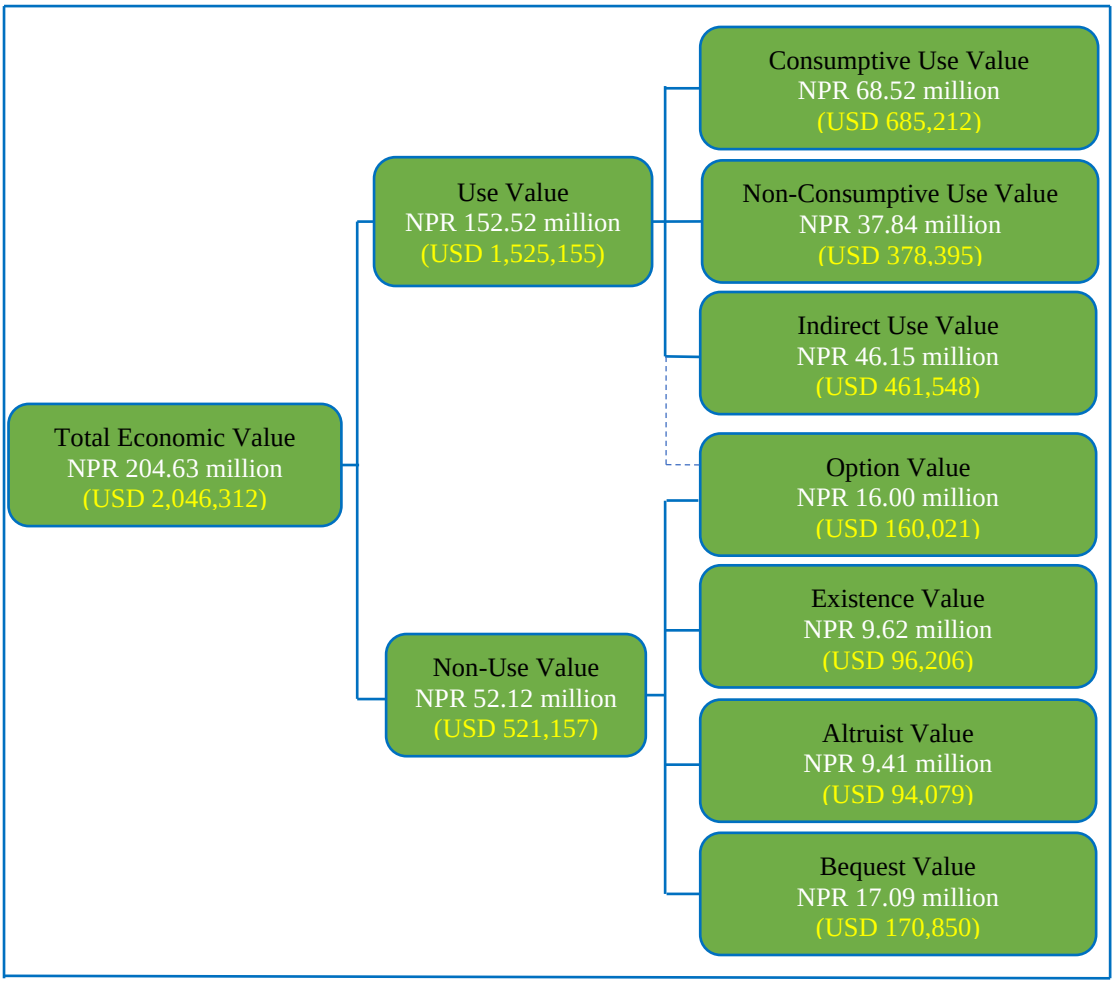

Figure 19: Total Economic Value of Panchase Protected Forest

The present study has found the contribution of consumptive use value, non-consumptive use value, indirect use value and non-use value to be 33.49%, 18.49%, 22.56% and 25.47%, respectively (Figure 20). The results show that both the use value and the non-use value have a substantial share in the total economic value of the Panchase Protected Forest indicating its importance for providing economic benefits. Moreover, the results show that the contribution of consumptive use value to the total economic value is 33%, whereas contribution from other values (non-consumptive use, indirect use and non-use value) is 67% (Figure 20). The results indicate that non-use value, indirect use value and non-consumptive use value have higher contribution to

the total economic value compared to consumptive use value. However, Nepal's National Accounting System only recognizes consumptive use value excluding all other values (non-consumptive value, indirect use value and non-use value) of ecosystem services. It indicates that the economic contribution of ecosystem services is undervalued and is not well reflected in the country's economic decisions.

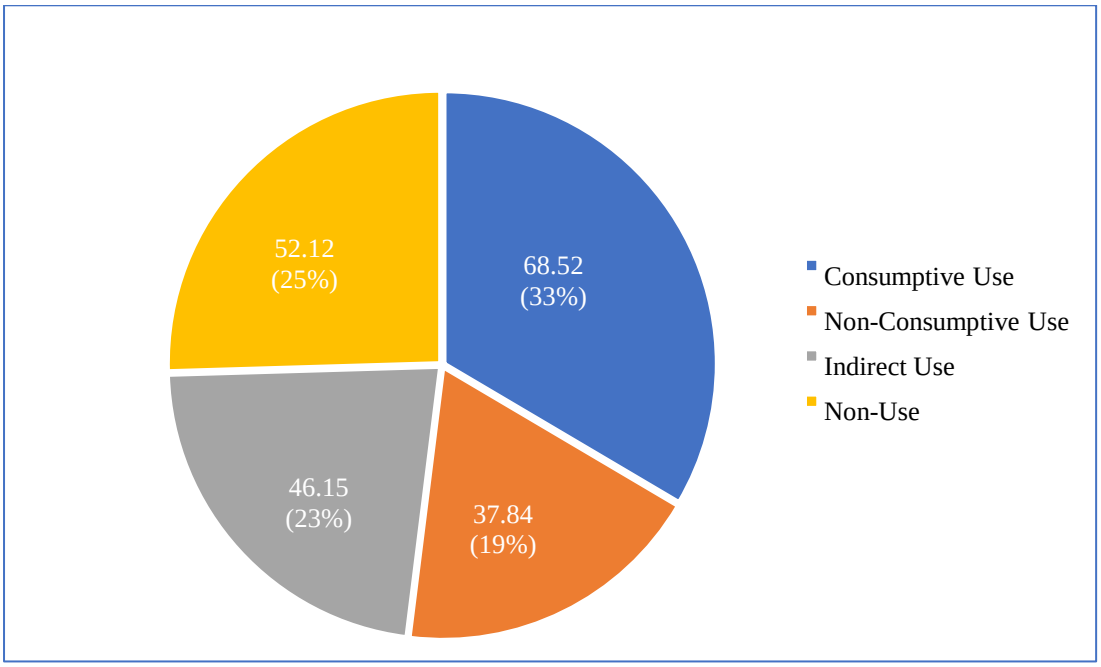

Figure 20: Share of different values to economic value of Panchase Protected Forest

The economic value of Panchase Protected Forest (USD 2.04 million) seems higher than the economic value of Ghodaghodi Lake Area (0.88 million) estimated by CSUWN (2011) and Jagadishpur Reservoir (USD 0.9 million) estimated by Baral et al. (2016). However, the economic value of Panchase Protected Forest seems lower than Koshi Tappu Wildlife Reserve (USD 16 million) estimated by Sharma et al. (2015), Bardia National Park (NPR 379 million) estimated by Basnyat et al. (2012), Shivapuri-Nagarjun National Park (USD 11 million) estimated by Peh et al. (2016) and Phewa Lake Area (USD 43.6 million) estimated by CSUWN (2011). The higher economic value of Bardia National Park, Shivapuri-Nagarjun National Park and Phewa Lake Area may be due to high tourist flow compared to the Panchase Protected Forest. On the other hand, the lower economic value of Ghodaghodi Lake Area and Jagadishpur Reservoir may be due to lower ecosystem services provided by these wetlands compared to the Panchase Protected Forest.

4.2.4 Willingness to Pay

Willingness to pay of the people in the 'Impact zone' for non-use values of ecosystem services of the Panchase Protected Forest was found to be NPR 52.12 million (USD 521,157) (Table 31). The sum of the annual WTP for option value, existence value, altruist value and bequest value were respectively found to be NPR 16.00 million (USD 160,021), NPR 9.62 million (USD 96,206), NPR 9.41 million (USD 94,079) and NPR 17.09 million (USD 170,850) (Table 31). The results indicate that the people in the 'Impact zone' of the Panchase Protected Forest have given highest preference for bequest value followed by option value, existence value and altruist value. The higher WTP for bequest value and option value indicates that people in the study area willing to contribute more in conserving forests for present as well as future generations. Moreover, average annual WTP of a household in the study area was found to be NPR 7,403.85 (USD 74.04) (Table 31). This result shows that average WTP of Panchase Protected Forest is higher than the average WTP of Jagadispur Reservoir area (NPR 2,597) estimated by Baral et al. (2016).

Table 31: WTP for non-use value of Panchase Protected Forest

Non-use value of ecosystem services	WTP (annual average)		WTP (annual total)	
	NPR	USD*	NPR (million)	USD*
Option value	2,273.35	22.73	16.00	160,021
Existence value	1,366.76	13.67	9.62	96,206
Altruistic value	1,336.54	13.37	9.41	94,079
Bequest value	2,427.20	24.27	17.09	170,850
Total	7,403.85	74.04	52.12	521,157

1 USD = NPR 100 (as of January 2018)

The present study has assessed the people's WTP with respect to eight socio-economic variables viz. gender, education, family size, position on forest, distance to forest, family income, landholding and livestock holding (Table 32). Out of 364 respondents, 245 (67%) were men and 119 (33%) were women (Table 33). Among the respondents, 36 persons (10%) were having university education, 246 (68%) having school education and 82 (22%) without having formal education (Table 33). Moreover, average family size of the respondent household was found to be 5.2 persons. With

respect to the landholding, 230 (63%) households were holding lands between six and 19 ropani (1 hectare = 19.66 ropani), 42 (12%) households were holding lands more than 20 ropani and 92 (25%) households were holding lands less than five ropani (Table 34) with an average landholding of 10.67 ropani (Table 32). Furthermore, 20 (5%) households were holding more than 5.1 livestock unit, 142 (39%) households were holding 2.1-5 livestock unit and 202 (56%) households were holding less than 2 livestock unit (Table 34) with an average livestock holding of 2.21 livestock unit (Table 32). Likewise, 199 (55%) households were having annual income less than NPR 0.4 million, 142 (39%) households were having annual income between NPR 0.4 to 1.2 million and 23 (6%) households were having annual income more than NPR 1.2 million (Table 34) with an average family income of NPR 0.48 million (Table 32). Majority of the respondent households (201) in the study area need to spend more than 15 minutes to reach their forest, whereas 163 households can reach to the forests in less than 15 minutes. It was observed that out of 364 respondents, 73 were holding executive position on community forest within the 'Impact zone' (Table 34).

Table 32: Socio-economic variables and their mean value

Variable (Unit)	N	Minimum	Maximum	Mean	Std. Deviation
Gender	364	0	1	0.67	0.470
Education (School year)	364	0	17	6.25	4.266
Family Size (Number)	364	1	10	5.22	1.737
Distance to Forest (minute)	364	2	35	19.84	9.585
Position on Forest	364	0	1	0.20	0.401
Family Income (NPR)	364	9600	3120000	476980.49	463887.993
Landholding (Ropani)	364	0	70	10.67	8.263
Livestock (Unit)	364	0	12	2.21	1.650

Table 33: Socio-economic characteristics of the respondents

District	VDC	No of Respondents	Gender		Age (year)				Education (school year)		
			Male	Female	15-24	25-54	55-64	65+	0	1-10	11+
Kaski	Bhadaure Tamagi	45	25	20	1	24	13	7	15	29	1
	Chapakot	35	23	12	1	22	6	6	10	20	5
	Pumdibhumdi	95	60	35	6	67	18	4	14	75	6
Parbat	Arthar Dadakharka	36	23	13	0	22	8	6	9	25	2
	Chitre	23	17	6	1	16	3	3	4	19	-
	Ramja Deurali	25	19	6	1	12	8	4	1	19	5
Syangja	Arukharka	45	36	9	1	25	7	12	16	20	9
	Bangefadke	15	12	3	-	6	2	7	2	13	-
	Bansing Deurali	45	30	15	1	21	11	12	11	26	8
Total		364	245	119	12	215	76	61	82	246	36

Table 34: Socio-economic condition of the respondent household

District	VDC	Family size	Landholding (Ropani)			Livestock Unit			Family Income (NPR in 100 thousand)			Distance to Forest (in minute)		Position on Forest	
			0-5	6-19	20+	0-2	2.1-5	5.1 +	0-4	4-12	12+	0-15	15+	With	Without
Kaski	BhadaureTamagi	5.1	14	28	3	19	19	7	28	17	-	31	14	11	34
	Chapakot	5.5	10	16	9	18	15	2	17	16	2	17	18	6	29
	Pumdibhumdi	5.2	38	53	4	61	29	5	54	31	10	40	55	13	82
Parbat	Arthardadakhark	5.4	8	18	10	22	10	4	22	12	2	14	22	12	24
	Chitre	4.6	4	16	3	16	6	1	11	10	2	10	13	4	19
	Ramja Deurali	5	1	19	5	19	5	1	11	10	4	15	10	7	18
Syangja	Arukharka	5	5	35	5	18	27	-	25	20	-	17	28	4	41
	Bangefadke	5.4	6	9	-	8	7	-	9	6	-	2	13	5	10
	Bansing Deurali	5.5	6	36	3	21	24	-	22	20	3	17	28	11	34
Total		5.2	92	230	42	202	142	20	199	142	23	163	201	73	291

The relationship between WTP and the socio-economic variables were assessed using a linear regression model. Normal 'probability plot' and the 'scatter plots' prepared for each socio-economic variable have shown linear relationship between the independent variables (gender, education, family size, family income, landholdings, livestock holdings, position on forest and distance to forest) and the dependent variable (WTP). The value of 'condition index' of the regression model, 14.057, has shown no multicollinearity effect between the independent variables. The F-statistics for overall goodness of fit of the model, 141.797 ($p < 0.05$), and the R^2 value (0.762) of the model assures that the regression model used in the present research is suitable for the analysis.

The results of the regression analysis reveal that out of eight socio-economic variables, WTP significantly correlated ($p<0.01$) with two variables *viz.* 'family income' and 'position on forest'. Moreover, WTP significantly correlated ($p<0.05$) with five variables *viz.* 'gender', 'education', 'family size', 'position on forest' and 'family income' (Table 35).

The variable 'gender' was found to be significantly negatively correlated with the WTP ($p<0.05$). The result indicates that women wish to contribute more for forest conservation compared to the men. According to local community, it may be due to more engagement of women in collecting forest products, particularly fuelwood, fodder and grass for their household use. Chaudhary et al. (2018) has also shown similar findings from Maipokhari Ramsar Site in the Eastern Mid-hills of Nepal.

The variable 'education' was found to be significantly positively correlated with the WTP ($p<0.05$). It indicates that educated people wish to contribute more to conserve forest compared to the less educated people. It may be due to a higher level of awareness of educated people on forest ecosystem conservation. This result suggests that education is important to engage people in conservation programs. This finding contradicts with the finding of Bhandari et al. (2016) who observed no significant correlation between WTP with education in the Chure region of Nepal.

The variable 'family size' was found to be significantly positively correlated with the WTP ($p<0.05$). The result indicates that households having bigger family size are willing to contribute more for forest conservation compared to the household having

smaller family size. It may be due to the availability of human resources, in bigger family, to involve in social works including forest resource management. On the other hand, smaller family needs to invest most of the time of their family members for household works and have limited time available for forest conservation. This finding is in line with the findings of KC et al. (2013) who observed significant positive correlation between family size and WTP in Bagmara Community Forest in the buffer zone of Chitwan National Park.

The variable 'position on forest' was found to be significantly positively correlated with the WTP ($p<0.01$). The result indicates that people having executive positions in community-based forest management committee are willing to pay more compared to those who are not in the executive positions. It may be due to the increased ownership of the people, in forest management, who holds the decision-making positions. The results suggest that community engagement in forest management is important to increase ownership and responsibility of local people in managing the protected forest.

The variable 'family income' was found to be significantly positively correlated with the WTP ($p<0.01$). The result indicates that households having higher income are willing to contribute more to conserve forest than the households having lower income. It may be due to people having low income need to invest primarily in the subsistence living rather than forest conservation. The results suggest that creation of economic opportunity, which increases income of local people, is important for implementing forest management interventions. Bhandari et al (2016) have also found significant positive correlations between WTP of ecosystem services and family income in Chure region of Nepal. Chaudhary et al. (2018) has also shown similar findings from Maipokhari Ramsar Site in the Eastern Mid-hills of Nepal.

The results of present study found that variables 'landholding', 'livestock' and 'distance to forest' are not correlated with WTP. The negative sign of the variable 'distance to forest' indicates that households living far from forest are willing to contribute less than the households living near to the forests. It may be due to feeling more ownership and accountability by the nearby households as they depend more on the forests.

