ICIMOD Working Paper 2017/10

ICIMOD

FOR MOUNTAINS AND PEOPLE

Framework for

Integrated Ecosystem Management in the Hindu Kush Himalaya

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About ICIMOD

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

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Cover photo: In March, 2015 a management plan for Ecosystem Services was prepared for Bans-Maitoli Micro Watershed of KSL in Pithoragarh, Uttarakhand, India

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Framework for Integrated Ecosystem Management in the Hindu Kush Himalaya

(For Pilot Testing within Transboundary Landscapes)

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Foreword

The complex ecosystems such as forests, rangelands, wetlands and farming lands in the HKH form the basis for the subsistence and development of over 225 million people living in the region. The diverse services obtained from these ecosystems benefit – directly or indirectly – over 1.3 billion people in the downstream areas and beyond. Climatic and non-climatic changes have posed a challenge to the livelihoods of mountain people and the stability of these fragile ecosystems. It is critical that these ecosystems are managed sustainably.

Mountain ecosystems have a universal importance: they provide water and other global goods and services to humanity. However, mountain ecosystems are highly vulnerable to climate change, extreme weather events and land degradation and recover slowly from disasters and shocks. To achieve the Sustainable Development Goals (SDGs) of the United Nations and the targets relating to mountains as well as to poverty, hunger, sustainable agriculture, climate change and gender equality, there is a need to prioritize mountain ecosystems by focusing on the specific challenges they face and the benefits they provide. For over 30 years, the International Centre for Integrated Mountain Development (ICIMOD) has been working as a learning, knowledge sharing and enabling centre in the Hindu Kush Himalayan (HKH) region. In particular, ICIMOD has made great efforts to increase scientific knowledge of mountain ecosystems and supported the sustainable management of these ecosystems for improving the living standards of mountain men, women and children now and for the future.

The Framework for Integrated Ecosystem Management (FIEM) presented in this publication is an important step towards harmonizing approaches for the management of natural resources in the HKH. This Framework, jointly developed by ICIMOD and its regional partners, focuses on the management of ecosystem services and emphasizes on holistic approaches, multi-stakeholder participation, decentralized management, multi-sectoral and disciplinary coordination, ecological integrity, adaptive management, equity and inclusiveness. It highlights the interactions between people and their environment in the HKH. It has primarily been designed for implementation in ICIMOD's Regional Programme on Transboundary Landscapes by ICIMOD and its partner organizations. This Framework and the 'Long-Term Environmental and Socio-ecological Monitoring Framework', developed by ICIMOD are complementary documents on monitoring and managing ecosystems. To support the use of this framework, an Operational Manual on Management for Ecosystem Services Planning has also been developed.

On behalf of ICIMOD, I would like to thank all the partners, stakeholders and authors that have contributed to and supported the development of this framework. I am optimistic that this framework will be beneficial to ICIMOD and its partners and will also be of great help in the design and implementation of integrated and holistic ecosystem management programmes and in increasing the socioeconomic resilience of the people living in the mountain regions.

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Director General
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The authors are grateful to the United Nations Environment World Conservation Monitoring Centre (UNEP-WCMC) for providing technical assistance and support.

* Refer to Annex 3 for the affiliation of lead authors and contributors.

Acronyms and Abbreviations

ADA	Austrian Development Agency
BMZ	German Federal Ministry for Economic Development Cooperation
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
DFID	Department for International Development
EbA	Ecosystem based Adaptation
FAO	United Nations Food and Agriculture Organisation
FIEM	Framework for Integrated Ecosystem Management
GIS	Geographic Information System
GIZ	German Corporation for International Cooperation
HKH	Hindu Kush Himalaya
ICIMOD	International Centre for Integrated Mountain Development
IUCN	International Union for Conservation of Nature
KSLCDI	Kailash Sacred Landsape Conservation and Development Initiative
LTESM	Long Term Environmental and Socio-Ecological Monitoring
MEA	Millennium Ecosystem Assessment
NGO	Non governmental organization
NTFP	Non-timber forest products
SDGs	Sustainable Development Goals
TEK	Traditional Ecological Knowledge
TRA	The Resilience Alliance
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEP-WCMC	United Nations Environment–World Conservation Monitoring Centre
WRI	World Resources Institute
WWF	World Wide Fund for Nature

Executive Summary

Management of ecosystems for sustaining services is a major focus area of the transboundary landscapes programme of ICIMOD. In line with the United Nations' Sustainable Development Goals (SDGs), the transboundary landscapes programme aims to sustain mountain biodiversity and ecosystems through better monitoring, management, valuation, conservation and restoration in the Hindu Kush Himalaya (HKH) region.

The mountain ecosystems in the HKH are under constant stress due to the rapidly increasing demand for ecosystem goods and services. Fragmentation and degradation of natural habitats, loss of catchment productivity, proliferating alien invasive species, frequent fires, and increased human-wildlife conflicts are some of the manifestations of stress on ecosystems. At the same time, dependence of local communities on biomass resources is increasing steadily. This rising threat to the mountain ecosystems calls for an integrated ecosystem management strategy based on participatory approaches and ecosystem based adaptation for sustainability.

This framework document has been prepared by the team at ICIMOD working on various aspects of ecosystem management in collaboration with the United Nations Environment – World Conservation Monitoring Centre (UNEP–WCMC), with technical inputs from eminent ecologists, gender and governance specialists, sociologists and economists from the region. The document provides basic background, principles and key terms for ecosystem management, major considerations in the context of the HKH and the process and practical steps required for the management of ecosystems.

The framework recognizes the need to integrate different interventions and analyse the biophysical, gender, governance and socioeconomic aspects of ecosystem services assessment. It recommends taking four major steps after identifying the area to be managed and establishing a stakeholders' forum: (1) Outlining the biophysical and socioeconomic context of the ecosystems; (2) Defining goals and objectives based on shared vision and identification of impact indicators; (3) Designing ecosystem management strategies and plans; and (4) Implementing and adapting the ecosystem management plan. These four steps form a cycle as indicated in the framework diagram, continuously incorporating learning and feedback to strengthen the management framework. Central to the management framework is information management, influencing policy and programmes, and building the scope for future innovations.

The framework also provides an indicative list of ecosystem services to be customised and elaborated for each pilot site, key references dealing with ecosystem management and a few questions for developing strategies for managing ecosystem services. This framework document will be circulated among the key partners in the transboundary landscapes of the HKH for a thorough review and testing its applicability in pilot areas. The framework will be continuously modified and refined to address site-specific issues and incorporate the input of partners in the transboundary landscapes.

Background

The Hindu Kush Himalaya (HKH) region harbours a variety of ecosystems which provide numerous goods and services to over 225 million people living in the region and in adjacent river basins. The major ecosystem services from the region include provisioning services (e.g., production of food and forest products), regulating services (e.g., the regulation of climate and water flows), supporting services (such as nutrient cycling and crop pollination) and cultural services (e.g., spiritual and recreational benefits). To ensure human well-being in the region, it is important that people manage these ecosystems and sustain the flow of goods and services.

The demand for ecosystem goods and services is growing due to rapid population growth and other socioeconomic processes such as accelerating globalization, with the added stress of climate change on ecosystems. This pressure has negative impact on the ecosystem structure, process, functioning and delivery of goods and services. Other causes of concern include inadequate enabling policies or their poor implementation, weak governance mechanism, and the paucity of good institutions and trained human resources for effective management of ecosystems. Some of the pressing issues pertaining to sustainable management of ecosystems in the region include:

i) Rapid changes in the structure and functioning of key ecosystems, viz., forests, agro-ecosystems, grasslands, and wetlands;
ii) Depletion of biological diversity and erosion of traditional knowledge;
iii) Poor land-use practices and distortion of farming systems leading to increased food insecurity;
iv) Excessive dependence of local communities on biomass resources and lack of alternative livelihoods;
v) Degradation and fragmentation of natural habitats, rapid proliferation of alien invasive species, frequent forest fires, and human-wildlife conflicts; and
vi) Rapid socioeconomic and demographic changes that result in changes in human-environment interactions.

Professionals and practitioners in conservation and development need to address these issues in an integrated manner at the local, national, and regional level. This would entail adopting the 'ecosystem approach' (Shepherd 2004, 2008), which takes interactions between humans and the environment into consideration for sustainable management of biodiversity and habitats. However, despite the increasing awareness of the interrelationships between ecosystems and development, some national and local governments including development practitioners in the HKH are still pursuing a model of economic development that overlooks the links between ecosystems health and development and the possibilities for harnessing synergetic effects from the ecosystem approach to development policy. Thus, achieving an integrated ecosystem based approach to development will require a strategy that will merge ecological and socioeconomic principles, initiate institutional change and coordination, and ensure stakeholder participation and collaborative decision making.

Management of ecosystems also requires a comprehensive framework and scientific understanding of the ecosystem structure, process and functioning. This can help build ecosystem resilience and develop sustainable land-use practices for practical application on the ground. To bring about a harmonized approach for the mountain context, enhance the capacity of the regional partners for ecosystem management at the landscape level and facilitate communication among practitioners, ICIMOD, in collaboration with UNEP-WCMC, developed the Framework for Integrated Ecosystem Management (FIEM). The framework will be used by ICIMOD and its regional partners for developing ecosystem management activities. It seeks to inform and influence conservation practices in the HKH and to share lessons from the region with conservation practitioners from all over the world, particularly from developing nations where ecosystem management approaches used in industrialized countries may not be feasible or appropriate.

This framework emphasizes a management approach geared towards a sustainable flow of ecosystem services and aims to provide a general guideline for ICIMOD partners to manage major ecosystems in the transboundary landscapes of the HKH. An Operational Manual has been developed by ICIMOD in collaboration with UNEP-WCMC to support the partners in the use of this framework. The two documents could also be used by agencies and professionals working directly with local communities for ecosystem management, though they are not meant to be used directly by the villagers.

Ecosystems, Ecosystem Functioning and Ecosystem Services

Ecosystems

The concept of an ecosystem comes from ecology, which is the study of the interactions and relationships between organisms and their environment. The Convention on Biological Diversity (CBD) and the Millennium Ecosystem Assessment (MEA, 2005) define an ecosystem as:

A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

In practice the spatial boundaries and scale of what is defined as an ecosystem are determined by the observer or user of the ecosystem. Ecosystems are often defined spatially in terms of their dominant vegetation or environmental features, for example, an oak forest, grassland, or lake.

The accumulated body of empirical evidence concerning natural, disturbed, and managed ecosystems points to the following key features of ecosystem structure and functioning (Holling & Gunderson, 2002):

- Change is neither continuous and gradual nor consistently chaotic. Rather, it is episodic with periods of slow accumulation of natural capital such as biomass, physical structures, and nutrients punctuated by sudden release and reorganization of those biotic legacies;
- Spatial attributes are neither uniform nor scale invariant over all scales. Rather, productivity and textures are patchy and discontinuous on all scales, from the leaf to the landscape to the planet;
- Ecosystems do not have a single equilibrium with homeostatic controls to remain near it. Rather, multiple equilibriums commonly define functionally different states;
- Policies and management that apply fixed rules for achieving constant yields (e.g., fixed carrying capacity of cattle or wildlife, or fixed sustainable yield of fish or wood), independent of scale, lead to systems that increasingly lose resilience.

The management implications of these key features and others are elaborated in Chapter 4 of this Framework.