Table 35: Socio-economic variables and coefficients

Variables	Coefficient	Standard Error	Standardized Coefficient	p-value
Constant	2868.638	482.057		0.000
Gender	-482.405	227.264	-0.058*	0.034
Education	52.055	25.722	0.056*	0.044
Family Size	143.523	62.372	0.063*	0.022
Distance Forest	-0.268	10.896	-0.001	0.980
Position Forest	1731.305	265.440	0.177**	0.000
Family Income	0.007	0.000	0.811**	0.000
Landholding	10.922	13.654	0.023	0.424
Livestock	21.609	64.984	0.009	0.740

$R^2 = 0.762$; adjusted $R^2 = 0.756$; *significance at 5% level; ** significant at 1% level

4.3 Beneficiaries of Ecosystem Services

The present results show that the benefits of ecosystem services provided by Panchase Protected Forest have been distributed from local level to sub-national, national and global levels (Table 36). The Local communities have been benefited with provisioning services (food, raw materials, medicines, energy sources, ornamental resources and water), regulating services (erosion prevention, water purification, air quality regulation, soil fertility maintenance and climate regulation), and cultural and amenity services (recreation and tourism, and cultural and religious). Likewise, sub-national level stakeholders have been benefited with provisioning services (raw materials and water), regulating services (erosion prevention, water purification, air quality regulation and climate regulation), habitat services (life cycle maintenance and genetic resource maintenance), and cultural and amenity services (recreation and tourism, cultural and religious, and cognitive). Similarly, national level stakeholders have been benefited with regulating services (climate regulation), habitat services (life cycle maintenance and genetic resource maintenance), and cultural and amenity services (recreation and tourism, cultural and religious, and cognitive). Likewise, the global level stakeholders have been benefited with regulating services (climate regulation), habitat services (genetic resource maintenance), and cultural and amenity services (recreation and tourism, cultural and religious, and cognitive). The findings of this study complement

to the findings of Paudyal et al. (2017) who have observed that the benefits of the ecosystem services provided by community-based forestry in Nepal have been distributed from local to global beneficiaries.

Table 36: Beneficiaries of ecosystem services provided by Panchase Protected Forest

Ecosystem services		Beneficiaries
Provisioning	Food	Local
	Medicines	Local
	Raw materials	Local, sub-national
	Energy sources	Local
	Ornamental resources	Local
	Water	Local, sub-national
Regulating	Water flows regulation	Local, sub-national
	Erosion prevention	Local, sub-national
	Water purification	Local, sub-national
	Soil fertility maintaining	Local
	Air quality regulation	Local, sub-national
	Climate regulation	Local, sub-national, national, global
Habitat	Life cycle maintenance	Local, sub-national, national
	Genetic resource maintenance	Sub-national, national, global
Cultural and amenity	Recreation and tourism	Local, sub-national, national, global
	Cultural and religious	Local, sub-national, national, global
	Cognitive	Sub-national, national, global

4.4 Financing for Ecosystem Service Management

4.4.1: Policy and Institution

The current policy and legal instruments of Nepal such as Forest Act 1993, Forestry Sector Strategy 2016-2025, Forest Policy 2019 and National Biodiversity Strategy and Action Plan 2014-2020 are supportive to develop ecosystem service based financial frameworks (Table 37). The National Biodiversity Strategy and Action Plan has proposed to engage public and private sector for biodiversity funding. Likewise, Forest Sector Strategy 2016-2025 has envisioned a separate financing mechanism for forestry

sector development. Moreover, Forest Policy 2019 has envisioned to establish a 'Forest Development Fund' (a trust fund) for forestry sector finance which has been provisioned in the recent (2019) amendment of Forest Act 1993. This creates an enabling condition to develop and implement 'Trust Fund' approach in the protected forest management. However, formulation of regulatory instruments at provincial and local government level is crucial to develop site-based financing mechanism for ecosystem service management.

Table 37: Policy and legal instruments relevant to ecosystem financing

Policy and legal instruments	Ecosystem financing provisions
Forest Act 1993	Community forest is an independent legal entity to manage fund generated from the forest management The recent amendment (in 2019) has provisioned a 'trust fund' called 'Forest Development Fund' to manage fund generated from the forest resources in the country
National Biodiversity Strategy and Action Plan 2014-2020	Proposed a strategy to generate fund for biodiversity conservation engaging public and private sector Payment for ecosystem services has been proposed for sustainable financing of ecosystem and biodiversity conservation
Forestry Sector Strategy 2016-2025	Payment for ecosystem services has been proposed for sustainable financing of forest and ecosystems Separate financing mechanism have been proposed for forestry sector development
Forest Policy 2019	Importance of ecosystem services has been recognized Proposed to establish 'Forest Development Fund' for the forestry sector finance management

With respect to institutions, all three federal, state and local governments, community-based organizations, civil society organizations and private sector were found to be existed in the Panchase Protected Forest region (Table 38). Federal level organizations include Fiscal and Natural Resource Commission, Ministry of Finance, Ministry of Forests and Environment, Department of Forests and Soil Conservation. Similarly, state level organizations include Ministry of Industry, Tourism, Forests and Environment,

Ministry of Finance and Development, Division Forest Offices (Kaski, Parbat and Syangja districts) and District Coordination Committees (Kaski, Parbat and Syangja districts). Likewise, local governments include six municipalities (one metropolitan city, one municipality and four rural municipalities). Community level organizations include 108 community forest user groups (Appendix III), mother groups, and civil society organizations such as Federation of Community Forestry Users' Nepal, Machhapuchhre Development Organization. Appropriate representation of these institutions is crucial for the financing mechanisms to be established in the protected forest.

Table 38: Major institutions for ecosystem financing

Level	Institutions
Federal level	Fiscal and Natural Resource Commission
	Ministry of Finance
	Ministry of Forests and Environment
	Department of Forests and Soil Conservation
State level	Ministry of Industry, Tourism, Forests and Environment
	Ministry of Finance and Development
	Division Forest Offices (Kaski, Parbat, Syangja)
	District Coordination Committees (Kaski, Parbat, Syangja)
Local level	Annapurna Rural Municipality, Kaski
	Pokhara Lekhnath Metropolitan City, Kaski
	Modi Rural Municipality, Parbat
	Kushma Municipality, Parbat
	Phedikhola Rural Municipality, Syangja
	Aandikhola Rural Municipality, Syangja
Community level	Community Forest User Groups (108)
	Mothers Groups
	Civil Society Organizations
Protected Forest level	Protected Forest Council
Private sector	Individuals (Tourism Entrepreneurs) and Cooperatives
	Bank and Finance Institutions
	Federation of Chamber of Commerce and Industry (Kaski, Parbat, Syangja)

4.4.2 Financing Mechanisms for Sustainable Management

Based on the supportive policy and legal instruments and presence of institutions from local to central levels, the present study has suggested 'payment for ecosystem services' and 'forest ecosystem trust fund' as appropriate financing mechanism for conservation and sustainable management of Panchase Protected Forest.

4.4.2.1 Payment for Ecosystem Services

Payment for Ecosystem Services (PES) is an incentive-based approach to improve the management of natural environment and natural resources. The concept of PES relies on the idea of monetary value of ecosystem services to internalize positive externalities of ecosystem conservation, which operates according to the logic of the 'free market' (Engel et al., 2008). PES is a voluntary transaction between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services (Wunder, 2015).

The present study reveals PES as a financing mechanism for sustainable management of ecosystems within the Panchase Protected Forest. Provisions of payment from beneficiaries for the services they received not only help in making them accountable but also generate finance for ecosystem conservation. The present study has found that the benefits of ecosystem services provided by Panchase Protected Forest have been widely distributed to local, sub-national, national and global levels. This study, thus, has recognized PES as a potential financing mechanism for sustainable management of Panchase Protected Forest.

Moreover, CSUWN (2011) has suggested PES for Ghodaghodi Lake Area, Khanal et al. (2014) have suggested PES for Beeshajari Lake Area, Birch et al. (2014) have suggested PES for Phulchoki Forest, Oort et al. (2015) have suggested PES for Jhiggu Khola watershed and Acharya et al. (2010) have argued PES for financing community forests in Nepal. Likewise, Bhatta et al. (2014) have also shown PES as a promising potential for conserving various ecosystem services.

Based on the availability of ecosystem services, enabling policies and institutions, the present study has proposed a PES framework for Panchase Protected Forest involving beneficiaries and stakeholders from local to global level (Figure 21). The framework has been proposed Panchase Protected Forest Council (PPFC) as 'service provider' and beneficiaries at local, sub-national, national and global levels have been proposed as 'service receivers'. Bhatta et al. (2017) have also suggested to involve multi-stakeholders, while setting institutions to establish a PES scheme. The local communities from the 'Impact zone' who do not only receive benefits from ecosystem services but also largely contribute to protect and manage the protected forest. Thus, local communities are both service receivers and service providers. In the proposed framework, PPFC represents local communities of the 'Impact zone' to act as service provider. Panchase Protected Forest Council shares benefits to the local communities by developing benefit sharing mechanism to execute the PES scheme. The local community, who get benefits, mostly provisioning services, contribute to the scheme as service receivers.

Sub-national level beneficiaries receive provisioning, regulating and cultural ecosystem services and pay for the received services to contribute to the PES scheme. Similarly, national and global level beneficiaries receive regulating, habitat and cultural services and pay for using those services to contribute to the PES scheme. Panchase Protected Forest Council, as a service provider, signs agreements with the service receivers (local, sub-national and national level). However, for global beneficiaries, PPFC coordinates with concerned federal government agencies to make agreement with service receivers. Panchase Protected Forest Council takes responsibility to coordinate with local, provincial (state) and federal government agencies and stakeholders to execute PES mechanism (Figure 21).

In order to maintain and increase ecosystem services from the Panchase Protected Forest, community-based organization in the 'Impact zone', particularly community forest user groups, protect and manage their community forest based on the approved forest operational plans. Panchase Protected Forest Council channels the benefits of ecosystem services received in the PES scheme down to the community forest user groups for forest management, economic upliftment and community development. The

Panchase Protected Forest Council itself protect and manage forest in the 'Core area' based on the management plan of Panchase Protected Forest. Division Forest Offices, Sub-Division Forest Offices and civil society organizations of the region support community forest user groups and PPFC for forest protection and management. Civil society organizations support PPFC in developing its capacity to execute PES scheme and for negotiation with the service receivers. Division Forest Offices (Kaski, Parbat and Syangja) and Ministry of Industry, Tourism, Forests and Environment of Gandaki State facilitate execution of PES scheme creating enabling environment and monitoring.

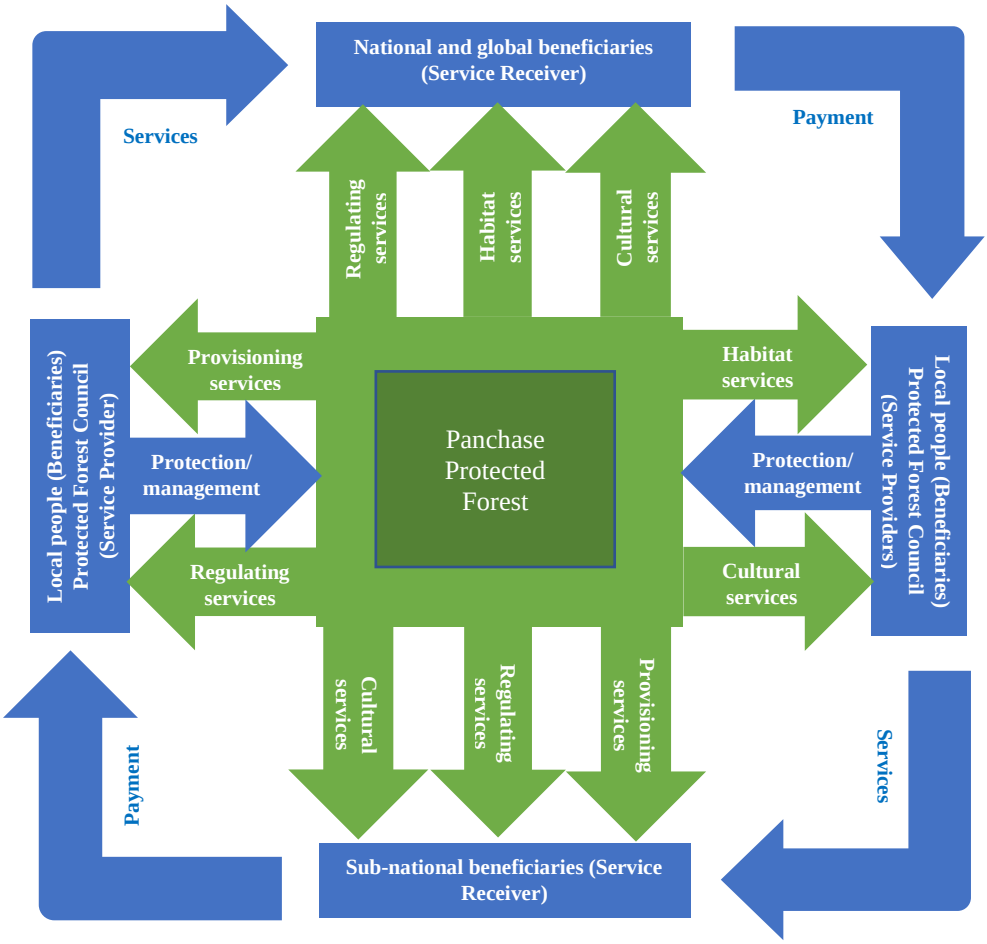

Figure 21: Proposed PES framework for Panchase Protected Forest

4.4.2.2 Forest Ecosystem Trust Fund

Trust Funds are financial vehicles established for raising funds and creating financial incentives (Droesse, 2011). This approach combines planning for the ecological, financial, social, political, and institutional measures for effective management of nature (WWF, 2015). Trust Funds are legally independent grant-making institutions which provide sustainable financing for conservation and sustainable development (Spergel & Taieb, 2008).

The present study reveals 'Trust Fund' as a financing mechanism for sustainable management of ecosystems within the Panchase Protected Forest. In the recent years, various multilateral environmental agencies have been practicing 'trust fund' approaches at global scale such as Global Environment Facility, Green Climate Fund and Forest Carbon Partnership Facility. In Nepal, there seems lacking 'trust fund' both at national and local scale. However, Forest Policy 2019 has provisioned a 'Forest Development Fund' with the aim of developing financing mechanism for sustainable forest management. Moreover, 'trust funds' have been reported practiced in various countries of South America, Africa and Asia. Some 'trust funds' practiced for conserving biodiversity and ecosystems include 'Mexican Fund for the Conservation of Nature' (Mexico), 'Mesoamerican Reef Fund' (Mexico, Belize, Guatemala and Honduras), 'Caribbean Biodiversity Fund' (Caribbean Region), 'Fund for the Protection of Water' (Ecuador), 'Protected Areas Conservation Trust Fund' (Belize), 'Fund for Environmental Action and Childhood' (Colombia), 'Phoenix Islands Protected Area Conservation Trust (Kiribati)', 'Banc d'Arguin Coastal and Marine Biodiversity Trust Fund' (Mauritania), 'Sangha Tri-National Foundation' (Cameroon, Central African Republic and Republic of Congo), 'Bangladesh Tropical Forest Conservation Foundation' (Bangladesh) and 'Bhutan Trust Fund for Environmental Conservation' (Bhutan). Moreover, Kauffman (2013) and BTFEC (2018) have reported 'trust fund' approach as potential financing mechanism to manage ecosystems to capitalize the interest of local and global communities for conservation and management of natural capital. Likewise, Bladon et al. (2014) have found 'trust fund' tying up financial resources over the long term available to conservation.

Based on the availability of institutions, stakeholders and enabling policies, the present study has proposed 'Forest Ecosystem Trust Fund (FETF)' as a 'trust fund' framework for Panchase Protected Forest (Figure 22). The potential contributors for the FETF are government agencies, civil society organizations and private sector (Table 38).

The federal government, provincial (state) government and local governments are the most reliable sources to contribute to the FETF through their priority conservation programs. Panchase Protected Forest falls under the jurisdiction of six local governments (Pokhara Lekhnath Metropolitan City, Annapurna Rural Municipality, Modi Rural Municipality, Kushma Municipality, Phedikhola Rural Municipality and Aadhikhkola Rural Municipality), one provincial government (Gandaki State) and federal government.

In context of Nepal, civil society organizations are crucial to generate fund for conservation and management of natural resources. National and international civil society organizations working in the natural resources and conservation sector are potential stakeholders to generate fund from various sources within and outside the country. Currently, Action Aid International Nepal (AAIN), CARE International, German International Development Cooperation (GIZ), International Center for Integrated Mountain Development (ICIMOD), International Union for Conservation of Nature (IUCN), Lutheran World Federation, National Trust for Nature Conservation (NTNC), Oxfam, Practical Action, Red Panda Network, Regional Community Forestry Training Center for Asia and the Pacific (RECOFTC), The Mountain Institute, United Nations Development Program (UNDP), World Vision International, World Wide Fund for Nature (WWF) and Zoological Society of London (ZSL) have been working in Nepal. Civil society organizations can also be engaged in developing institutional capacity in the initial stage. Moreover, local level civil society organizations such as community forest user groups in the 'Impact zone', can be a part of this 'trust fund' through investing part of their income generated from the sale of forest products. Currently, there are 108 community forest user groups in the 'Impact zone' of the Panchase Protected Forest.

Furthermore, private sector such as individuals (particularly tourism entrepreneurs), corporates, and bank and finance institutions are also potential stakeholders to invest in

the ‘trust fund’. Entry fee of the visitors, if provisioned, and revenue of the ecosystem services from the protected forest are also sources of fund to the Panchase Protected Forest to contribute to the FETF.

In the proposed framework, Panchase Protected Forest Council (PPFC) is envisioned to take responsibility of executing the FETF in collaboration with the concerned local governments (municipalities), provincial government (Ministry of Industry, Tourism, Forests and Environment of Gandaki State) and federal government (Ministry of Forests and Environment). Ministry of Industry, Tourism, Forests and Environment of Gandaki State and federal Ministry of Forests and Environment facilitate execution of FETF creating enabling environment, developing regulatory mechanisms and monitoring. Civil society organizations provide support to PPFC in developing its capacity to execute FETF along with raising the funds. Panchase Protected Forest Council and community forest user groups engage in protection and management of forest and other natural ecosystems in ‘Core area’ and ‘Fringe area’ respectively.

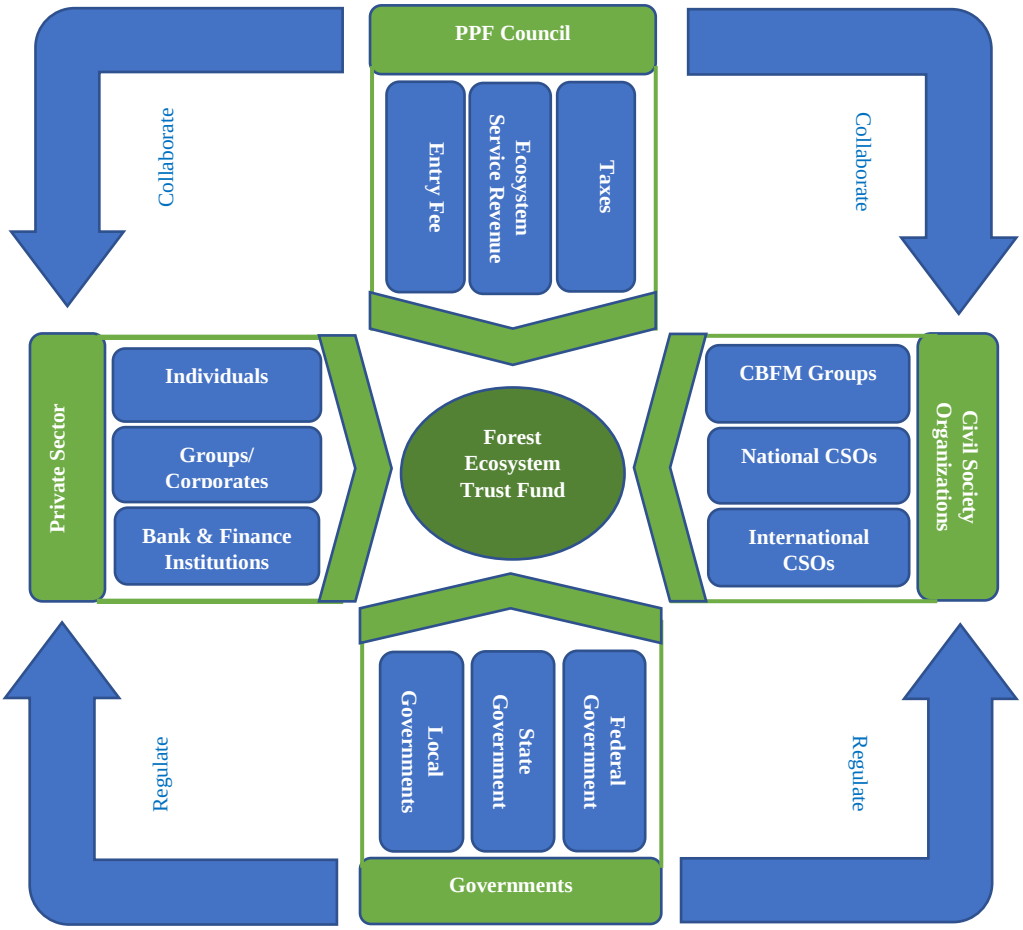

Figure 22: Proposed ‘Forest Ecosystem Trust Fund’ framework for Panchase Protected Forest

CHAPTER 5

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Panchase Protected Forest is a rich repository of ecosystems providing wide range of ecosystem services including provisioning, regulating, habitat and cultural and amenity services. Panchase Protected Forest has been providing 17 ecosystem services among them six are provisioning, six are regulating, two are habitat and three are cultural and amenity services. The provisioning services include food, medicines, raw materials, energy sources, ornamental resources and water. As provisioning services, 35 species of plants have been used as food, 40 species as medicines, 22 species as raw materials, 17 species as energy sources and 119 species as ornamental resources from the protected forest. Moreover, 29 streams originated from the protected forest are the source of drinking water in the region and the major source for downstream rivers and lakes. Likewise, the regulating services provided by the protected forests include water flow regulation, erosion prevention, water purification, soil fertility maintenance, air quality regulation and climate regulation. The Panchase Protected Forest has been regulating climate by sequestrating 29,948.56 tons of atmospheric carbon (equivalent to 92,309 tons of CO_2) annually. Moreover, the habitat services provided by the protected forest include life cycle maintenance and genetic resources maintenance. The protected forest is habitat for 875 species including 589 species of plants, 262 species of birds and 24 species of mammals. Furthermore, the cultural and amenity services provided by the protected forest include recreation and tourism, religious and cognitive resources. Annually, 3,600 foreign visitors and 25,340 pilgrims visit the protected forest for recreation and pilgrimage, respectively.

Panchase Protected Forest is not only important for conserving biodiversity and safeguarding environment, but also important for providing economic benefits to the society. The ecosystem services provided by the protected forest has substantial economic value. The total annual economic value of the ecosystem services of the Panchase Protected Forest is NPR 204.63 million (USD 2,046,312). Out of the total

economic value, 33% is from consumptive use and 67% from non-consumptive use, indirect use and non-use values. Nepal's national accounting system recognizes only consumptive use (33% in the present case) ignoring non-consumptive use, indirect use and non-use values. The economic contribution of ecosystem services provided by the forest is, thus, undervalued and not well reflected in the national accounting system.

People's WTP to conserve the Panchase Protected Forest is worthy. Household annual WTP is NPR 7,404 (USD 74.04). WTP of th households having position in executive committee of community-based forest management is higher compared to the households having no position. Similarly, WTP of the households having higher income is larger compared to the households having lower income. Likewise, WTP of the person having more education is higher than the person of having less education. Moreover, households having bigger family size willing to pay more compared to households having smaller family size. By gender, the women are willing to pay more than the men.

The benefits of ecosystem services provided by Panchase Protected Forest widespread from local to sub-national, national and global levels. The benefits of provisioning services are distributed to local level whereas, the benefits of regulating services are distributed to both local and sub-national levels. The benefits of habitat services are distributed to national and global levels and the benefits of cultural and amenity services are distributed to all local, sub-national, national and global levels.

Ecosystem based financing mechanisms are crucial to capture the value of ecosystem services for conservation and sustainable management of ecosystems. In Panchase Protected Forest, 'Payment for Ecosystem Services' and 'Forest Ecosystem Trust Fund' may be appropriate financing mechanisms internalizing positive externalities of widely distributed benefits of ecosystem services.

5.2 Recommendations

Being rich repository of ecosystems and providing wide range of ecosystem services and benefits from local to global levels, sustainable management of Panchase Protected Forest is crucial. In order to conserve ecosystems and increase ecosystem services provided by Panchase Protected Forest, the present study has made following recommendations.

- Realizing under-representation of substantial values, well recognition of economic values of forest ecosystem services in National Accounting System is needed to reflect in policy instruments and economic decisions.

- Recognizing high willingness to pay of households having higher family income, forest management paradigm in the 'Fringe area' need to be shifted from 'protection focus' to 'production focus' without compromising ecosystem integrity to create economic opportunities to local communities.

- Realizing high willingness to pay of women and people engaged in community forestry, community participation and women participation need to be increased in forest management decisions to increase ownership, accountability and contribution of local communities.

- Capturing values of ecosystem services, 'Payment for Ecosystem Services' mechanism and 'Forest Ecosystem Trust Fund' is urged to be established to finance sustainable management of Panchase Protected Forest.

- Realizing inadequate quantitative information, quantification of regulating services of Panchase Protected Forest and economic valuation of other protected forests are suggested as future research areas to recognize substantial economic values of forest ecosystem services.

CHAPTER 6

6. SUMMARY

Diverse geography and altitudinal variations have resulted in rich diversity of natural ecosystems in Nepal. Ecosystem has both structural and functional components and through continuous interaction of these components, ecosystem delivers crucial materials and services to the functioning of ecosystem itself and to the human society as a whole. Ecosystem services are broadly classified into provisioning, regulating, cultural and amenity, and habitat services. The ecosystem services have both ecological as well as economic values. Thus, valuation of ecosystem services is important in creating markets and developing incentive mechanisms for ecosystem conservation and management.

Globally, ecosystem services agenda has been moving forward from scientific research agenda to decision making tools. However, in Nepal, it is still in the initial stage of research and exploration. There seem limited studies have been carried out on ecosystem services in few protected areas and wetlands of Nepal. However, there seems no research carried on ecosystem services of protected forest regime in Nepal. Most of the studies so far conducted in Nepal have realized inadequate recognition of ecosystem services in policy and economic decisions. Moreover, preceding studies have urged the need of ecosystem financing for sustainable management of ecosystems. Therefore, the present study has been carried out with the aim of assessing ecosystem services of Panchase Protected Forest by identifying ecosystem services, estimating their economic values, assessing distribution of benefits and framing financing mechanisms for sustainable management of the Panchase Protected Forest.

The Panchase Protected Forest having an area of 5,775.7 hectares lies at the juncture of Kaski, Syangja and Parbat districts of Gandaki State ranging from 900 to 2,517 meter above mean sea level. It represents five forest types *viz.* Alder Forest, Chirpine-Broad Leaved Forest, Oak-Laurel Forest, Lower Temperate Oak Forest, and *Schima-Castanopsis* Forest. Panchase Protected Forest has been divided into ‘Core area’, for protection and conservation, and ‘Fringe area’, for management and sustainable use.

The adjacent settlements outside the protected forest have been declared as an 'Impact zone'. In total, 27,482 people inhabit in the 'Impact zone' of the protected forest in 7,039 households.

Multiple methods have been used to achieve the objectives of the study. The ecosystem services provided by the protected forest were identified through transect walk observations, Focus Group Discussions, Key Informant Interviews and expert consultations. The economic value of ecosystem services was estimated applying Total Economic Valuation framework considering both use values (consumptive use, non-consumptive use and indirect use) and non-use values (option value, existence value, altruist value and bequest value) of ecosystem services. Market Price Method was applied for estimating consumptive use and indirect use values, whereas Travel Cost Method was applied to estimate non-consumptive use values. Visitors survey was conducted to feed information for Travel Cost Method. Stem volume data presented in the management plans of Panchase Protected Forest were used to calculate carbon sequestration as an indirect use value. Contingent Valuation Method was applied to estimate non-use values of ecosystem services through 'willingness to pay' of the people in the 'Impact zone' of the protected forest. A multiple regression equation was developed to understand relationship between 'willingness to pay' and various socio-economic variables. Questionnaire survey was administered in the 'Impact zone' of the protected forest to collect information required for consumptive use of ecosystem services and for Contingent Valuation. The distribution of benefits of the ecosystem services was assessed through Focus Group Discussions, Key Informant Interviews and expert consultations. The financing mechanisms were explored and identified through adopting Focus Group Discussions, Key Informant Interviews and expert consultations. The present study has also used secondary sources of information reviewing relevant literature with due acknowledgements.

The results reveal that Panchase Protected Forest has been providing 17 types of ecosystem services including six provisioning, six regulating, two habitat and three cultural and amenity services. The provisioning services include food (35 species of plants), medicines (40 species of plants), raw materials (22 species of plants: 1,954.88 m^3 of timber per year), energy sources (17 species of plants: 8,537.39 tons of fuelwood per year), ornamental resources (119 species of plants) and water (29 streams). The

regulating services include water flow regulation, erosion prevention, water purification, soil fertility maintenance, air quality regulation and climate regulation (sequestrating 29,948.56 tons of carbon in a year). The habitat services include life cycle maintenance and genetic resources maintenance (589 species of plants, 262 species of birds and 24 species of mammals), and the cultural and amenity services include recreation and tourism (3,600 foreign visitor per year), cultural and religious (25,340 pilgrim per year), and cognitive resources.

The total economic value of the ecosystem services provided by Panchase Protected Forest was found to be NPR 204.63 million (USD 2,046,312) per year. In the total economic value, use value has higher contribution with NPR 152.52 million (USD 1,525,155) compared to non-use value, which contributes NPR 52.12 million (USD 521,157). In the total use value, consumptive use value has the highest contribution worth NPR 68.52 million (USD 685,212) followed by indirect use value worth NPR 46.15 million (USD 461,548) and non-consumptive use value worth NPR 37.84 million (USD 378,395).

The contribution of consumptive use value to the total economic value was found to be 33% (NPR 68.52 million), whereas contribution from other values (non-consumptive use, indirect use and non-use value) was found to be 67% (NPR 136.11 million). It indicates that Panchase Protected Forest is not only important for conserving biodiversity and safeguarding natural environment, but also important for providing economic benefits to the society. However, only consumptive use value of provisioning services has been recognized in the current National Accounting System of Nepal, excluding non-consumptive value, indirect use value and non-use value of ecosystem services from the system. It indicates that the economic contribution of ecosystem services is undervalued and is not well reflected in the country's economic decisions.

The people's willingness to pay from the 'Impact zone' for non-consumptive value of ecosystem services of the Panchase Protected Forest was found to be NPR 52.15 million (USD 521,157) per year with an average worth of NPR 7,403.85 (USD 74.04) per household. The highest contribution was from bequest value worth NPR 17.09 million (USD 170,850) followed by option value, existence value and altruist value worth NPR 16.00 million (USD 160,021), NPR 9.62 million (USD 96,206) and NPR 9.41 million

(USD 94,079), respectively. The highest WTP for bequest value indicates that people in the study area are interested to contribute more in conserving forest, so that future generations will also have access to the benefits of ecosystem services. The results of the regression analysis revealed that out of eight socio-economic variables, WTP was found to be significantly positively correlated ($p < 0.05$) with the five variables *viz.* 'gender', 'education', 'family size', 'position on forest' and 'family income'. The beneficiaries of the ecosystem services from the protected forest range from local to sub-national, national and global levels.

The present study has proposed 'payment for ecosystem services' and 'forest ecosystem trust fund' as appropriate financing mechanism for conservation and sustainable management of Panchase Protected Forest. The present study has suggested to shift forest management paradigm in the 'Fringe area' from 'protection focus' to 'production focus' to create economic opportunities to local communities without compromising ecosystem integrity. However, community participation and women participation need to be increased in forest management decisions to increase ownership, accountability and contribution of local communities. Moreover, the present study has suggested to revise current National Accounting System recognizing the value of forest ecosystem services in economic decisions.

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APPENDIX I

Ecosystems of Nepal

Physiographic zone	SN	Name of ecosystem
Highlands	1	Glaciers, snow, rock
	2	Alpine meadows with *Graminae* and *Cyperaceae*
	3	Xerophytic mat patches and scarcely vegetated rocks and screes
	4	Mesophytic mat patches and scarcely vegetated rocks and screes
	5	Mesophytic and hydrophytic mat patches and scarcely vegetated rocks and screes
	6	Alpine meadows on the southern side of the Himalaya
	7	Dry alpine vegetation on the northern side of Himalaya
	8	High altitude discontinuous vegetation cushion plants
	9	Meadows: mat patches
	10	Scarcely vegetated rocks and screes of upper alpine level
	11	Meadows *et lande communes aux*
	12	Rhododendron mesohygrophytic scrublands, *Juniperus*…, meadows
	13	*Rhododendron* mesohygrophytic scrublands (*R. anthopogan, R. nivale*…)
	14	Juniper mesohygrophytic scrublands (*J. indica, J. recurva, J. squamata*)
	15	Xerophytic closed alpine mat and scrub
	16	Mesophyti closed alpine mat and scrub
	17	Shrublands with patches of abundant *Rhododendron anthopogon, R. nivale*…
	18	Mesophytic closed sub-alpine mat and scrub (*R. anthopogon*…)
	19	Rhododendron-Birch forest (*Betula utilis, R. campanulatum*)
	20	Birch-Blue pine open forest
	21	North Himalayan alpine vegetation
	22	*Betula utilis* forest with Rhododendron… and *Abies spectabilis*
	23	Rhododendron shrublands
	24	Rhododendron-Juniper shrublands
	25	Mesophytic Fir forest with oak and rhododendron
	26	Hygrophytic Fir-Hemlock-Oak forest
	27	Fir forest (*Abies spectabilis*)
	28	*Abies spectabilis* forest with rhododendron
	29	*Larix griffithiana* forest
	30	*Larix griffithiana, L. potanini* forest
	31	*Larix potanini* forest
	32	High altitude cushion plant formation

	33	*Caragana versicolor, Lonicera spinosa* steppe
	34	*Caragana gerardiana, Lonicera spinosa* xerophile steppe
	35	*Caragana bresispina, Artemisia* steppe
	36	*Caragana pygmaea, Lonicera spinosa* xerophile steppe
	37	*Myricaria-Hippophae*-Salix riverine thickets
	38	*Sophora moorcroftiana, Oxytropis mollis* steppe
	39	Water bodies
Midhills	40	Mesophytic monatne Oak-Rhododendron forest
	41	Mixed Blue Pine-Oak forest
	42	Mixed hygrophytic Oak-Hemlock-Fir forest
	43	Open and dry montane Blue Pine forest
	44	Blue Pine-Spruce forest
	45	Juniper forest (*Juniperus indica*)
	46	Rhododendron-Hemlock-Oak forest
	47	Hemlock forest (*Tsuga dumosa*)
	48	Mountain Oak forets (*Quercus semecarpifolia*)
	49	Blue Pine-Spruce-Fir forest
	50	Spruce mountain forest (*Picea smithiana*)
	51	*Lithocarpus pachyphylla* forest
	52	*Rhododendron cinnamonum* forest
	53	Deciduous mixed broad-leaved forest
	54	Mixed broadleaved forest, *Rhododendron-Acer-Symplocus-Lauraceae*
	55	*Daphniphyllum himalayense* forest with a few *Rhododendron grande*
	56	Blue Pine-Cypress forest
	57	Cypress forest with dwarf Barberry
	58	Collinean Oak forest (*Quercus leucotrichophora, Q. lanata*)
	59	Mixed Blue Pine-Oak forest
	60	Mixed Oaks-Laurels forest with shrubs
	61	Mixed hygrophytic broad-leaved forest with oaks
	62	Cedar forest (*Cedrus deodara*)
	63	Open Blue Pine forest (*Pinus wallichiana*)
	64	Collinean Oak-mixed broadleaved forest (*Q. lanata*)
	65	*Aesculus, Juglans* riverine forest
	66	Deciduous broadleaved forest (*Alnus, Juglans, Acer*)
	67	Hygrophytic *Quercus lamellosa* forest
	68	Hygrophytic forest with *Quercus lamellosa*
	69	Hygrophytic forest with *Casnanopsis tribuloides*
	70	Mesohygrophytic forest with *Quercus glauca*
	71	Mesohygrophytic forest with *Quercus lanata*, *Pinus excelsa*
	72	*Eugenia tetragona*, *Ostodes paniculata* forest