Ecosystem Functioning

The ecosystem concept entails recognizing the functioning, or 'working', of the land, water and living organisms as an 'ecological system' and incorporating this understanding in the management of the environment. In other words, the services people receive from the environment depend on its functioning as an ecosystem (Hooper et al., 2005).

The term 'ecosystem function' is also sometimes used to mean an ecosystem's ability to be useful to people; for example, 'the function of the forest ecosystem is to provide timber and regulate water flows'. This usage of 'ecosystem function' is basically the same concept as ecosystem services.

Ecosystem functioning, like any system, can be understood in terms of the processes, or changes, that occur in the system, the structure of the ecosystem, and key ecological interactions. The supply of any specific ecosystem service from a locality can be described in terms of the ecosystem processes (water cycling, mineral cycle, solar energy flow and biological growth), structure (of the food web, vegetation layers, soil cover, etc.) and key ecological interactions (herbivore, predation, decomposition, pollination and seed dispersal) for that service.

Ecosystem Services

This Framework emphasizes management for ecosystem services and highlights the interrelations between human societies and environment. The simplest and most widespread definition of ecosystem services is, "the benefits people obtain from ecosystems", as defined by the Millennium Ecosystem Assessment (MEA, 2005). The MEA categories of ecosystem services, namely provisioning, regulating, cultural and supporting, are still the most widely used classification. There are some overlaps and inter-relationships between these categories.

Because ecosystem services are defined in terms of the benefits they provide to people, it is important to recognize that the value or importance assigned to any ecosystem service is context dependent. This means that the same feature can be considered a valuable ecosystem service by one group of people but not by another group. These values can even differ within the same group, such as gender-specific needs and priorities of women and men. The physical supply of ecosystem services is determined by the functioning of the ecosystem. The demand for ecosystem services is determined by the needs and decisions of the people who receive the services (Costanza et al., 1997; De Groot et al., 2012; Costanza et al., 2014).

The MEA (2005) analysed 24 ecosystem services globally and found that 15 were undergoing degradation or being used unsustainably. The decline in services affects the world's disadvantaged people the most, impedes sustainable development globally and, in developing countries, poses a considerable barrier in achieving the SDGs of reducing poverty and hunger (Goal 1: End poverty in all its forms everywhere; and Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture).

A more complete list of ecosystem services by the World Resources Institute based on the MEA categories is provided in Annex 1. For a more detailed description of ecosystem, ecosystem services and ecosystem functioning, please refer to the Operational Manual.

Four categories of ecosystem services

Provisioning ecosystem services, such as physical goods and products from ecosystems, are the easiest to identify and quantify. Farming for provisioning ecosystem services and harvesting of natural products are often the objective of many livelihood strategies. Many farming and land management activities alter the structure and processes of ecosystems for the supply of provisioning ecosystem services.

Regulating ecosystem services are the benefits obtained from an ecosystem's influence on natural processes, such as regulation of water flows and flooding by the type of vegetation structure. The functioning, or supply, of many regulating ecosystem services greatly influences the supply of many provisioning ecosystem services.

Cultural ecosystem services are the non-material benefits obtained from ecosystems. The 'supply' of cultural ecosystem services depends on people's interaction with the physical structure of the ecosystem. This could include intellectual, health, cultural and spiritual values derived from provisioning ecosystem services through farming and harvesting wild products.

Supporting ecosystem services are ecosystem processes (e.g., conversion of the sun's energy to organic matter by plants) that are necessary for the supply of other ecosystem services. In our upcoming Operational Manual on Planning Management for Ecosystem Services, supporting ecosystem services are treated as ecosystem functioning.

Agricultural ecosystem services- women sell vegetables in a local market of Putao, Myanmar

Ecosystem Management

Definitions

'Ecosystem management' or 'ecosystem-based management' (often used interchangeably) has been defined in many different ways (Rowe, 1992; Brussard et al., 1998; Pirot et al., 2000), but all the definitions emphasize the need to adopt an ecological approach to natural resources management and to manage the interactions between human societies and environment so as to maintain ecological integrity for sustainable supply of ecosystem services. This Framework uses the same definition as the MEA, (2005):

> ***Ecosystem management:*** *An approach to maintaining or restoring the composition, structure, function, and delivery of services of natural and modified ecosystems for the goal of achieving sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries.*

Ecosystem management uses an ecosystem-based approach to resources (land, water, biodiversity, etc.) management in order to address the myriad challenges that arise from fragmented landscapes and diverse management strategies. It is an integrated process geared towards conserving and improving ecosystem functioning to sustain the supply of ecosystem services for human well-being. It places particular emphasis on integrating human needs with conservation practices, and recognizes the interrelations between ecological, socio-cultural, economic and institutional structures while developing solutions (Grumbine, 1994; Brussard et al., 1998; Daily and Matson, 2008).

The traditional approaches to environmental management, which were based on sectors (e.g., forestry, agriculture) or biomes (geographically and climatically linked natural communities), have a number of shortcomings. For example, they consider ecosystem concerns as separate from development concerns; they ignore the interdependence of ecosystem services and human needs; and they do not acknowledge the diverse effects of declining ecosystem services on various social groups. By taking a more holistic view of the links between ecosystem services and human well-being, the ecosystem management approach can correct these shortcomings and focus on maintaining the functioning and resilience of ecosystems and ensuring equitable access to ecosystem services. Furthermore, ecosystem management is not a replacement for or an alternative to the existing ways of working or modifying the natural environment for human benefit, such as farming, forestry, watershed management and conservation of biodiversity. It adds dimension and capacity to these practices to help the managers provide sustainable benefits for society. In general, the purpose of ecosystem management is to restore and protect the health of ecosystems over the long term while accounting for the variety of social and economic benefits derived from those ecosystems. Ecosystem management is thus not a single strategy but rather a general approach to resource management that emphasizes cooperative decision-making combined with a broad perspective and understanding of the ecosystem.