	73	Mixed Chir Pine-Oak forest (*Pinus roxburghii, Q. leucotrichophora*)
	74	*Quercus glauca, Alnus nepalensis, Betula alnoides* riverine forest
	75	Open *Olea cuspidate* forest
	76	Sub-tropical mixed broadleaved forest
	77	*Quercus incana, Schima wallichii* forest
	78	Hygrophytic *Schima wallichii, Castanopsis tribuloides* forest
	79	*Castanopsis tribuloides* forest with *Schima walichii*, …
	80	*Castanopsis hystrix* forest with *C. tribuloides* …
	81	*Alnus nepalensis* forest
	82	Chir Pine forest with grasses and *Engelhardria*
	83	Mixed Chir Pine-Broadleaved forest
	84	*Alnus nepalensis* riverine forest
	85	*Euphorbia royleana* steppe in inner valleys
	86	Grasses-*Artemisia* steppe
	87	Hygrophytic *Schima wallichii* forest
	88	*Schima wallichii, Castanopsis indica* hygrophile forest
	89	*Schima wallichii, Pinus roxburghii* mesohygrophile forest
	90	*Pinus roxburghii* xerophile forest with *Phyllanthus emblica*
	91	*Schima wallichii, Lagerstromia parviflora* hygrophile forest
	92	Pokhara cultivated areas
		Waterbodies
Siwaliks	93	Upper Siwalik Chir Pine-Oak forest
	94	Siwaliks Chir Pine forest
	95	*Alnus nitida* riverine forest
	96	Tropical hill Sal forest in large valleys
	97	Tropical riverine forest (*Albizia lebbek, Toona ciliata*, …)
	98	Sal forest in inner valleys (*Shorea robusta, Terminalia tomentosa*)
	99	Mesophytic tropical forest on southern slopes of the Siwaliks
	100	Hygrophytic tropical forest on northern slopes of the Siwaliks
	101	Siwalik tropical deciduous forest
	102	Tropical hill Sal forest
	103	Dense forest with *Shorea robusta, Lagerstromia parviflora*, …
	104	Dense forest with *Terminalia tomentosa, T. belerica*, …
	105	Dun valleys Sal forest
	106	Dun cultivated areas
Tarai	107	Tropical riverine forest
	108	Sal forest (*Shorea robusta*)
	109	Tarai tropical Sal forest (*Shorea robusta, Terminalia tomntosa*, …)
	110	Khair-Sissoo riverine forest
	111	*Samalia malabarica, Trewia nudiflora* riverine forest

112	Bhabar light Sal forest
113	Pseudo steppe with *Graminae*, Tropical elephant grasses
114	Tarai tropical Sal forest
115	Tropical mixed wet forest
116	Tropical dense forest with *Terminalia* sp.
117	Cultivated areas
118	Tarai cultivated areas
	Waterbodies

Source: Dobremez (1976)

APPENDIX II

Protected areas of Nepal

SN	Name of protected areas	Area (hectare)		Established Year
		Core area	Buffer zone	
1	Chitwan National Park	95,263	72,937	1973
2	Bardia National Park	96,800	50,700	1976
3	Shukla Phanta National Park	30,500	24,350	1976
4	Langtang National Park	171,000	42,000	1976
5	Rara National Park	10,600	19,800	1976
6	Sagarmatha National Park	114,800	27,500	1976
7	Khaptad National Park	22,500	21,600	1984
8	Shey Phoksundo National Park	355,500	134,900	1984
9	Parsa National Park	62,739	28,530	1984
10	Makalu Barun National Park	150,000	83,000	1991
11	Shivapuri Nagarjun National Park	15,900	11,861	2002
12	Banke National Park	55,000	34,300	2010
13	Koshi Tappu Wildlife Reserve	17,500	17,300	1976
14	Dhorpatan Hunting Reserve	132,500	-	1987
15	Annapurna Conservation Area	762,900	-	1992
16	Kangchenjunga Conservation Area	203,500	-	1997
17	Manaslu Conservation Area	166,300	-	1998
18	Krishnasar Conservation Area	1,695	-	2009
19	Api Nampa Conservation Area	190,300	-	2010
20	Gauri Shankar Conservation Area	217,900	-	2010
	Total Area	2,873,197	568,778	

Source: DNPWC (2018)

APPENDIX III

Lists of community forests in the 'Fringe area' of Panchase Protected Forest

		Community forest		
District	SN	Name	Area (ha)	Household (No)
Kaski	1	Latrepakha	51.01	34
	2	Kudwidanda	11.36	42
	3	Shrutipakha	5.87	42
	4	Tamagi	71.68	90
	5	Pattharepakha	10.50	46
	6	Shanti Salghari	28.74	145
	7	Panchase Laligurans	57.00	38
	8	Dhadpakha	5.50	83
	9	Naulo Chharchhare	69.50	230
	10	Raniban	14.90	201
	11	Bhirpani	114.08	134
	12	Margibhyapu	28.20	54
	13	Majhuwalausi	66.50	84
	14	Jauchhare Dadakharka	105.00	34
	15	Banpala	13.36	77
	16	Majuwa	68.40	131
	17	Nibin Budiraha	12.88	42
	18	Dhursedanda	7.52	59
	19	Ghurpure	10.16	58
	20	Ghaderi	4.37	20
	21	Tarebhir Bhulbhule	18.36	34
	22	Raibhandar Chuchchi	90.00	154
	23	Bamdibhir	48.50	134
	24	Kadeni Tallobhanjyang	9.48	91
	25	Lekkopakha	3.64	93
	26	Dhadyankhadarko Goudamuni	28.30	114
	27	Bhusetari	12.50	60
	28	Baunne Mohariya	2.60	45
	29	Karangkot	74.32	201
	30	Tilhar	9.00	91
	31	Byadchaur	41.20	107
	32	Sila	31.80	65
	33	Atmeko Agan	7.20	72
	34	Khaltu	10.64	65

	35	Patleswara	51.40	80
	36	Tarebhir	2.84	40
	37	Kadeni Banpale	7.25	24
	38	Samundra Dadapari	70.25	254
	39	Bhedikharka Tallokharka	121.50	307
	40	Panchphohate	3.25	69
	41	Margjyotipawar Mahila	3.76	24
	42	Samundre Dasmare	5.75	91
	43	Loktantrik	1.04	72
	44	Ramlaxman	278.00	211
		Sub-Total	1,689.11	4,142
Syangja	1	Jalkeni	1.89	79
	2	Kharidada Chhiruwapani	16.25	104
	3	Bajhokhet	7.86	112
	4	Chhahara	18.00	68
	5	Dihigadhare	2.70	20
	6	Jaukhet Gaigaru	29.75	115
	7	Gahatero Biroute	20.00	79
	8	Todkemathiko	68.67	75
	9	Simle	2.72	118
	10	Pale	8.00	65
	11	Kucheko Muhan	4.88	49
	12	Ralkhola	23.84	119
	13	Rapupakho	7.20	49
	14	Kodali Wang	7.68	91
	15	Galyang Siddeshwar	34.69	91
	16	Lukuwa	34.33	264
	17	Noulokharka	194.00	454
	18	Adherikhola Rause	22.58	69
	19	Noulonigale	69.50	51
	20	Hadikhola Basyani	97.85	82
	21	Gopepatalo	94.00	291
	22	Reshganti Pang	95.00	354
	23	Nigale Budhaghare	11.10	88
	24	Baliko Khoriya	3.00	84
	25	Basyahari	20.00	51
	26	Devisthan Batase	9.91	89
	27	Thamtaletro	79.87	187
	28	Hadikhola Dhungesagu	18.20	36
	29	Lampang Phalate	243.00	352

	30	Tamu Khyo	0.70	17
	31	Thadokhoriya	1.28	57
	32	Maidan	2.10	28
	33	Thadopakho	45.14	90
	34	Basulpakho	29.20	30
	35	Samakhoriya	3.59	104
		Sub-Total	1,328.48	4,012
Parbat	1	Odarepakha	5.00	105
	2	Charipani Guphadada	24.87	104
	3	Pokharipakha Charipani	13.27	34
	4	Patal	76.75	62
	5	Ramchepakha	61.25	32
	6	Chihandada	8.00	140
	7	Kaurebhir	2.20	37
	8	Janaekata	18.61	154
	9	Gahate Salghari	1.49	23
	10	Thuldhunge	7.37	33
	11	Dhadko Chour	3.85	43
	12	Chinardada	48.00	140
	13	Sahelepakha	9.15	40
	14	Tarebhir	27.25	77
	15	Ransepatal	18.61	142
	16	Bakhlesim	70.17	101
	17	Himkharka	12.92	206
	18	Chyandada	4.00	55
	19	Adheripakha	15.40	153
	20	Masinechour Chihandada	3.15	55
	21	Jarekhola Pakho	1.85	12
	22	Nakatipakha	20.00	146
	23	Maledada	24.71	194
	24	Chauka Salghari	10.25	120
	25	Shanti	20.32	82
	26	Talbaraha	267.84	501
	27	Chitre Siddabaraha	402.37	319
	28	Pairepakha	3.91	24
	29	Phalgu	15.00	76
		Sub-Total	1,197.56	3,210
		Total	4,215.15	11,364

Source: DoF (2017)

APPENDIX IV

Checklists for transect walk observation, Focus Group Discussion and Key Informant Interview

1. What are the ecosystem services provided by Panchase Protected Forest?
    - Provisioning services
        - Plant species or products used as food
        - Herbal or plant species used as medicines
        - Plant species used as timber
        - Plant species used as raw materials
        - Handicrafts made from this region
        - Fiber extracted from the forest
        - Plant species used as fuelwood
        - Plant species used for charcoal
        - Plant species used for ornamental purposes
        - Water: water sources and water use
    - Regulating services
        - Air/water purification
        - Climate regulation
        - Natural hazards prevention
        - Water flow regulation
        - Erosion control
        - Soil fertility
        - Pollination
        - Pest and disease control
    - Habitat services (important species)
        - Lives
        - Gene pool
    - Cultural and amenity services
        - Religious and cultural sites
        - Religious and cultural occasions
        - Tourist attractions and facilities
        - Aesthetic

2. Who are the beneficiaries of the ecosystem services provided by the PPF? (specific beneficiaries for specific services)
    Provisioning services
    Regulating
    Habitat
    Cultural and amenity

3. What are the possible financial sources available to conserve and manage Panchase Protected Forest?
    Existing policy instruments related to ecosystem financing
    Existing institutions
    Existing financing sources
    Possible financing sources for future

APPENDIX V

List of Key Informants and experts consulted during the research

Key Informants:

1. Mr. Gopal Gurung, PPFC
2. Ms. Tilmaya Gurung, PPFC
3. Mr. Dhaka Ram Dhakal, Bangefadke VDC, Syangja
4. Mr. Himlal Poudel, Bangefadke VDC, Syangja
5. Mr. Birkha Bahadur Gurung, Chitre VDC, Parbat
6. Mr. Bishnu Kumari Gurung, Chitre VDC, Parbat
7. Mr. Siri Prasad Gurung, Bhadaure Tamagi, Kaski
8. Ms. Khem Kumari Gurung, Bhadaure Tamagi VDC, Kaski
9. Ms. Maya Gurung, Hotelier, Bhanjyang, Kaski
10. Mr. Khusi Man Gurung, Hotelier, Panchase Peak, Parbat

Experts

1. Dr. Thakur Silwal, Tribhuvan University, Institute of Forestry, Pokhara
2. Dr. Krishna Prasad Acharya, Ministry of Forests and Environment
3. Dr. Buddi Sagar Poudel, Ministry of Forests and Environment
4. Mr. Sanjaya Tiwari, Panchase Protected Forest Office
5. Mr. Madhab Baral, Panchase Protected Forest Office
6. Mr. Somesh Das, Panchase Protected Forest Office
7. Mr. Prabhat Sapkota, District Forest Office
8. Mr. Shiv Raj Bhatta, WWF
9. Mr. Laxmi Dutt Bhatta, ICIMOD

APPENDIX VI

Questionnaire for Household Survey

Interviewer:

Date:

VDC/Ward:

1. General information of the respondent/household head

    Name:

    Gender:

    Age:

    Family size:

    Education:

    Occupation:

    Distance from forest:

    Position in Forest User Group:

    Position in Panchase Protected Forest:

2. How much land does the household have?

    Khet (Irrigated paddy field) in *Ropani*:

    Bari (non-irrigated farm land) in *Ropani*:

    Other:

3. How many livestock does the household hold?

    Buffalo:

    Cow:

    Goat:

    Sheep:

    Others:

4. What is the annual income of the household and what are the sources of the income?

Sources of Income	No of HH member involved	Annual Income (NPR)
Agriculture		
Livestock		
Service (Salary)		
Family Business		
Remittance		
Pension		
Wage Labor		
Other		

5. What are the ecosystem services (provisioning) annually received by the household from Panchase Protected Forest? what is quantity of the collected/received goods? and what is the amount to be paid to receive/collect the goods?

Goods/services	Quantity received	Amount paid
Timber		
Fuelwood		
Drinking water		
Other		

6. What is the frequency of visit to Panchase Protected Forest as pilgrims in a year? what are the associated cost for the visits and how much?

Time/season of visits:

No of visits:

No of family members in a visit:

Time spent in a visit (days):

Expenses per person (food/transportation/others)

7. What is your willingness to pay to conserve Panchase Protected Forest for the following services/values to be received from the forest?

Service/Value*	No of days willing to contribute (annually)
Option value	
Existence value	
Altruist value	
Bequest value	

Option value

Future use of known and unknown benefits. Relates to the importance that people give to the future availability of ecosystem services for personal benefit.

Existence value

Satisfaction of knowing that ecosystem exists. Value related to the satisfaction that individuals derive from the mere knowledge that species and ecosystems continue to exist

Altruist value

Satisfaction of knowing that other people have access to nature's benefits. Value attached by individuals to the fact that other people of the present generation have access to the benefits provided by species and ecosystems (intra-generational equity concerns).

Bequest value

Satisfaction of knowing that future generations will have access to nature's benefits. Value attached by individuals to the fact that future generations will also have access to the benefits from species and ecosystems (inter-generational equity concerns).

APPENDIX VII

Questionnaire for Visitor Survey

Interviewer:

Date:

Place of interview:

1. General information of the respondent/visitor

    Name (optional):

    Country of citizenship (optional):

2. Have you plan to visit only Panchase? If no, what are the visiting destinations in Nepal you are planning in this trip?

3. How many days you are going to spend in Panchase Protected Forest?

4. How much amount do you spend for the following items for Panchase visit?

Items	Amount in NPR
Food	
Accommodation	
Transportation (from Pokhara to Panchase and vice versa)	
Other	

APPENDIX VIII

Dissertations in Panchase Protected Forest by TU-IoF students

Degree	Title of thesis
M.Sc.	Assessment of threats and human Asiatic black bear conflict in Panchase Protected Forest (Hari Narayan Acharya, 2016)
	Social Preference and Valuation of Ecosystem Services in Panchase Area of Phewa Watershed (Megharaj Poudel, 2016)
	Climate change vulnerability and adaptation strategies in Panchase Region of Nepal (Bishnu Prasad Adhikari, 2016)
	Analysis of Bio-engineering measures: Status and Potentiality in Panchase Region (Raj Kumar Gupta, 2016)
	Climate Change Vulnerability and ecosystem-based adaptation in Panchase region of Nepal (Sanjay Tiwari, 2016)
	Resource Condition and market potential of Chirayito, Amriso and Timur from people's perspective in Panchase region (Sandesh Bolakhe, 2016)
B.Sc.	Evaluation of status and anti-bacterial properties of *Swertia chirayita* of Panchase Hill (Khagendra Raj Baral)
	Ecological and Social status of *Paris polyphylla* in Panchase area and its anti-bacterial activity: A case study from Bhadaure-Tamagi (Meena Suyal Chhetri, 2011)
	Ecological distribution and habitat conservation status of endemic orchids (*Eria pokharensia*) of Nepal in Panchase Protected Forest (Anil Khanal, 2016)
	Valuation of goods and services of protected forest: A case study from Panchase Protected Forest (Daya Ram Pandey, 2016)
	An assessment of opportunities and challenges of ecotourism in Panchase Protected Forest (Anupa Silwal, 2016)
	Human Asiatic Black Bear conflict in Panchase Protected Forest: A case study from Bhadaure Tamagi VDC of Kaski district (Rabin Poudel)
	Ecology and ethnobotany status of *Cyathea spinulosa* (Tree fern) in Panchase Area: A case study from Bhadaure Tamagi VDC of Kaski district (Bijay Kumar Thapa 2016)
	Species identification and diet analysis of Asiatic Black Bear in Panchase Protected Forest (Dhruv Bahadur Malla, 2012)
	Threats and Conservation of *Paris polyphylla* a Vulnerable Medicinal Plant in the Panchase Protected Forest, Nepal (Geeta Pokharel, 2018)

Source: IoF Library (2018)

APPENDIX IX

List of Research Article Published

SN	Title	Author(s)	Published date	Journal
1	Ecosystem services in the Mid-hills of Western Nepal: A case of Panchase Protected Forest	Ananta Ram Bhandari, Udhab Raj Khadka, and Keshav Raj Kanel	October 2018	Journal of Institute of Science and Technology (JIST), Tribhuvan University. DOI: 10.3126/jist.v23i1.22146
2	Valuation of ecosystem services: A case of Panchase Protected Forest in the Mid-hills of Western Nepal	Ananta Ram Bhandari, Udhab Raj Khadka, and Keshav Raj Kanel	February 2018	Asian Journal of Science and Technology (AJST) (www.journalajst.com). DOI: 10.21275/ART20179741
3	Economic value of cultural ecosystem services: An assessment from Protected Forest of Nepal	Ananta Ram Bhandari, Udhab Raj Khadka, and Keshav Raj Kanel	January 2018	International Journal of Science and Research (IJSR) (www.ijsr.net). DOI: 10.21275/ART20179741

APPENDIX X

Research article published in Asian Journal of Science and Technology, February 2018

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RESEARCH ARTICLE

VALUATION OF ECOSYSTEM SERVICES: A CASE OF PANCHASE PROTECTED FOREST IN THE MID-HILLS OF WESTERN NEPAL

***Ananta Ram Bhandari, Udhab Raj Khadka and Keshav Raj Kanel**

Tribhuvan University, Central Department of Environmental Science, Kathmandu, Nepal

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ABSTRACT

Forests provide numbers of ecosystem services for human wellbeing. However, the importance of ecosystem services arising from forests is poorly recognized in developing countries like Nepal. The present study has estimated economic value of ecosystem services provided by Panchase Protected Forest of Nepal. Applying contingent valuation method, 364 people were surveyed for their willingness-to-pay to estimate indirect use value of ecosystem services. The analysis revealed that total annual economic value of the Panchase Protected Forest is NPR 52.2 million (USD 521,930) and the per hectare annual economic value is NPR 9037.75 (USD 90.37).The regression analysis concludes that people having higher income and people having access to executive positions in community based forest management are willing to pay more to conserve forests. Creation of economic opportunities for local people and strengthening community engagement in forest management decisions are crucial for better management of protected forests.

INTRODUCTION

Natural ecosystems provide a wide range of services and economic benefits for local livelihoods (Pant et al., 2012) and human wellbeing (MEA, 2005). These benefits are the multiple commodities and services that are supplied by natural ecosystems as a result of their structure, ecological characteristics, functions or processes that directly or indirectly contribute to human wellbeing (Daily, 1997; Costanza *et al.,* 2017). Ecosystem services are the benefits people obtained from ecosystem (MEA, 2005). After the Millennium Ecosystem Assessment (MEA), ecosystem services science has made much progress in framing the concepts and approaches (Small *et al.,* 2017). MEA (2005) classifies ecosystem services into four broad categories *viz.* provisioning, regulating, cultural and supporting services. Later, the Economics of Ecosystem and Biodiversity (TEEB) slightly modified the MEA categories of ecosystem services into provisioning; regulating; habitat; and cultural and amenity services. Costanza *et al.* (2017) argues that the TEEB framework added more of the economic aspect of ecosystem services. Some of the ecosystem services have market prices, but others do not have since they are not traded in the market place (Dasgupta *et al.,* 2011). However, these services which are not measured through market mechanism are of high use or non-use value for the human wellbeing. TEEB (2010) has framed these non-use values into option value, existence value, altruistic value and bequest value.

Corresponding author: **Ananta Ram Bhandari,**
Tribhuvan University, Central Department of Environmental Science, Kathmandu, Nepal.

This study adopts the TEEB's frame and definition of non-use values.*Option value* is the future use of known and unknown benefits and relates to the importance that people give to the future availability of ecosystem services for personal benefit. *Existence value* is the satisfaction of knowing that ecosystem exists and relates to the satisfaction that individuals derive from the mere knowledge that ecosystems continue to exist. *Altruistic value* is the satisfaction of knowing that other people of the present generation have access to the benefits provided by ecosystems. *Bequest value* is the satisfaction of knowing that future generation will also have access to the benefits from ecosystems.

The complex dynamics between the ecology-economy interface, market and institutional failure, and human activities often lead to degradation of natural environment and accelerated loss of ecosystem services (TEEB, 2010). The failure to account for the full economic values of ecosystems has been a significant factor in their continuing loss and degradation (MEA, 2005). As the benefits received from ecosystem services are usually neglected or undervalued in decision-making due to the lack of market prices of such services, alternative valuation shows how conservation can deliver a range of economic advantage (TEEB, 2010). Moreover, valuation enables to estimate the value of goods and services provided by the ecosystems and helps in creating incentive mechanisms to conserve these ecosystems (DEFRA, 2007).

Despite smaller in size, 118 natural ecosystems exist in Nepal (Dobremez, 1976) of which forests have the most important

stake as it covers 44.74% (6.61 million hectare) of the total area of the country (DFRS, 2015). Nepal recently initiated 'protected forest', a new category of forest management regime, to balance human needs through conserving biodiversity and safeguarding environment (Shrestha *et al.,* 2014). Nepal has declared eight protected forests covering 133,754.8 hectares (GoN/MoFSC, 2014). Protected forests assumed to provide numbers of ecosystem services, however, the understanding and importance of ecosystem services arising from forests are not properly recognized in policy and management decisions (Paudyal, 2015). Therefore, valuation of ecosystem services is crucial in identifying economic benefits provided by the forests. The present research aimed at valuing a representative protected forest highlighting the non-use values of ecosystem services such as option value, existence value, altruistic value and bequest value.

MATERIALS AND METHODS

Study area

We conducted the research in Panchase Protected Forest (PPF). The PPFwas declared as protected forest, in 2012, considering its significance for biodiversity, ecotourism and religion (GoN/MoFSC). It comprises an area of 5,775 hectares at the juncture of *Kaski, Syangja* and *Parbat* districts in the western Nepal. The forest is rich in biodiversity as it has wide range of altitudinal variation from 900 m to 2,517 m above mean sea level. DoF (2012) has recorded 589 species of flowering plants including 107 medicinal and aromatic plants and 113 orchids, 56 species of wild mushrooms, and 98 species of ferns in this region. Out of total 35 forest types found in Nepal (Stainton, 1972), the PPF represents five forest types- alder forests, chirpine-broad leaved forest, oak-laurel forest, lower temperate oak forest, and *Schima-Castanopsis* forest (DoF, 2012).

The PPF has been zoned as core area (for conservation) and fringe area (for sustainable use) (Figure 1). Core area covers 2,035 ha in the innermost area whereas fringe area covers 3,740 ha outside the core area. The settlements outside the protected forest have been declared as impact zone. Impact zone covers the settlements within nine Village Development Committees (VDCs)-three VDCs of each Kaski, Parbat and Syangja districts. A total of 26,025 people resides within the total 7039 households in the impact zone (CBS, 2011).

Sampling and survey

Out of the total 7039 households in the impact zone of the Panchase Protected Forest, we selected 364 sample households (at a confidence level of 95% with a marginal error of 5%) for the research using Krejcie and Morgan (1970) sample size calculation formula.

$$n = \frac{NZ^2P(1-P)}{Nd^2 + Z^2P(1-P)}$$

Where,

n = sample size
Z = Z-value (1.96 for 95% confidence level)
P = population proportion (used 0.5 since this would provide the maximum sample size)
d = degree of accuracy (maximum acceptable error) expressed as a proportion (0.05)
N = population size (total number of households)

We distributed the sample size in all nine VDCs of the study area proportionally. After determining the sample size in each VDCs, we adopted simple random sampling method to select the sample household within the VDC. We conducted a survey within the sampled household in April 2017 using structured questionnaire. We designed questionnaire reviewing literatures

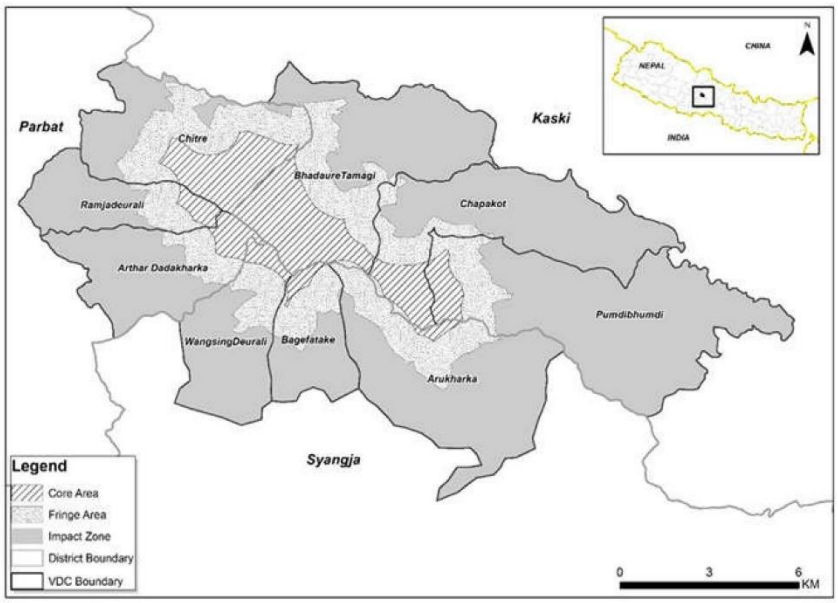

Figure 1. Panchase Protected Forest showing core area, fringe area and impact zone

and pre-tested in the study site. We conducted in-person interviews using the questionnaire through the help of three trained university students. We choose household head as a respondent for this survey.

Contingent valuation

We estimated the value of ecosystem services provided by the forests through applying Contingent Valuation Method (CVM). CVM is a survey based stated preference method most frequently used (Spangenberg and Settele, 2010) to estimate the non-use values of ecosystems (TEEB, 2010) creating a hypothetical market (Haque *et al.,* 2011). The CVM uses questionnaires to ask people to express their preferences in terms of their Willingness to Pay (WTP) to conserve the ecosystems services (CSUWN, 2011). Economic value is often defined in strict economic terms as aggregate willingness to pay for the stream of services (Costanza *et al.,* 2017). In the present research, we used labor contribution as a payment vehicle to estimate WTP. It is more realistic in a subsistence economy where most of the economic transactions are non-monetized (Rai and Scarborough, 2012). In this method, respondents are asked to measure their annual WTP in terms of their labor contribution. We asked separate WTP for option value, existence value, altruistic value and bequest value, and summed-up to calculate total WTP of a respondent. We converted the labor contribution into the monetary value using the average wage rate of the study site (NPR 500/day) as an opportunity cost of unskilled labor. The WTPs of all individual respondents then totaled and divided by the total number of respondents to calculate the average WTP of a household. The average value was then multiplied by total number of households within the study area to calculate the total WTP.

Econometric Model

We developed a multiple regression equation to understand the relationship between WTP and various socio-economic attributes. The socio-economic attributes considered for this research include age, gender, education, family size, landholding, livestock holding, income, distance to forest, and position in the community based forest management groups. As log-linear model is a commonly used form of regression model (Greene, 1993) that expresses linear relationship between dependent and independent variables (Gujarati, 2003), we used regression equation with logarithmic function of variables. The following log-linear model was used in this research.

$$\ln Yi = \beta + \sum \beta ij \ln Xij + ei$$

Where,

Y = WTP
β = regression coefficient
X = attributes
e = error

The model is described as the following equation, which analyzes the relationship between WTP and socio-economic attributes.

$$\text{Ln WTP} = \beta 0 + \beta 1 \ln \text{AGE} + \beta 2 \text{ GENDER} + \beta 3 \ln \text{EDUCATION} + \beta 4 \ln \text{FAMILYSIZE} + \beta 5 \ln \text{LANDHOLDING} + \beta 6 \ln \text{LIVESTOCK} + \beta 7 \ln \text{INCOME} + \beta 8 \ln \text{DISTANCEFOREST} + \beta 9 \text{ POSITIONFOREST}$$

Community based forest management is one the successful model of forest management in Nepal (Paudyal, 2015). This research intended to identify the relationship between WTP and position holders in executive committees of community based forest management (community forests/protected forest council). Similarly, various researchers (e.g. Bhandari and Uibrig, 2008) consider income as a strong socio-economic variable in Nepal's community based forest management. Therefore, this research is intended to observe the relationship between annual income and WTP. Moreover, based on literature review and consultation with the experts, other socio-economic variables such as age, gender, family size, landholdings, livestock, and distance to forest were chosen (Table 1). The qualitative variables used in this model are quantified as dummy variables. The data were analyzed using IBM SPSS 23.

RESULTS AND DISCUSSION

Economic value of protected forest

The results of the CVM survey reveal that the annual WTP of the people of impact zone in conserving Panchase Protected Forest is Nepalese Rupees (NPR) 52.2 million (USD 521,930 at the conversion rate of USD 1 = 100 NPR) (Figure 2). The per hectare annual economic value of the PPF is NPR 9037.75 (USD 90.37).The people of the impact zone of the PPF have highest WTP of NPR 17.1 million (USD 171,044) for bequest value followed by NPR 16.02 million (USD 160,215) for option value. The WTP for existence value and altruistic value are NPR 9.6 million (USD 96,399) and NPR 9.4 million (USD 94,272) respectively. The highest WTP for bequest value reveals that people in the study area are interested to contribute more in conserving forest so that future generations will also have access to the benefits of ecosystem services. Similarly, higher contribution to option value reveals that people are willing to contribute in conserving forest for future use of known and unknown benefits. This finding implies that protected forests are not only important for conserving biodiversity and environmental safeguards, but also provides economic benefits. It has policy implications. We did not find literatures to compare our findings with other protected forests in Nepal. However, Shrestha *et al.* (2007) has estimated annual economic value of USD 1.6 million for Koshi Tappu Wildlife Reserve of Nepal. Moreover, Baral *et al.* (2016) has estimated annual economic value of USD 0.9 million for Jagadishpur Ramsar Site of Nepal. The economic value of the Panchase Protected Forest is lower compared to the economic value of Koshi Tappu Wildlife Reserve and Jagadishpur Ramsar Site. It could be due to considering only non-use values in the present research.

Socio-economic attributes and WTP

The higher value of R^2(0.87) and adjusted R^2 (0.86) shows the strength of the model used for analyzing the WTP in this research (Table 2). Executive position in community based forest management are willing to pay more than the others. It is due to the increased ownership of local people in forest management.

Table 1. Socio-economic variables and description

Variables	Expected sign	Description
Age (AGE)	-	Age of household head in year
Gender (DENDER)	+	Sex of the respondent (male = 1, female = 0)
Education (EDUCATION)	+	Education of the respondent (no of school years)
Family size (FAMILYSIZE)	+	No of people in family
Landholdings (LANDHOLDING)	+	Land area owned by the household (in ropani, 1 ropani = 0.05 ha)
Livestock (LIVESTOCK)	+	Number of livestock unit owned by the household
Income (INCOME)	+	Annual income of the household
Distance to forest (DISTANCEFOREST)	-	Distance of the Panchase Protected Forest from the respondent's home
Position in forest management committee (POSITIONFOREST)	+	Position of the respondent in forest management committee (position holder=1, other=0)

Table 2. Socio-economic variables and coefficients

Variables	Coefficient	Standard Error	Standardized Coefficient	t-value	p-value
Constant	2.116	.241		8.788*	.000
GENDER	-.042	.029	-.033	-1.450	.148
POSITIONFOREST	.226	.031	.150	7.194*	.000
INCOME	.521	.012	.902	41.923*	.000
LANDHOLDING	-.008	.018	-.010	-.425	.671
LIVESTOCK	-.003	.019	-.003	-.167	.868
AGE	.005	.053	.002	.090	.928
EDUCATION	.002	.018	.003	.107	.915
FAMILYSIZE	.038	.033	.024	1.152	.250
DISTANCEFOREST	-.010	.018	-.010	-.521	.603

R^2 0.87; adjusted R^2 0.86
*significance at 5% level

It implies that community engagement in forest management needs to be increased for better conservation of forest and ecosystem services. The variable INCOME is positively and significantly related with the WTP. It reveals that people having higher income are willing to contribute more to conserve forest and ecosystem services than the people having lower income. It is due to the reason that the preferences of a poor people is to manage for subsistence living. This finding suggests that forest management interventions need to be focused on creating economic opportunities that increase income of the surrounding communities. This study finding is similar to the findings of Paudyal *et al.* (2015) and Bhandari et al (2016).The variables AGE, EDUCATION and FAMILYSIZE are positively related to the WTP but not statistically significant. Bhandari *et al.* (2016) also observed no significant correlation between the amount of WTP with age and education. The positive relationship indicates that adult persons and educated persons pay more to conserve forest than the youth and less educated people. It implies that conservation awareness and education programs need to be implemented with particular focus on youths.

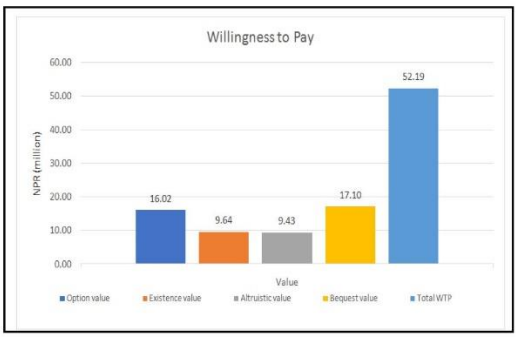

Figure 2: People's willingness to pay

Similarly, households having larger family size are willing to contribute more for forest conservation. It is partly due to their high demand of goods and services from the forests. The variable GENDER is negatively and insignificantly related with the WTP. Paudyal *et al.* (2015) has similar finding on it. The negative relationship indicates that women are willing to contribute more than the men to conserve the forest. It is partly because women are engaged more in collecting forest products such as fuelwood and fodder for their household needs. The variables LANDHOLDING and LIVESTOCK are negatively related with WTP although they are not statistically significant. The results indicate that the households having more lands and more livestock are willing to contribute less time than others. It is because they have goods and products to their own land and they need to spend more time in their lands and for their livestock, which reduces their time to contribute to forest management. Similarly, the variable DISTFOREST is negatively but insignificantly related with the WTP. The negative relationship indicates that households living far from forest contributes less than the households living near to the forests. It is partly because people near to forests are feeling more ownership as they depend more on forests.