An ecosystem-based management plan should emphasize the health of the whole ecosystem ahead of the concerns of special interests, be place-based, with boundaries scientifically defined, consider the way things or actions in this place can influence or be influenced by things or actions on land (like dams or fertilizers in the watershed), in the air (like air pollution), or in different parts of the ocean (like fishing or oil spills); and integrate the concerns of the environment, society, the economy and our institutions.

It is important to distinguish between the landscape approach and the ecosystem approach to management. The landscape approach is a framework for making landscape-level conservation decisions, developed by WWF (2002) and IUCN (Brown et al., 2004). It contributes to broad-scale approaches to conservation, such as WWF's ecoregion conservation programme (Dinerstein at al., 2017). According to Sayer et al., 2013 landscape approaches can be viewed as "tools and concepts that help allocate and manage land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals" and people are central to this approach. Thus, the landscape approach recognizes spatial and social-ecological systems comprising patches and metrics valued by humans in terms of economic, socio-cultural,

and ecological benefits (DeFries et al., 2004). It helps us reach decisions about the advisability of particular interventions (such as a new road or plantation) and to facilitate the planning, negotiation and implementation of activities across a whole landscape. Furthermore, it sets out a stakeholder negotiation framework for land and resource use decisions and for balancing the trade-offs inherent in such large-scale approaches. This approach also recognizes and uses overlapping cultural, social, and governance 'landscapes' within biologically defined areas (WWF, 2002).

A Historical Review

The systemic ecosystem-based approach to natural resources management started in the Great Lakes of North America in the late 1970s. The legislation created the 'Great Lakes Basin and the Great Lakes Water Quality Agreement of 1978', which was based on the claim that "no park is an island", with the purpose of showing that strict protection of the area is not the best method for preservation (Slocombe, 1998).

However, its historical development can be traced back to the 1930s whence it has evolved through the testing and challenging of common ecosystem management practices. During the 1930s, the scientific communities who studied ecology realized that current approaches to the management of national parks did not effectively protect the species within the parks. In 1932, the Ecological Society of America's Committee for the Study of Plant and Animal Communities recognized that US national parks needed to protect all the ecosystems contained within the park in order to create an inclusive and fully functioning sanctuary, and be prepared to handle natural fluctuations in its ecology. The committee also explained the importance of interagency cooperation and improved public education, as well as challenged the idea that proper park management would "improve" nature (Grumbine, 1994). These ideas became the foundation of modern ecosystem-based management.

This shift in the understanding of park management gave rise to new principles of ecosystem management. Biologists George Wright and Ben Thompson (1935) studied the size and boundaries of parks and contributed in changing the method of demarcating park boundaries. They explained, for example, how large mammals could not be supported within the restricted zones of a national park and that a new approach would be needed to protect these animals and their ecosystems (Wright and Thomson, 1935). Other scientists followed suit, but none were successful in establishing a well-defined ecosystem-based management approach.

In 1970, policy analyst Lynton Caldwell published an article that advocated using ecosystems as the basis for public land policy and required the conventional (political) matrix to be unravelled and rewoven in a new pattern. In 1979, the importance of ecosystem-based management resurfaced in ecology from two biologists: Frank and

Humans have a long history of ecosystem management: a village in German Alps

John Craighead. They found that the population of grizzly bears of the Yellowstone National Park could not be sustained if they were only allowed to live within park boundaries. This reinforced the need for a broader definition of ecosystem, one based on the biotic requirements of the largest mammal present (Grumbine, 1994).

The idea of ecosystem-based management began to catch on and projects throughout American National Parks reflected the idea of protecting an ecosystem in its entirety and not based on legal or ecological restrictions as previously used. By the late 1980s, an ecosystem approach to land management was being supported by many scientists, managers, and others (Grumbine, 1994). Agee and Johnson (1988) published a book-length report on managing ecosystems, explaining the theoretical framework of management which included both general goals and processes for achieving these goals. While they did not fully embrace ecosystem-based management and still called for "ecologically defined boundaries", they stated the importance of "clearly stated management goals, interagency cooperation, monitoring of management results, and leadership at the national policy levels" (Grumbine, 1994). Most importantly they demanded the recognition of human influence. It was argued that scientists must keep in mind the "complex social context of their work" and always be moving towards "socially desirable conditions" (Grumbine, 1994). This need to understand the social aspects of scientific management is a fundamental step going from ecological management to ecosystem-based management. Although this need is recognized at present, debate over ecosystem management continues. Different users have different concepts and perspectives. In the middle of the 1990s, the US Forest Service defined ecosystem management as, "a holistic approach to natural resource management, moving beyond a compartmentalized approach focusing on the individual parts of the forest. It … integrates the human, biological, and physical dimensions of natural resource management. Its purpose is to achieve sustainability of all resources" (Thomas, 1994). Brussard et al. (1998) proposed that the major objective of ecosystem management is to ensure that ecological services and biological resources do not erode irreversibly as a result of human activities. Thus, his definition of ecosystem management is, "managing areas at various scales in such a way that ecosystem services and biological resources are preserved while appropriate human uses and options for livelihood are sustained" (Brussard et al., 1998).

Grumbine (1994) believes that while the approach of ecosystem management has evolved, it has not been fully incorporated into management practices because the most effective forms of it have yet to be seen. The current ecological climate calls for the most holistic approach to ecological management. This is in part due to the rapid decline in biodiversity and partly due to the constantly changing perspectives on nature. Conflicts over public interest and understanding of the natural world have created social and political climates that require interagency cooperation. In fact interagency cooperation has become the backbone of ecosystem management. According to Brussard et al. (1998), there are a number of barriers to implementing ecosystem management. First among these is the lack of scientific knowledge. Ecosystem management will require (1) linking necessary data on ecosystems at several spatial scales, and (2) analysing socioeconomic data to determine the relationships among ecological conditions and human activities and the tradeoffs between ecological and socioeconomic values (for details, see Brussard et al., 1998). In most cases, data required for these two tasks is inadequate or lacking, especially data on developing countries or remote mountain regions (e.g., the HKH).