Conclusion

The economic value of the ecosystem services of the Panchase Protected Forest estimated through WTP is NPR 52.2 million (USD 521,930). The per hectare annual economic value of the PPF is NPR 9037.75 (USD 90.37).This study concludes that protected forests are not only important for conserving biodiversity and environmental safeguards, but also important for economic benefits. Local people have the highest WTP for bequest value followed by option value. Based on this finding, this research concludes that people intend to conserve and manage forests keeping in priority that future generation will have access to ecosystem services. The regression analysis concludes that the people having higher income are willing to pay more to conserve forest. It suggests decision makers to

design forest management interventions that can create economic opportunities. Similarly, people having access to executive position in community based forest management are willing to pay more. Based on this conclusion, this study suggests strengthening community engagement in forest management decisions. It is also observed that women, educated persons, people proximity to forests are willing to pay more compared to men, less educated persons and people distant to forest, respectively. These trends suggest increasing investment to empower women in forest management decisions, and to raise awareness and education in forest resource conservation. This research highlighted on the non-use value of ecosystem services provided by protected forests in Nepal. It is suggested to conduct further research on economic valuation of protected forests including all use and non-use values of ecosystem services.

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APPENDIX XI

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Economic Value of Cultural Ecosystem Services: An Assessment from Protected Forest of Nepal

Ananta Ram Bhandari[1], Udhab Raj Khadka[2], Keshav Raj Kanel[3]

Tribhuvan University, Central Department of Environmental Science, Kirtipur, Kathmandu, Nepal

Abstract: ***Forests provide numbers of cultural ecosystem services for human wellbeing. However, the importance of cultural ecosystem services arising from forests is poorly recognized in developing countries like Nepal. The present study has estimated economic value of cultural ecosystem services provided by Panchase Protected Forest of Nepal. Travel cost method was adopted interviewing 388 people to estimate the value of cultural and recreational services. The analysis revealed that total annual economic value of cultural ecosystem services of the Panchase Protected Forest is NPR 37.84 million (USD 378,395). It is estimated that 25,340 pilgrims and 3,600 tourists visit every year in the Panchase Protected Forest. Promotion of tourism as an economic opportunity for local people and the society are crucial for better protection of protected forests. Provision of entry fee will help in regulating tourism in protected forests. Inclusion of aesthetic and cognitive benefits will worth in future cultural ecosystem valuation researches.***

Keywords: ecosystem services, protected forest, travel cost method, valuation

1. Introduction

Since the Millennium Ecosystem Assessment (MEA), ecosystem services science has made much progress in framing concepts and approaches [14]. MEA [11] classifies ecosystem services into four broad categories viz. provisioning, regulating, cultural and supporting services. Later, the Economics of Ecosystem and Biodiversity (TEEB) slightly modified the MEA categories of ecosystem services into provisioning; regulating; habitat; and cultural and amenity services. Costanza et al. [2] argues that the TEEB framework added more of the economic aspect of ecosystem services. However, approaches informing understanding of cultural ecosystem services remain the subject of ongoing debate [8].

Cultural ecosystem services encompass the 'non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences [11]. Recently, Fish et al. [8] developed a framework on cultural ecosystem services and distinguishes four types of cultural practices with regards to ecosystem services viz. playing and exercising; creating and expressing; producing and caring; and gathering and consuming.

The failure to account for the full economic values of ecosystems has been a significant factor in their continuing loss and degradation [11]. Ecosystem valuation enable estimates the value of goods and services provided by the ecosystems to create incentive mechanisms [5]. As the benefits received from ecosystem services are usually neglected or undervalued in decision-making due to the lack of market prices of such services, valuation show how conservation can deliver a range of economic advantage [15].

Despite smaller in size, Nepal is rich in forest resources as it covers 44.74% (6.61 million hectare) of the total area of the country [6]. There has been a long tradition in Nepal that forest is a source of leisure and recreation. Protected areas in Nepal recognize recreational services of forests keeping wildlife and nature base tourism in a priority. Nepal has established 20 protected areas covering 23.23% of the total area of the country [9]. Considering the importance of biodiversity and environmental safeguards outside protected areas, Nepal initiated protected forests, a new forest management regime in 2012 [7]. Protected Forest is a special category of forest balancing human needs through conserving biodiversity and safeguarding environment [13]. Forests provide numbers of ecosystem services, including cultural services. However, the importance of cultural ecosystem services arising from forests are not properly recognized outside the protected areas in Nepal. Protected forests assumed to provide numbers of cultural ecosystem services, however, the understanding and importance of such services provided by forests are not properly recognized [12]. Therefore, valuation of cultural ecosystem services is crucial in identifying economic benefits provided by the forests. The present research aimed at valuing cultural ecosystem services of a representative protected forest highlighting religious and recreational values.

2. Materials and Methods

2.1 Study area

This study was conducted in Panchase Protected Forest. Comprising 5,775 ha at the juncture of Kaski, Syanja and Parbat districts, it represents the mid-hills forests of Nepal. The protected forest is rich in biodiversity as it has wide range of altitudinal variation from 900 m to 2517 m. Over 589 flowering plants including 107 medicinal and aromatic plants and 113 orchids, 56 species of wild mushrooms, and 98 species of ferns have been recorded in the area [7]. The Panchase Protected Forest is also important due its cultural values. Panchase peak and Panchase Lake are the major natural heritages within the forests whereas it is a vintage point for the natural landscape with a panoramic view of the Himalaya range including Mt. Annapurna, Mt. Machhapuchre, Mt. Dhaulagiri, and Mt. Manaslu. Cultural-religious heritages within the forest include Siddhababa temple, Siddhabarah temple, Harpandevi, Buddha temple,

and cremation site of Shrawan Kumar [7].

The PPF has been zoned as core area and fringe area. Core area includes 2,035 ha as the innermost area and fringe area includes 3,740 ha of outer area. An impact zone has been declared around the PPF that covers the settlements within nine Village Development Committees (VDCs) - three VDCs of each Kaski, Parbat and Syangja districts. A total of 26,025 people resides in the impact zone within the 7039 households [1].

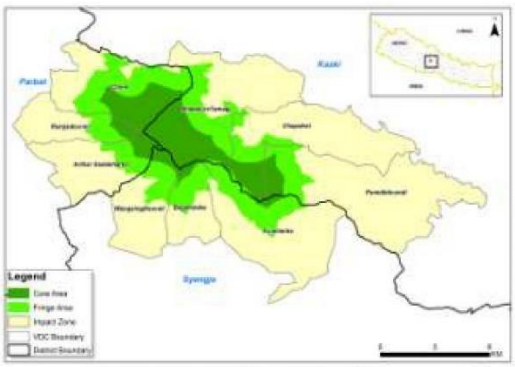

Figure 1: Panchase Protected Forest showing core area, fringe area and impact zone

2.2 Key Informants Interview

Key Informants Interview (KII) was employed to identify cultural and religious sites and events, natural heritages, recreation sites, trekking routes, strategic locations for visitors, and other information related to cultural services. PPF council members, community forest user group members, hoteliers and village leaders were selected as key informants. A total of 10 key informants were interviewed within the study area. A checklist was prepared before the interview to systematically collect the required information.

2.3 Travel Cost Method

Travel Cost Method (TCM) was used to estimate economic value of cultural and amenity services. It is based on the rationale that cultural and recreational experiences are associated with a cost (direct expenses and opportunity costs of time). TCM is a well-known technique that uses the costs that visitors bear in travelling to a recreational site [10]. TCM is a survey technique where questionnaire is often prepared and administered to estimate the recreation value of a site [4].

2.3.1 Religious travels

Religious value was estimated based on the number of pilgrims visit to the Panchase Protected Forest for religious or cultural motives. People mostly visit to the PPF during Balachaturdasi, the most famous religious occasion in this region. Since most of the pilgrims are from the impact zone (as identified by key informants' interview), a questionnaire survey was conducted in the impact zone of PPF in April 2017 under the TCM framework. Out of the total 7039 households in the impact zone of the Panchase Protected Forest, 364 was selected (at a confidence level of 95% with a marginal error of 5%) for the survey using standard sample size calculation formula. The samples were distributed in all 9 VDCs proportionately. The number of days to be spent in PPF as a pilgrim, transportation costs and other associated costs were captured through questionnaire. The number of days was converted into the monetary value using the average wage rate of the study site as an opportunity cost of unskilled labor. Opportunity cost of time, transportation cost and other associated costs were taken into account to calculate religious value of an individual pilgrim. Total religious value was calculated through multiplying the value of individual pilgrims by total number of pilgrims per year.

2.3.2 Recreational travels

Recreational value, which is associated with the tourists who visit to the protected forest for recreation, was estimated through a questionnaire survey with visitors under the TCM framework. A total of 24 foreign visitors were surveyed, in April 2017, in Bhanjyang, the most strategic place on the trekking route to Panchase peak. Since there is no any formal record keeping system for the visitors in the study area, consultations were made with the hoteliers in Bhanjyang and Panchase peak to estimate the number of visitors. Due to unavailability of reliable information on domestic visitors, only foreigners were counted in for this research. Cost of accommodation and food, transportation cost and other associated costs were taken into account to calculate individual recreation value. Then the individual value of sampled visitors was totaled and averaged to calculate average recreational value. Total recreational value was calculated through multiplying average recreational value by the total number of visitors.

Total religious value and total recreational value was added to calculate the value of cultural ecosystem services.

3. Results and Discussion

3.1 Religious value

This study verified that the Panchase Protected Forest is rich in religious and cultural assets and values. Siddhababa temple at the top of the hill and Panchase lake just beneath the peak are the most popular religious and cultural destinations within the protected forest. A large number of pilgrims, mostly Hindus, visit to the PPF during Bala-Chaturdasi every year. The Bala-Chaturdasi, the most famous festival in this region, is celebrated every year on the 14th day of the dark-half of the lunar calendar in the month of Mangsir (late November or early December). The worshippers scatter "Satbij", seven types of grains and seeds, along the path as they go. The seeds are scattered on behalf of deceased relatives in the hope that this act will secure a better place in heaven for them. These rituals are also carried out to appease the restless souls of departed ones who were not properly cremated.

The results of the TCM survey reveal that total religious value of the PPF is Nepalese rupees (NPR) 23.44 million

(USD 234,395 at the conversion rate of USD 1= NPR 100) per annum (Table 1). It is estimated that 25,340 pilgrims visit to the PPF every year during Bala-Chaturdasi. Out of them, 19,005 (75%) are from the impact zone of the PPF and 6,335 (25%) are from outside the impact zone. The pilgrims from the impact zone spend a day and half for the festival whereas pilgrims from outside the impact zone spend two and half days in an average to visit the PPF. Average wage rate of the study site (NPR 500/day) was used to calculate the opportunity cost of time. The average transportation cost for pilgrims outside the impact zone of the PPF is NPR 200 per trip whereas pilgrims from the impact zone usually walk instead of using vehicles.

Table 1: Economic value of cultural services in the PPF

Value/services	Economic value	
	NPR (million)	USD
Religious	23.44	234,395
Recreational	14.40	144,000
Total (cultural ecosystem services)	37.87	387,395

3.2 Recreational value

There is a huge potential of tourism in the Panchase Protected Forest as it is very close to the Pokhara city, one of the major tourist hubs of Nepal (CSUWN, 2011). PPF offers magnificent views of Mt. Dhaulagiri, Mt. Manaslu, Mt. Machchhapuchhre, and Mt. Annapurna. It has become an easily accessible destination reached by seasonal roads linking all villages and to the Bhanjyang. The trekking routes within the PPF are: 1) Bhadaure-Bhanjyang-Panchase; 2) Pame-Bhanjyang-Panchase; 3) Pumdibhumdi-Bhanjyang-Panchase; 4) Kusma-Arthar-Bhanjyang-Panchase; 5) Kusma-Arthar-Panchase; and 6) Sirubari-Arthar-Bhanjyang-Panchase. Bhanjyang is the main junction from where tourist climb up to the top of the Panchase hill. Tourists can stay at Bhanjyang where hotel facilities are available. Homestays are also increasingly available in the villages within the impact zone of the PPF.

The results of the travel cost method reveal that the recreation value of the Panchase Protected Forest is NPR 14.40 million (USD 144,000) (Table 1). Based on the survey with the hoteliers in Bhanjyang and Panchase Peak, it is estimated that 3,600 tourists visit to the PPF every year during autumn (September-November) and spring (March-May). Tourists spend two days in the PPF in an average. There is no any entry fee provision in the Panchase Protected Forest. No tourists were found to come only for Panchase, but they allocate few days while visiting to Pokhara. Thus, transportation expenses include only from Pokhara to Panchase and vice versa, was estimated NPR 1,000 per trip. Average expenses of visitors in the PPF for accommodation and food was NPR 1,500 per day. As this study does not count the domestic tourists and only foreigners are considered, it underestimates the recreational value. The recreational value can be further increased through promoting tourism and improving tourism facilities. Provision of entry fee not only regulate the tourism but also increases the value.

3.3 Value of cultural ecosystem services

Analyzing the religious value and recreational values, the study results reveal that total value of cultural ecosystem services of the PPF is NPR NPR 37.84 million (USD 378,395) per annum (Table 1; Figure 2). The religious value is higher compared to the recreational value. It implies that the Panchase Protected Forest is a very important destination for religious and spiritual purpose. The lower recreational value of the PPF is due to its under estimation because this study accounted only the foreign visitors. Increase in publicity and tourism infrastructure will help in increasing number of tourists and thus the recreational value. This finding implies that protected forests are not only important for conserving biodiversity and environmental safeguards, but also provides cultural and economic benefits.

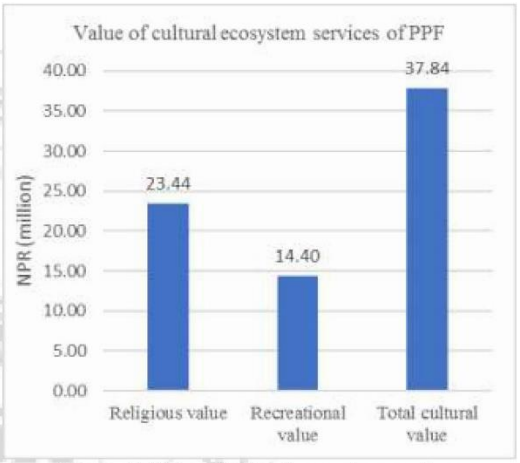

Figure 2: Value of cultural ecosystem services

4. Conclusions

This study concludes that protected forests are not only important for conserving biodiversity and environmental safeguards, but also important for cultural and economic benefits. The annual economic value of cultural ecosystem services of the Panchase Protected Forest is NPR 37.84 million (USD 378,395). A total of 25,340 pilgrims and 3,600 tourists visit to the Panchase Protected Forest each year for their cultural and recreational needs. Promotion of tourism is crucial for better management of protected forests as it creates an economic opportunity to benefit local people and the society. Provision of entry fee will help in regulating tourism in the targeted forests.

This study highlights the religious and recreational values of the protected forest. Inclusion of aesthetic and cognitive benefits will worth in future cultural ecosystem valuation researches.

5. Acknowledgments

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APPENDIX XII

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Research Article

ECOSYSTEM SERVICES IN THE MID-HILL FOREST OF WESTERN NEPAL: A CASE OF PANCHASE PROTECTED FOREST

Ananta Ram Bhandari, Udhab Raj Khadka*, Keshav Raj Kanel

Central Department of Environmental Science, Tribhuvan University, Kathmandu, Nepal
**Corresponding author: ukhadka@cdes.edu.np*

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ABSTRACT

This paper identified ecosystem services of Panchase Protected Forest (PPF) in the mid-hills of western Nepal using the Economics of Ecosystem and Biodiversity (TEEB) framework. Transect walk, focus group discussion, key informants interview and expert's consultation were used. This study revealed that PPF offered wide range of ecosystem services including provisioning, regulating habitat, and cultural and amenity services. Provisioning services offered by PPF included food (35 species), raw materials (22 species), energy (17 species), medicines (40 species), ornamental resources (3 species) and water resources. The forest was also a source of water for irrigation and domestic consumption. The regulating services offered by PPF included water flow regulation, erosion prevention, water purification, soil fertility maintenance, air quality regulation and climate regulation. PPF provided habitat for 589 species of flowering plants, 24 species of mammals and 262 species of birds maintaining life cycles and genetic diversity. By maintaining landscape integrity and heritages, PPF provided opportunities for recreation and tourism. A total of 3,600 tourists and 25,340 pilgrims visit PPF every year. The beneficiary of ecosystem services from PPF ranged from local level to sub-national, national and global levels.

Keywords: Beneficiaries of forest, Cultural services, Habitat services, Provisioning services, Regulating services

INTRODUCTION

Ecosystem has both structural and functional components, and through continuous interaction of these components, ecosystems deliver crucial services to its functioning and to human society. Natural ecosystems provide a wide range of services and economic benefits to local livelihoods (Pant *et al.* 2012) and human wellbeing (MEA 2005). Millennium Ecosystem Assessment (MEA) defines ecosystem services as 'the benefits people obtain from ecosystems'. These benefits are the multiple commodities that are supplied by natural ecosystems as a result of their structure and function; the conditions and processes through which nature 'sustains human life' on earth (Daily 1997). Ecosystem services are ultimately the planet's life support systems we cannot live without (Cavelier *et al.* 2012).