Over the last ten years, numerous international organizations or conventions (e.g., UNEP, IUCN, FAO, and CBD) have adopted the ecosystem management approach for biodiversity conservation, green economy development, poverty alleviation, and ecosystem-based adaptation enhancement (Naumann et al., 2013)). A lot of efforts have gone into demonstrating the foundational significance of ecosystems management in maintaining societies, drawing the attention of policy makers to the challenges and opportunities in ecosystem management, and promoting capacity building and regional cooperation. Through the implementation of ecosystem management in Africa, UNEP addressed the significance of institutional innovations that require merging ecosystems management with economic management at relatively larger spatial and temporal scales. It was suggested that embracing and capturing the economic values of ecosystem services in mainstream decision making tools and indicators, for example, a national income and growth matrix, can help in designing effective policies for sustainable growth and societal well-being. Recently, the ecosystem management approach was also implemented in the tropical western Pacific (e.g., Fiji) for conserving the oceanic and coastal ecosystems, improving the resilience of their communities, reversing the tide of degradation, and protecting human health and livelihood for future generations (Clarke and Jupiter, 2010).

Key Principles and Considerations for Ecosystem Management

The considerations for ecosystem management vary according to the context and focal concern of the management, but there is an increasing set of generally accepted principles for implementing ecosystem management activities. The Convention on Biological Diversity (CBD, 2000) has outlined 12 principles for the ecosystem approach to CBD implementation. Others have suggested different principles according to their own specific management objectives (Overbay, 1992; Bernard et al., 1994; Jesen and Everett, 1994; Lackey, 1998, 1999; Cowling et al., 2008; Leech et al., 2009). Below is an overview of some of the principles based on an up-do-date understanding of ecosystem science and management practices.

Managing for People (for Ecosystem Services) and Managing People

Implementing ecosystem management depends on the management of social, economic, and institutional factors (Quinn, 2002). Ecosystem management requires that ecosystems be managed in a sustainable manner to be able to provide for a wider array of uses, values, products, and services from the land to an increasingly diverse public (Overbay, 1992). The objectives of the management of land, water and living resources are a matter of societal choice, and they should be expressed as clearly as possible in management planning. We manage ecosystems so that they can provide sustained ecosystem services for sustainable development of human societies. This is why this framework emphasizes management for ecosystem services. Therefore, it is important to have a good understanding of the full range of services human societies derive from the ecosystems under consideration.

On the other hand, human activities are one of the major drivers of ecosystem change. In ecosystem management, it is human activities that can and should be managed to sustain ecosystem services. . A socio-ecological approach to ecosystem management that emphasizes interactions between social subsystems and ecological subsystems should be adopted. This focus on "managing people" highlights the importance of institutions, policies and governance, not just technologies, in successful and effective ecosystem management. Human institutions affect the resilience of the environment (Hardin, 1968 and 1998; Ostrom, 1990; Dietz et al., 2003).

A study on the application of the Principles of the Ecosystem Approach by the IUCN Commission on Ecosystem Management (Shepherd, 2008) found that the institutional aspects of ecosystem management need to be fully taken into account. Ecosystem management needs to foster institutional mechanisms and ownership for sustaining the services people obtain from the environment. It needs to use appropriate tools and mechanisms to develop management frameworks for achieving multiple benefits of ecosystem restoration, livelihood improvement and job creation. This includes working with governance structures, stakeholder engagement, and strengthening policies and protocols, strategies and practices.

> ***Institution:*** *'Institution' refers to the ways things are organized and are humanly devised constraints that structure human interaction. They are made up of formal constraints (rules, laws, and constitutions), informal constraints (norms of behaviour, conventions and self-imposed codes of conduct) and their enforcement characteristics. Institutions are "the set of rules actually used (the working rules or the rules in use) by a set of individuals to organize repetitive activities that produce outcomes affecting those individuals and potentially affecting others" (Ostrom, 1990; Ostrom, 1992; North, 1993; Berkes and Folke et al., 1998; Dietz, 2003).*

Multi-functionality, Multi-stakeholder Participation and Coordination

Ecosystems are multifunctional and provide multiple services to people. The same plot of rangelands can at the same time produce fodder for livestock, provide habitat for wildlife and biodiversity conservation, function as a catchment area for a watershed and act as a venue for tourism activities. Very often, the beneficiaries and users of

these different services and functions are different. Different sectors of society view ecosystems in terms of their own economic, cultural and societal needs and each has its own focus and priority.

Multi-stakeholder participation and sectoral coordination in ecosystem management is very important for ensuring that the interests and needs of all stakeholders are duly taken into account and those whose interests have been sacrificed for public interest are duly recognized. In particular, local people and other local communities benefiting from the land are important stakeholders and their rights and interests should be recognized.

Ecosystem management thus requires cooperation and coordination across jurisdictions, government agencies, and industries, and this necessitates significant institutional change (Cortner et al., 1998).