MEA (2005) classifies ecosystem services into four broad categories *viz*. provisioning, regulating, cultural and supporting services. The Economics of Ecosystem and Biodiversity (TEEB 2010) classifies ecosystem services into four broad categories including provisioning, regulating, habitat, and cultural and amenity services. Provisioning and regulating services are similar in both TEEB and MEA classifications. However, supporting services of MEA classification is mostly included into the regulating services of TEEB classification. Cultural services of MEA classification are elaborated as 'cultural and amenity' services in TEEB classification. A new service type 'habitat services' is included in the TEEB classifications.

Despite small in size, Nepal is rich in natural resources and biodiversity that includes 118 ecosystems (Dobremez 1976) and 35 forest types (Stainton 1972). These forest types have been aggregated and categorized into 10 major groups namely, tropical forests, subtropical broadleaf forests, subtropical conifer forests, lower-temperate broadleaf forests, lower-temperate mixed broadleaf forests, upper-temperate broadleaf forests, upper-temperate mixed broadleaf forests, temperate conifer forests, subalpine forests, and alpine scrubs (GoN/MoFSC 2014). Forests cover 44.74 % (6.61 million hectare) of the total area of the country (DFRS 2015). Forest Act (second amendment), 2016 classifies forests into two major categories, i.e. national forests and private forests. National forests are further classified into government managed forests, block forests, protected forests, collaborative forests, community forests, leasehold forests and religious forests (GoN 2016).

In order to better conserve these forests, Nepal has established 20 protected areas covering 23.3 % of the total land area of the country. These protected areas represent 80 ecosystems out of 118 natural ecosystems of the country (GoN/MoFSC 2014). Emphasizing the importance of biodiversity and ecosystem services outside protected areas, Government of Nepal initiated 'protected forest' in 2012. Protected Forest is a special category of forest balancing human needs through conserving biodiversity, regulating ecosystem services and safeguarding environment (Shrestha *et al.* 2014). Panchase Protected Forest (PPF) was declared as a

protected forest in 2012 (DoF 2012a). Till date, eight protected forests have been declared in Nepal covering 133,754.8 hectares of forests (GoN/MoFSC 2014).

Although forests provide various goods and services for human wellbeing, the importance of ecosystem services arising from forests is not properly recognized in Nepal. Few ecosystem service studies have been conducted in Nepal's protected areas such as Koshi Tappu Wildlife Reserve (Sharma *et al.* 2015) and Shivapuri-Nagarjun National Park (Peh *et al.* 2016) and wetland sites such as Phewa Lake (CSUWN 2011), Beeshajari Lake (Khanal *et al.* 2014) and Jagadishpur Reservoir (Baral *et al.* 2016). However, no comprehensive study on ecosystem services of 'protected forest' is available. Even in Panchase Protected Forest, such information seems lacking. Therefore, the present research was carried out with the aim of identifying ecosystem services offered by Panchase Protected Forest and the beneficiaries of those services.

MATERIALS AND METHODS

Study area

The Panchase Protected Forest (PPF), lying at the juncture of Kaski, Syanja and Parbat districts in the western Nepal, comprises an area of 5,775.73 hectares (Fig. 1). It represents forests ecosystems of the mid-hills of Nepal. The forest is rich in biodiversity, as it has wide range of altitudinal variation from 900 m to 2517 m. Out of total 35 forest types found in Nepal, PPF represents five forest types - alder forests, chirpine-broadleaved forest, oak-laurel forest, lower temperate oak forest, and *Schima-Castanopsis* forest (DoF 2012b). The PPF is dominated by *Schima-Castanopsis* forests, covering 69.89 % (4036.39 ha) of the total area, which is one of the representative forest types of the mid-hills of Nepal. Chirpine-broadleaved forest covers 12.11 % (699.25 ha), east Himalayan oak-laurel forest covers 11.14 % (643.58 ha), the lower temperate oak forest covers 5.86 % (338.27 ha) and alder forest covers 1.01 % (58.24 ha) of the forest area (DoF 2012b).

The PPF has been zoned as the core area and the fringe area. The core area includes 2,035 ha as the innermost area and fringe area includes 3740 ha of outer area. An impact zone has been declared around the PPF that covers the settlements within nine former VDCs (Village Development Committees) - three VDCs from each Kaski, Parbat and Syangja districts.

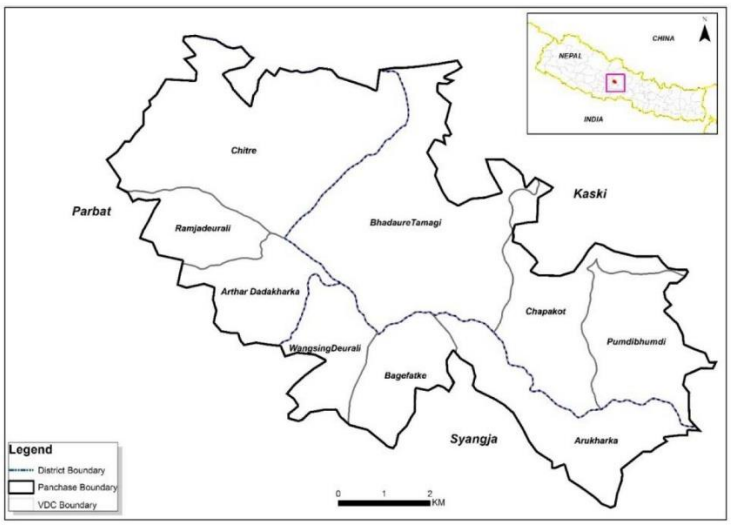

Fig. 1: Panchase Protected Forest and associated VDCs and districts

Methods

This study relied on both primary and secondary data. Transect walk, focus group discussion, key informants interview and expert's consultation was made to collect primary data whereas relevant literatures were reviewed to collect secondary data. A transect walk was made across the PPF in participation with local key informants in March 2015. A transect walk was a tool for describing and showing the location and distribution of resources, features, landscape, major land used along a given transect. Observation was made along transect to explore and identify ecosystem services of that particular forest. A checklist was used to capture information during field observation during the transect walk.

Focus Group Discussion (FGD) was employed to gather information on ecosystem services particularly

availability, use pattern and beneficiaries of provisioning, and cultural and amenity services. FGD is a useful technique to gather data when the researcher is interested to exhume more deeply into an interest area (Baker 1999). Total three FGDs were conducted in three VDCs, one VDC from each district, using checklist. Among the VDCs, Bhadaure-Tamagi from Kaski district, Chitre from Parbat district and Bangephadke from Syangja district were selected for this purpose. A total of 39 local community members (n = 39) participated in the FGDs. Key Informants Interview (KII) was employed to identify ecosystem services offered by the forests, cultural and religious sites and events, natural heritages, and the beneficiaries of the services. It was also used to triangulate the information collected during field observation along transect. PPF council members, community forest user group members, hoteliers, and experts were selected as key informants. A total of 10 key informants (n = 10) were interviewed during the study. Experts were consulted particularly for regulating services and habitat services.

The beneficiaries of the ecosystem services were categorized as local, sub-national, national and global. Local beneficiaries included people from the impact zone of the protected forest. The VDCs within the impact zone of PPF include Pumdibhumdi, Chapakot, Bhadaure-Tamagi of Kaski district; Chitre, Ramjhadeurali and Arther-Dandakharka of Parbat district; and Wansingdeurali, Bangephadke and Arukharka of Syangja district. Sub-national level beneficiaries include people from other VDCs of Syangja, Parbat and Kaski districts and downstream city areas such as Pokhara, Kusma, Baglung and Putalibazar. National level beneficiaries are the stakeholders beyond sub-national level beneficiaries within Nepal. Global level beneficiaries include the people from elsewhere outside Nepal.

RESULTS AND DISCUSSION

Ecosystem services

Ecosystem services available in the PPF were discussed under the categories of provisioning, regulating; habitat, and cultural and amenity services following the TEEB framework (TEEB 2010) which is primarily based on the MEA.

Provisioning services

Food, medicines, raw materials, energy sources, ornamental resources and water are provisioning services provided by PPF. The food products used by local people from PPF included leaves, shoots, fruits and seeds of plants. A total of 35 plant species have been found to be used as food in Panchase region (Table 1). The major plant species used as food include *Juglans regia*, *Myrica esculenta*, *Rubus ellipticus*, *Berberis aristata*, *Emblica officinalis*, *Morus alba*, *Castanopsis indica*, *Dioscorea deltoidea*, *Ficus semicordata*, *Bauhinia variegata*, *Urtica dioica*, *Aesandra butyracea and Choerospondias axillaris.* Bamboo shoots and mushrooms were also commonly used as food by local people in this area. PPF was rich in wild foods, but there seems to be no specific information available in terms of yields, distribution and seasonality of the products (GoN/DoF/UNDP 2014).

Panchase Protected Forest has been observed as a good source of medicinal herbs. A total of 40 medicinal plants from PPF were found to be traditionally used for medicine (Table 1). The major plant species used in the medicines were *Justicia adhatoda*, *Emblica officinalis*, *Swertia chirayita*, *Rubia manjith*, *Berberis aristata*, *Acorus calamus, Aloe vera, Artimisia indica, Asparagus racemosus, Paris polyphylla, Terminalia bellirica, Terminalia chebula* and *Zanthoxylum armatum.* Medicinal plants such as *Swertia chirayita*, *Paris polyphylla* and *Asparagus racemosus* were more important in this area due to their high market value (Chikanbanjar, 2015). However, detailed data on the status and consumption of the medicinal plants was lacking.

This assessment has found that timber was one of the prominent raw materials extracted by local people from PPF. A total of 16 species of plants have been used as timber. The tree species commonly used as timber are *Schima wallichi, Castanopsis indica*, *Alnus nepalensis, Pinus roxburghii, Pinus wallichiana, Abies spectabilis, Daphniphyllum himalense, Quercus semicarpifolia, Quercus lamellosa, Quercus glauca, Rhododendron arboreum, Juglans regia,* and *Shorea robusta* (Table1). Similarly, *Arundinaria species, Bambusa nepalensis* and *Dendrocalamus strictus* were widely used as construction materials as well as for making baskets and handicrafts. *Daphne bholuwa* and *Edgeworthia gardneri* were also available in this region, which were used for preparing Nepali handmade paper. Construction materials such as sand, gravel and stones were also extracted from the river streams within PPF mostly for local use. If a set of environment friendly guidelines are developed, the upstream of Pame can be a potential area for mining sands and gravels brought by the monsoon rains, which will also contribute in reducing siltation in Phewa Lake (Kanel 2015, GoN/DoF/UNDP 2014).

Fuel-wood was the major source of energy used for cooking and heating in this region. Left over biomass from tree species were used as fuel-wood. A total of 17 tree species from PPF were found to be used as fuel-wood (Table 1). The major fuel-wood species of PPF included *Schima wallichi, Castanopsis indica*, *Alnus nepalensis, Daphniphyllum himalense, Rhododendron arboreum, Engelhardia aspicata, Lyonia ovalifolia, Symplocos racemosa, Eurya cerasifolia.* High consumption of these species is due to their high burning efficiency. Although, it is in decreasing trend, charcoal was found to be used by

occupational castes for local use in this region. The species mainly used to produce charcoal include *Schima wallichii* and *Castanopsis indica.* However, all species used for fuel-wood and timber seemed to be used in making charcoal.

Table 1. Provisioning services provided by Panchase Protected Forest

Services	Name of the species used
Food	*Juglans regia*, *Myrica esculenta*, *Rubus ellipticus*, *Berberis aristata*, *Emblica officinalis*, *Morus alba*, *Castanopsis indica*, *Dioscorea bulbifera*, *Dioscorea deltoidea*, *Tinospora sinensis, Ficus carica*, *Ficus lacor*, *Ficus semicordata, Ficus glaberrima, Ficus nerifolia, Ficus roxburghii, Artocarpus lacucha, Streblus asper, Bauhinia variegata, Hydnum repandum, Termitomyces eurhizus, Urtica dioica, Diplazium esculentum, Aesandra butyracea, Choerospondias axillaris, Ficus auriculata, Nephrolepis auriculata, Picrasma javanica, Viburnum mullaha,Cinnamomum tamala, Cinnamomum glaucescens, Asparagus racemosus, Nephrolepis cordifolia, Bambusa nepalensis,* and *Dendrocalamus strictus*
Medicines	*Justicia adhatoda*, *Centella asiatica*, *Emblica officinalis*, *Rhododendron arboreum*, *Swertia chirayita*, *Myrica esculenta*, *Rubia manjith*, *Bergenia ciliate, Taxus baccata*, *Berberis aristata*, *Lycopodium clavutum, Acorus calamus, Aloe vera, Artimisia indica, Asparagus racemosus, Bauhinia variegata, Brassaiopsis hainla, Paris polyphylla, Rubus ellipticus, Terminalia bellirica, Terminaia chebula, Vitex negundo, Viscum album, Eurya acuminata, Zanthoxylum armatum, Rhus javanica, Tribulus terrestris, Amomum aromaticum, Cuscuta reflexa, Lyonia ovalifolia, Litsea monopetala, Semecarpus anacardium, Sapium insigne, Woodfordia fruticosa, Osyris wightiana, Aconitum bisma, Centella asiatica, Taxus wallichiana, Persea duthiei* and *Dactylorhiza hatagirea*
Raw materials	Timber: *Schima wallichi, Castanopsis indica*, *Alnus nepalensis, Pinus roxburghii, Pinus wallichiana, Abies spectabilis, Daphniphyllum himalense, Castanopsis tribuloides, Quercus semicarpifolia, Quercus lamelossa, Quercus glauca, Michelia champaca, Rhododendron arboreum, Juglans regia,Taxus wallichiana* and *Shorea robusta*
	Bamboo: *Arundinaria species, Bambusa nepalensis* and *Dendrocalamus strictus*
	Fiber: *Girardinia diversifolia, Daphne bholuwa* and *Edgeworthia gardneri*
	Construction materials: Sand, gravel and stone
Energy sources	*Fuel-wood: Schima wallichi, Castanopsis indica*, *Alnus nepalensis, Pinus roxburghii, Pinus wallichiana, Abies spectabilis, Daphniphyllum himalense, Quercus semicarpifolia, Quercus lamelossa, Quercus glauca, Rhododendron arboreum, Engelhardia spicata, Lyonia ovalifolia, Symplocos racemosa, Castanopsis tribuloides, Eurya cerasifolia, Shorea robusta*
	Charcoal: *Schima wallichii* and *Castanopsis indica,* but all species used for fuel-wood and timber can be used for making charcoal
Ornamental resources	*Rhododendron arboreum, Lycopodium japonicum,* Orchid species
Water	Drinking water, water for irrigation

PPF was found as a source of ornamental plants in the region. The mostly used ornamental plants include; *Rhododendron arboreum, Lycopodium clavatum* and orchid species (Table 1). A total of 113 species of orchids, including two endemic species, were recorded in PPF (DoF 2012b). The local people used those ornamental plants in decorating their homes, gardens and gates. These ornamental plants were also found to be commonly used by hotel entrepreneurs in decorating their hotels and gardens.

No study was found in protected forests of the country to compare with this study. However, Khanal *et al.* (2014) observed 12 species of fish, 17 species of fruits, 12 species of timber, 15 species of fodder, and 31 species of medicinal plants in Beeshajari Lake, in the central lowland of Nepal. Large number of species used in PPF compared to Beeshajari Lake is due to the diversity in physiographic zone, local people's dependency on forest for living, and limited number of alternative options. Oort *et al.* (2015) observed that availability of forest goods, in particular fuel wood, fodder and litter, have decreased because of a strict regulation on forest goods extraction.

In PPF, a total of 20.41 ha (2.8 %) area was found to be covered by water bodies like streams (*Khola*), lakes and ponds. Among others, the Harpan Khola, Aandhi Khola and Modi Khola are the major streams originated from the

PPF. Local communities relied on these water streams and spring sources for drinking water and water for irrigation. The local communities were found to be responsible for protecting, maintaining and managing their water sources used for drinking water and irrigation. They have also formed user committees to regulate drinking water supply and irrigation schemes within the communities. However, the number of households and area of land benefited from irrigation services was very low- nearly 2,000 households and 550 ha respectively (GoN/DoF/UNDP 2014). PPF was also found as a source of water for downstream communities of Kaski, Parbat and Syangja districts. The Harpan Khola, originated from the PPF, was one of the major sources of water for the maintenance of Phewa Lake of Pokhara valley which lies in the downstream of the PPF. The Phewa Lake is the most popular tourist destination of Nepal and one of the lakes of the Ramsar site, the Pokhara Valley Lake cluster.

Regulating services

Based on experts' opinion and literatures, this study revealed that regulating services offered by PPF include water flow regulation, erosion prevention, water purification, soil fertility maintenance, air quality regulation and climate regulation (Table 2). The PPF is a headwater source for streams such as the Harpan Khola, Aandhi Khola and Modi Khola. Harpan Khola is the major source of water for Phewa Lake in the downstream. The mixed forests, shrub lands and grasslands of PPF control timing and magnitude of runoff and regulate surface-flow and base-flow which ultimately contribute in controlling floods. Mixed forests covered 4,154 ha (72 %), shrub-lands cover 966 ha (17 %) and grasslands cover 161 ha (3%) of the total area of the PPF (DoF 2012b). Experts and key informants claimed that the Panchase Lake, located at the peak of the Panchase Mountain, and numbers of spring sources within the protected forests are contributing in water recharge in this region. Assessment is needed to quantify the water recharge by the Lake and the spring sources. Over 91 % of the PPF area was covered by vegetation (DoF 2012b) with mixed forests, shrubs and grasslands. The vegetation cover and forest ecosystems act as sponge, intercept rains, and absorb water through root systems. Water is then stored in porous forest soils and debris and then slowly released into surface water and ground water. Through this process, the PPF maintained base-flow and recharged groundwater resulting in continuous flow of streams originated from this area (GoN/DoF/UNDP 2014). PPF helps keeping soil intact and in preventing soil erosion by intercepting rain through forest canopy, slowing down runoff through leaves and natural debris, and stabilizing stream banks through trapping soils by plant roots.