> ***Stakeholders and Participation:*** *Stakeholders are individuals or groups of people who are affected by environmental decisions and actions, but they may also have power to influence the outcomes of environmental decisions relating to ecosystem management (Reed et al., 2009). Stakeholders will often have different interests in ecosystem services (Shepherd, 2008; Martın-Lopez, 2012). The complex nature of decisions made in ecosystem management, on a local to global scale, requires stakeholder participation, that is the active involvement and empowerment of stakeholders (Billgren and Holmen, 2008; Reed 2008). This means that effective management of ecosystems requires a negotiation process that builds mutual trust in issues of common interest with the objective of creating mutually beneficial partnerships (Mushove and Vogel, 2005). Adequate institutional setups are essential for meaningful participation of all stakeholders in ecosystem management. There are plenty of methods, tools and approaches that have been developed to facilitate the active participation of stakeholders in natural resources management.*

Zoige Wetland in eastern Tibetan Plateau is highly valued for tourism, pastoralism and biodiversity conservation

Managing Ecosystems along Ecological rather than Administrative Boundaries

Ecosystems can be defined in terms of biophysical and social boundaries. In natural resources management, these are usually landscape-scale boundaries such as watersheds. Boundaries for management will be defined operationally by users, managers, scientists and indigenous and local peoples. Ecological connectivity between areas should be promoted where necessary. The ecosystem approach is based on the hierarchical nature of biological diversity characterized by the interaction and integration of genes, species and ecosystems. Management along ecological boundaries such as the watershed approach requires interagency or cross-border cooperation, for which an appropriate institutional framework needs to be in place.

Developing Ecosystem Management Activities at Appropriate Spatial and Temporal Scales

Ecological processes and functioning and interactions between ecosystems and human societies occur at different spatial and temporal scales. Multiple-use sustained-yield management of land and resources depends on sustaining the diversity and productivity of ecosystems at many geographic scales. Therefore, ecosystem management activities shall also be undertaken at appropriate scales within ecosystem boundaries based on the issues at hand and the objectives of management. Ecosystem connections at various scales and across ownerships make coordination of goals and plans for certain resources essential to success (Armitage, 2008; Berkes, 2008). Scale mismatch is a main cause of failure in ecosystem management.

Decentralization, Community-based Management and Local Ownership

Management should be decentralized to the lowest appropriate level. Decentralized systems and local ownership may lead to greater efficiency, effectiveness and equity. The closer management is to the ecosystem, the greater the responsibility, ownership, accountability, participation, and use of local knowledge. Besides, "uncertainties" in ecosystem dynamics require close monitoring of and quick responses to the problems and crisis arising in the process. Decentralizing management tasks can authorize the direct users of the ecosystem services and those closer to the ecosystem to quickly respond to ecosystem changes, which is crucial for social-ecological resilience (Holling and Gunderson, 2002; Adger and Vincent, 2005).

Evolutionary Nature of Ecosystems and Adaptive Management for Resilience

Ecosystems are evolutionary and complex adaptive systems and follow their own adaptive cycles (Holling and Gunderson, 2002). Management must recognize that change is inevitable and management should adapt to the changes.

The ecosystem approach must utilize adaptive management in order to anticipate and cater for such changes and events and should be cautious in making any decision that may foreclose options, but, at the same time, consider mitigating actions to cope with long-term changes such as climate change.

This 'inherent uncertainty' in ecosystem dynamics means that management policies are only trials and experimental and shall change over time according to the outcome of implementation. Learning by doing, or adaptive management shall be the norm of management. Management institutions shall be designed such that they can respond to uncertainties and adapt management strategies when it is needed (Adger and Vincent, 2005).

Ecosystems are ever-changing systems; given the natural dynamics and complexity of ecosystems, conditions are not perfectly predictable and any ecosystem offers many options for uses, values, products, and services that can change over time. Therefore, the goal of management shall be to maintain the resilience of ecosystems to avoid catastrophic shifts rather than to obtain constant maximum yield of certain products or services (Holling, 1973; Holling, 1986; Scheffer et al., 2001; Holling & Gunderson, 2002). To maintain ecosystem services, conservation of ecosystem structure and functioning should be a priority target of the management.

Pastoralism has shown strong resilience under harsh conditions, western Tibet

> ***Resilience:*** *Resilience is the capacity of a socio-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions, or more generally 'resilience' is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity and feedback. It describes the degree to which the system is capable of self-organization, learning and adaptation (Holling, 1973; Gunderson & Holling, 2002; Walker et al., 2004).*

The term 'resilience' is widely used in discussions of complex adaptive systems such as ecosystems, and many new dimensions have been added to it (Holling and Gunderson, 2002). In this framework, 'resilience' refers to how well a system, either ecological or social, can maintain its critical functions and processes in response to disturbance. The two main components of resilience are: (1) the ability to resist changing in the face of disturbance; and (2) the ability to quickly recover from it.

The likelihood of an ecosystem shifting to an unfavourable state is increased through human actions that reduce resilience, such as removing entire functional groups or trophic levels, creating increased stress from pollutants, and altering the magnitude and frequency of disturbances (Folke et al., 2004). The new state of the system may be less desirable if ecosystem services that benefit humans are diminished, as in the case of productive freshwater lakes that become eutrophic and biodiversity-depleted. Restoring a system to its previous or original state can be complex, expensive, and sometimes impossible. Research suggests that restoring some systems to their previous state requires a return to conditions that existed well before the point of collapse (Scheffer et al., 2001). The management implication of this ecosystem attribute is that ecosystem management shall aim to maintain the resilience of the system rather than a constant yield of certain ecosystem goods so that it can continue to function as a healthy system (Walker et al., 2004).

> ***Adaptive Management:*** *Adaptive management emphasizes 'learning by doing' in contrast to the conventional 'command-and-control' approach. It is based on the concept that predicting future influences on/disturbance to an ecosystem is limited and unclear (Pahl-Wostl, 2007) and that ecosystems are moving targets, with multiple futures that are uncertain and unpredictable.*

Thus, ecosystem management has to be flexible, adaptive, and experimental at scales compatible with the scales of critical ecosystem functions (Walters, 1986; Gunderson et al., 1995). In fact, it is an adaptive process that entails continuously readjusting and improving management tools. The goal of adaptive management is to manage the

ecosystem so that it maintains the greatest amount of ecological integrity, but also to utilize management practices that have the ability to change based on new experience and insights (Holling, 1978; Pahl-Wostl, 2007).

Adaptive management aims to identify uncertainties in the management of an ecosystem while using hypothesis testing to further understand the system (The Resilience Alliance, 2010). In this regard, adaptive management encourages learning from the outcomes of previously implemented management strategies (Pahl-Wostl, 2007). Ecosystem managers form hypotheses about the ecosystem and its functionality and then implement different management techniques to test the hypotheses. The implemented techniques are then analysed to evaluate any regressions or improvements in the functionality of the ecosystem caused by the technique. Further analysis allows for modification of the technique until it successfully meets the ecological needs of the ecosystem (Holling, 1978). For this reason, adaptive management should be a social process as well as scientific, focusing on institutional strategies while implementing experimental management techniques (TRA, 2010).

Balancing Conservation and Sustainable Use

The ecosystem management shall seek to strike a balance between conservation and sustainable use of biological diversity, and integrate conservation and development goals, especially in the HKH where local communities rely on mountain ecosystem services for survival and development.

Biological diversity is critical both for its intrinsic value and because of its key role in forming the ecosystem and providing services on which we all ultimately depend. There has been a tendency in the past to manage components of biological diversity either as protected or non-protected entities. There is a need to shift to more flexible approaches by which conservation and use are understood in a specific context and the full range of measures is applied (Balvanera et al., 2006; De Groot et al., 2010; Muller et al., 2010).

Making Use of Both Scientific Knowledge and Indigenous and Local Knowledge

Both scientific knowledge and indigenous knowledge, especially traditional ecological knowledge (TEK), shall be used for ecosystem management. Traditional ecological knowledge is accumulated by local communities over generations and thus complements modern scientific knowledge (Berkes et al., 1995). Besides, information from all sources is critical to arriving at effective ecosystem management strategies. All relevant information from any concerned area should be shared with all stakeholders and actors.

Where traditional knowledge, ecosystem management and market economy meet: Intercropping trees with wheat in northern India

Indigenous Knowledge: *The term 'indigenous knowledge' (IK) in this framework refers to local knowledge held by indigenous people, or local knowledge unique to a given culture or society. The term can be used interchangeably with traditional knowledge. Traditional ecological knowledge (TEK) refers to a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and their environment. Traditional and local management is contrasted with Western Resources management science, or so-called scientific resources management, and conventional resources management (Berkes et al., 1995).*

Women are the major custodians of watershed in northern India

Equity and Inclusiveness

Successful management and sustainable use of natural resources requires meaningful participation of all stakeholders, especially the marginalized groups, in the management process, from planning and implementation to monitoring of management activities, and benefit sharing among all stakeholders.

One essential aspect that cuts across people and institutions is gender. Gender intersects with other key social aspects such as class, caste, ethnicity, and other dimensions of marginality to shape roles and responsibilities as well as status and identities of women and men in the household and community. The issue of gender and ecosystem is based on two principles: (1) that gender mediates human/environment interactions and all environmental use, knowledge, and assessment; and (2) that gender roles, responsibilities, expectations, norms, and the division of labour shape all forms of human relationships with the environment. Thus, gender differences and inequalities influence the extent and nature of almost every form of environmental encounter, use, and impact.

Gender differences and inequalities are manifested in the following ways: Women play decisive roles in using and preserving biodiversity, water, land and other natural resources at the local scale. Thus they are often a storehouse of traditional and sometimes contemporary knowledge of these areas. On the other hand, while environmental degradation has severe consequences for all human beings, it particularly affects the most vulnerable, like women and children. It is important to understand the linkages between gender relationships and ecosystems as this will lead to better analysis of patterns of use, knowledge and skills regarding conservation and sustainable use of natural resources. A gender perspective is critical to get a more complete picture of human relationships and ecosystems (Aguilar et al., 2011). Ecosystem management needs to analyse the critical linkages between gender equality and ecosystem as well as the innate value and need of addressing gender inequality issues while designing and developing management strategies, plans and monitoring mechanisms. For this, there should be meaningful engagement of women in decision-making processes and gender equality should be acknowledged as a driver of social, economic and environmental transformation for sustainable development.

It should be noted that in recent years, extensive scientific research has demonstrated the value of an integrated 'ecosystem-based' approach to manage the mountain environment, yet there are relatively few examples of its successful implementation on the ground, and those that do exist typically focus on temperate ecosystems in the developed world. Recommendations for the implementation of ecosystem management principles are often made in the context of developed countries and may not be entirely applicable to developing countries, including the HKH.

Ecosystem Management in the Hindu Kush Himalaya Context

The HKH harbors highly diverse and complex ecosystems due to its varying topography, inclinations, and sharp gradients of altitude and anthropogenic activities. These ecosystems provide numerous goods and services to over 225 million people living in the region and in the adjacent river basins, and more people in the downstream areas benefit from these services. The region is home to 4 of the 36 global biodiversity hotspots. A total of 488 protected areas of various categories have been established by the governments of the countries in the HKH. These protected areas account for 39% of the total geographical area of the region.

Major ecosystems that sustain local livelihoods in the HKH include forests, grasslands, wetlands, aquatic (lacustrine and riverine), agro-ecosystems and their interfaces. Each of these ecosystems has evolved under certain environmental conditions, with varying degrees of resilience to anthropogenic pressures and natural perturbations or stressors. Therefore, management will have to work within the limits or thresholds of change in these ecosystems, to ensure flows of goods and services. An example for the region is management of sub-tropical dry deciduous forests dominated by sal (*Shorea robusta*) and Himalayan Chir-pine (*Pinus roxburghii*). These forests have a tendency to accumulate enormous leaf litter on the forest floor, which takes a long time to decompose. However, both tree species have a high ability to withstand forest fires. Occasional, controlled fires during cool season in these forests promote fire-adapted species, such as grasses and other browse species. Management of these forests for multiple functions should, therefore, consider these characteristics. This could mean allowing sustainable harvest of excessive leaf litter, dead wood and other surplus biomass, so as to reduce fuel load and fire hazard at the same time. In particular, there is a need to consider the implications of such management on ecosystem processes including nutrient cycling in relation to the supply of ecosystem services. In fact, adaptive management of forest ecosystems could help control alien invasive species and aid the regeneration of desired species and sustainable harvest of NTFPs, provided the stakeholders know the limits of production and levels of harvest. Similarly, forest management in most cases needs to be linked with watershed development, climate change adaptation, rural livelihoods and energy needs of local communities.