PPF contributes in purifying water through maintaining porous soil by roots of forest, shrub and grass species. Root systems of plants keep soil porous and allow water to filter through various layers of soil before entering groundwater. Although data was not available, the stakeholders believed that through this process, the PPF is also contributing to filter toxic and other substances that pollute water. Forest vegetation improves soil fertility through decomposition of leaf litters, branches, roots and stems. Kalu *et al.* (2015) has observed that soil quality of the PPF is better than the pasturelands and the cultivated lands in this region. Forest produces humus, regulates nutrient cycling and contributes to soil formation process in the long run.

Table 2. Regulating services provided by Panchase protected forest

Ecosystem services	
Water flows regulation	Headwater source for streams/rivers; regulates runoff, surface flow and base flow, control floods; groundwater recharge
Erosion prevention	Soil retention due to vegetation cover and intercepting rain, stabilize stream banks by sediment retention
Water purification	Maintenance of soil porosity, filter toxic and other substances
Soil fertility maintaining	Decomposition of leaf litters, branches, roots and stems; produce humus: regulates nutrient cycling; soil formation process
Air quality regulation	Capture dusts and carbon as sink
Climate regulation	Carbon sequestration, resilient micro-climate by regulating temperature and precipitation

Plants capture carbon dioxide from the atmosphere and release oxygen during photosynthesis process. They also sink dusts from the atmosphere. The PPF, covering vegetation over 91% of land area and having intact ecosystems, contributed to improve air quality of the nearby areas. As PPF is close to cities such as Pokhara, Kusma, Baglung and Putalibazar, it contributes significantly to improve air quality of those cities. Climate regulation is one of the important services that PPF is providing by sequestrating atmospheric carbon. The forests provide shade, reduce air temperature and create favorable micro-climate in land and water bodies.

Habitat services

Maintenance of life cycle and genetic resources were found to be the major two habitat services identified

during the assessment (Table 3). DoF (2012b) has recorded 589 species of plants including 107 species of medicinal herbs, 113 species of orchids (2 species endemic to Panchase), 5 species of rhododendrons, 56 species of fungi, 98 species of ferns; 24 species of mammals; and 262 species of birds. Kunwar and Upadhya (2013) have recorded 113 species of orchids in this region. The enriched habitat of PPF is contributing to protect gene pool. It was reported that the PPF was also a habitat for a number of endemic floral species like *Ficus neriifolia, Arisaema tortosum, Cissampelos pareira, Berberis aristata, Asparagus racemosus, Reinwardtia indica, Phyllanthus emblica, Cleistocalyx operculatus* (GoN/DoF/UNDP 2014).

Cultural and amenity services

This study revealed that cultural and amenity services of PPF are recreation and tourism, cultural and religious, and cognitive use (Table 4). The PPF offered landscape panorama and a natural heritage site, and thus acts as an attractive destination for domestic and international tourists. Mt. Dhaulagiri, Mt. Manaslu, Mt. Machchhapuchhre, and Mt. Annapurna can be seen from PPF. Bhandari *et al.* (2018) has estimated that 3,600 tourists visit to PPF every year during autumn (September-November) and spring (March-May). Tourists spend two days in PPF in an average. Being very close to Pokhara city, PPF represents one of the major tourist destinations of Nepal. The *Balachaturdasi* is one of the major festivals in this region, celebrated on the 14thday of the dark-half of the lunar calendar in the month of *Mangsir* (late November or early December). Bhandari *et al.* (2018) has estimated that 25,340 pilgrims visit to PPF every year during *Balachaturdasi*. Though, most of the pilgrims are Hindus, it also includes other ethnic groups from various parts of the country. Panchase Lake and *Panchadham* (the temple at the top of Pahchase hill) are the major attractions for the pilgrimage.

In the recent years, PPF is growing as a cognitive site, where students from nearby villages and researchers from different part of the country and across the globe visit to observe and learn various dimensions of nature and people. In 2015, the Central Department of Environmental Science, Tribhuvan University has carried out 22 research works in Panchase Protected Forest including 14 Master's dissertations and eight case studies (CDES-TU 2015).

Beneficiaries of ecosystem services

The benefits of the ecosystem services provided by PPF range from local, sub-national, national and global levels (Table 5). Paudyal *et al.* (2017) found that community-based forestry provides many ecosystem services from local to global beneficiaries. Local communities are mostly benefited from provisioning services (food, raw materials, medicines, energy sources, ornamental resources and water), regulating services (erosion prevention, water purification, air quality regulation, soil fertility maintenance and climate regulation), and cultural and amenity services (recreation and tourism, and cultural and religious). Sub-national level stakeholders are benefited with provisional services (raw materials and water), regulating services (erosion prevention, water purification, air quality regulation and climate regulation), habitat services (life cycle maintenance and genetic resource maintenance), and cultural and amenity services (recreation and tourism, cultural and religious, and cognitive). National level stakeholders mainly benefited with regulating services (climate regulation), habitat services (life cycle maintenance and genetic resource maintenance), and cultural and amenity services (recreation and tourism, cultural and religious, and cognitive). The global level stakeholders are benefited with regulating services (climate regulation), habitat services (genetic resource maintenance), and cultural and amenity services (recreation and tourism, cultural and religious, and cognitive).

Table 3. Habitat services provided by Panchase protected forest

Ecosystem services	
Life cycle maintenance	107 species of medicinal herbs/plants, 113 species of orchids, 5 species of rhododendrons, 56 species of fungi, 98 species of ferns; 24 species of mammals & 262 species of birds (DoF 2012b)
Genetic resource maintenance	Endemic floral species: *Ficus neriifolia, Arisaema tortosum, Cissampelos pareira, Berberis aristata, Asparagus racemosus, Reinwardtia indica, Phyllanthus emblica, Cleistocalyx operculatus*

Table 4. Cultural and amenity services provided by Panchase protected forest

Ecosystem Services	
Recreation and tourism	Landscape, natural and cultural heritages
Cultural and religious	Panchase Lake, Panchadham, cultural festivals such as *Balachaturdasi*
Cognitive	Educational: students and researchers

Table 5. Beneficiaries of ecosystem services provided by PPF

Ecosystem Services		**Beneficiaries**
Provisioning services	Food	Local
	Medicines	Local
	Raw materials	Local, sub-national
	Energy sources	Local
	Ornamental resources	Local
	Water	Local, sub-national
Regulating services	Water flows regulation	Local, sub-national
	Erosion prevention	Local, sub-national
	Water purification	Local, sub-national
	Soil fertility maintaining	Local
	Air quality regulation	Local, sub-national
	Climate regulation	Local, sub-national, national and global
Habitat services	Life cycle maintenance	Sub-national, national
	Genetic resource maintenance	Sub-national, national, and global
Cultural and amenity services	Recreation and tourism	Local, sub-national, national, and global
	Cultural and religious	Local, sub-national, national, and global
	Cognitive	Sub-national, national, and global

CONCLUSION

PPF provided wide range of ecosystem services including provisioning, regulating, habitat, and cultural and amenity services. The provisioning services offered by PPF included food, raw materials, energy, traditional medicines, ornamental resources and water resources. This study concludes that 35 species were used as food, 22 species as raw materials, 17 species as energy sources, 40 species as medicines and 3 species as ornamental resources in Panchase region. Water flow regulation, erosion prevention, water purification, air quality regulation, soil fertility maintenance and climate regulation were the regulating services provided by PPF. Similarly, habitat services offered by PPF included life cycle maintenance for species and genetic resources. Recreation and tourism, cultural and religious, and cognitive values were among the cultural and amenity services provided by PPF. A total number of 3,600 tourists and 25,340 pilgrims visited to PPF every year.

The beneficiaries of the ecosystem services from PPF ranged from people and stakeholders at local, sub-national, national and global levels. Most of the provisioning services were distributed at local level; however, raw materials and water resource were distributed at both local and sub-national levels. Similarly, regulating services were distributed at both local and sub-national levels. The habitat services were mostly distributed at national and global levels. Cultural and amenity services were distributed at all local, sub-national, national and global levels.

ACKNOWLEDGEMENTS

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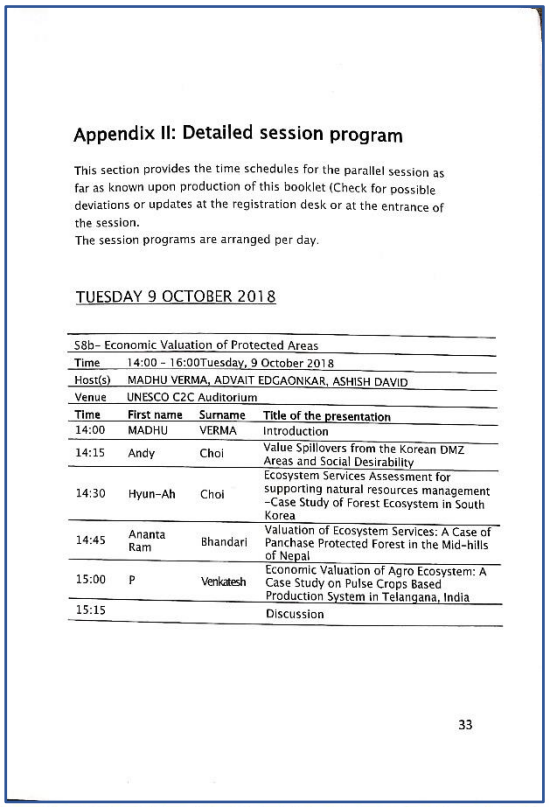
APPENDIX XIII

List of Papers Presented in Conferences

SN	Title of paper presented	Authors	Conference attended	
			Name	Venue & date
1	Valuation of Ecosystem Services: A Case of Panchase Protected Forest in the Mid-hills of Nepal	Ananta Ram Bhandari, Udhab Raj Khadka and Keshav Raj Kanel	ESP Asia Conference: Communicating and Engaging Ecosystem Services in Policy and Practice	Dehradun, India 09-12 October 2018
2	Assessing Forest Ecosystem Services: A Case of Panchase Protected Forest	Ananta Ram Bhandari, Udhab Raj Khadka and Keshav Raj Kanel	International Conference on Biodiversity, Climate Change Assessment and Impacts on Livelihoods	Kathmandu, Nepal 10-12 January 2017
3	Exploring Ecosystem Services in Forest Ecosystems: A Case of Panchase Protected Forest	Ananta Ram Bhandari, Udhab Raj Khadka and Keshav Raj Kanel	Conference on Ecosystem Based Adaptation (EbA)	Kathmandu, Nepal 01 April 2016

APPENDIX XIV

Participation in International Conference: 2018 ESP Asia Conference, Dehradun, India, October 2018



Appendix II: Detailed session program

This section provides the time schedules for the parallel session as far as known upon production of this booklet (Check for possible deviations or updates at the registration desk or at the entrance of the session.
The session programs are arranged per day.

TUESDAY 9 OCTOBER 2018

S8b- Economic Valuation of Protected Areas			
Time	14:00 - 16:00Tuesday, 9 October 2018		
Host(s)	MADHU VERMA, ADVAIT EDGAONKAR, ASHISH DAVID		
Venue	UNESCO C2C Auditorium		
Time	**First name**	**Surname**	**Title of the presentation**
14:00	MADHU	VERMA	Introduction
14:15	Andy	Choi	Value Spillovers from the Korean DMZ Areas and Social Desirability
14:30	Hyun-Ah	Choi	Ecosystem Services Assessment for supporting natural resources management -Case Study of Forest Ecosystem in South Korea
14:45	Ananta Ram	Bhandari	Valuation of Ecosystem Services: A Case of Panchase Protected Forest in the Mid-hills of Nepal
15:00	P	Venkatesh	Economic Valuation of Agro Ecosystem: A Case Study on Pulse Crops Based Production System in Telangana, India
15:15			Discussion

33

APPENDIX XV

Abstract of presentation in International Conference: Biodiversity, Climate Change Assessment and Impacts on Livelihoods, Kathmandu, Nepal, January 2017

ICBCL 330

Assessing Forest Ecosystem Services: A Case of Panchase Protected Forest, Nepal

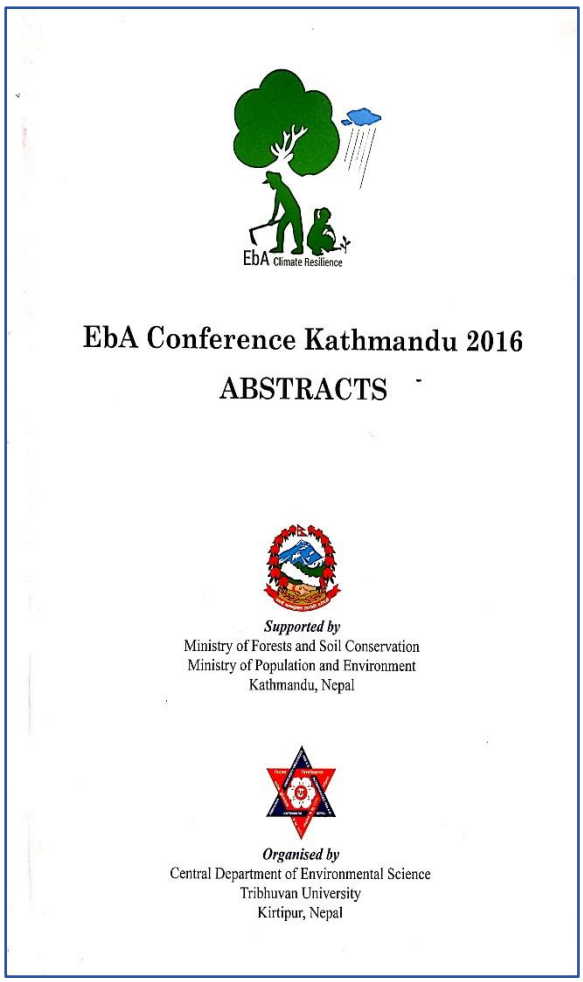
Ananta R Bhandari[1]* and Udhab R Khadka[2]
[1]World Wildlife Fund (WWF) Nepal, Kathmandu, Nepal
[2]Central Department of Environmental Sciences, Tribhuvan University, Kathmandu, Nepal
*Email: ananta.bhandari@wwfnepal.org

Ecosystem services, the planet's life support systems, are becoming scarcer and thus there seems growing concerns nowadays. Services provided by many ecosystems including forests are not well explored or poorly known. The present paper aims to identify ecosystem services provided by forest with particular reference to Panchase Protected Forest of western Nepal. The ecosystem services were identified adopting the framework of 'The Economics of Ecosystem and Biodiversity' that classifies the services into four broad categories including provisioning; regulating; habitat; and cultural and amenity services. The methods adopted to identify ecosystem services include consultations with local communities and stakeholders, rapid assessment through transect walk, and review of relevant literatures. Panchase Protected Forest provides provisioning services such as food, raw materials, medicines, and ornamental resources. It is a source of water for hydropower, irrigation and domestic consumption for both upstream and downstream communities. It also provides carbon sequestration benefits as a global public good. Regulating water flows, it contributes in preventing erosion and reducing sedimentation load. Moreover, itregulates air quality and maintains soil fertility and nutrient cycling. It provides shelter for residential and migratory species and maintains life cycles and genetic diversity. By maintaining landscape integrity and heritages, it provides opportunities for recreation and tourism.

Key words: Ecosystem, Forest, Ecosystem services, Panchase

APPENDIX XVI

Abstract of presentation in National Conference: EbA Kathmandu Conference, Kathmandu, Nepal, April 2016



EbA Climate Resilience

EbA Conference Kathmandu 2016

ABSTRACTS

Supported by
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Ministry of Population and Environment
Kathmandu, Nepal

Organised by
Central Department of Environmental Science
Tribhuvan University
Kirtipur, Nepal

Exploring Ecosystem Services in Forest Ecosystem: A Case of Panchase Protected Forest

Ananta Ram Bhandari[1*], Udhab Raj Khadka[2], Keshav Raj Kanel[2]
[1]Central Department of Environmental Science, Tribhuvan University, Kirtipur, Nepal
[2]Amrit Science Campus, Tribhuvan University, Kathmandu, Nepal

Abstract

Ecosystem services, the planet's life support systems, are becoming scarcer and thus are growing concerns now-a-days. Services provided by many ecosystems including forests are not well explored or poorly documented. This paper aims to identify ecosystem services provided by forest ecosystems with particular reference to Panchase Protected Forest. Ecosystem services were identified within the framework of 'The Economics of Ecosystem and Biodiversity' that classifies the services into four broad categories namely provisioning; regulating; habitat; and cultural and amenity services. The methods adopted to identify ecosystem services include consultations with local communities and stakeholders, rapid assessment through transect walk, and review of relevant literatures. Panchase Protected Forest provides provisioning services such as food, raw materials, medicines, and ornamental resources. It is a source of water for hydropower, irrigation and domestic consumption for both upstream and downstream communities. It also provides carbon sequestration benefits as a global public good. Regulating water flows, it contributes in preventing erosion and reducing sedimentation load. It regulates air quality and maintains soil fertility and nutrient cycling. It provides shelter for residential and migratory species and maintains life cycles and genetic diversity. Maintaining landscape integrity and heritages, it provides opportunities for recreation and tourism.

Keywords: Ecosystem, Ecosystem services, Forest