Human activities are the key driving force of ecosystem change in HKH region: a view of Pithoragarh, Uttarakhand, India

Rangelands cover about 54% of the 4.2 million square kilometres of the HKH. They are the primary source of subsistence for thousands of mountain communities. High altitude rangelands in many parts of the HKH, despite their short growing season, low primary productivity and fragility, have the ability to seasonally support a considerable herbivore biomass. Under a well-managed livestock grazing regime, these rangelands could continue to provide various ecosystem services, such as providing specific habitats for high-value medicinal and aromatic plants, water flow regulation, carbon storage, and aesthetic and cultural services. Management will have to assess all the activities associated with pastoralism that influence the structure and functioning of rangelands, working with the changing climate and socioeconomic conditions of herders. Based on such assessments and participatory processes, the management agencies need to promote innovative and enterprise-based activities that do not impinge upon the biomass

resources of rangelands, and also find out alternatives to 'not so eco-friendly' activities. All good practices that are accepted and adopted by the herders will have to be promoted for policy uptake by the respective states.

Meanwhile, the HKH is characterized by high levels of reliance on mountain resources, limited government management capacity and strong traditions of community based natural resource management. Degradation of mountain ecosystems directly threatens the livelihoods of local communities in the region and increases their vulnerability to natural disasters and climate change. Human well-being in the region depends to a great extent on people's ability to manage these ecosystems for sustained flow of goods and services.

Barring a few forestry and community based organizations, the institutional arrangements for the overall management of ecosystems in the HKH are still evolving. The local communities and conservation and natural resource management agencies in the region have, so far, been managing the land and key resources (ecosystem goods) as per the national legislations and to some extent according to customary laws. In most of the countries, land is owned by the state and the local communities have 'rights' to use their resources to meet basic needs. Management of ecosystems for sustained yield of goods and services for the broader public has not taken place yet. For example, management of forest ecosystems began with timber production. The role of forests as a source of NTFPs, a protector of watershed, a habitat for wildlife and a repository of biodiversity has only been recognized in recent decades. This recognition, however, is not yet uniform across the region and various sections of society. In many areas there are conflicts due to a lack of clear policies and lack of good governance, and these essential issues have to be addressed to create the conditions for sustainable development in the region.

Given the high level of direct dependence of local communities on the mountain resources in the HKH and the importance of the mountain ecosystems to the downstream areas, management of ecosystems in the HKH would entail setting limits for resource use, reaching agreement on land use practices, and striking a balance between conservation and development. The challenge of managing resources has grown amid rapid socioeconomic changes brought about by globalization, infrastructure development, and expansion of small towns and urban centres as a result of outmigration by rural communities. The state agencies are faced with the challenges of managing all categories of ecosystems i.e., productive, protective, multiple use and urban-industrial environment.

Another important dimension of ecosystem management in the HKH is that many issues are of a transboundary nature and resolving them requires regional cooperation. Many eco-regions cover more than one country; ecosystem services flow between countries and many fauna species migrate across the national borders. Illegal cross-border trade in wildlife products is common. All these issues need to be addressed in an integrated manner by the professionals and practitioners in conservation and development at the local, national, and regional level using the ecosystem approach. New scientific understanding, updated management strategies and better methods for interaction are needed to begin solving the most pressing natural resource issues.

ICIMOD has been promoting the landscape approach to conservation and development in the HKH; this approach entails integrated management of the ecosystems. For instance, under the Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI), public awareness building, action researches, livelihood diversification, value chain development, funding mechanisms were all packaged together to achieve a synergistic outcome of ecosystem management.

Management of ecosystems requires a comprehensive framework and scientific understanding of ecosystem structure and functioning to build ecosystem resilience and develop sustainable land-use practices for practical application on the ground. This document provides a basic framework and guidelines for the management of ecosystems in the HKH. The document has the potential to provide holistic management necessary for sustaining resources in the complex ecological/political landscapes.

Common issues facing ecosystem management in the HKH

Ecological concerns including loss of biological diversity, invasion by alien species, fragmentation of habitat and landscapes, and declines of key ecosystem processes. These changes have resulted in the decline of species, loss of genetic resources, degradation of forests and grasslands, shrinkage of wetlands as well as the erosion of traditional knowledge throughout the countries within the HKH.

Economic difficulties due to decline in the supply of ecosystem services, resulting in loss of economic capacity in forestry, agriculture and pastoralism; lowered resilience to catastrophic change caused by flood, drought, fire or other disturbances; loss of aesthetic value due to the change of land covers such as urban sprawl; and poor land-use practices and distortion of farming systems leading to increased food insecurity.

Ineffective decision-making processes including top-down approaches that restrict creative strategies and undermine support by affected parties; adversarial processes that have led to excessive conflict and impasses; and narrow regulatory strategies that have failed to induce needed changes in behaviour.

Social concerns including the disassociation of people from the land and from each other, which has eroded the social fabric that holds communities together; excessive dependence of local communities on biomass resources and lack of alternative livelihoods.

Priority areas of ecosystem management in the HKH

i) ***Sustainable management of ecosystems for multiple services***

a. managing agro-ecosystems for conservation of soil, water and nutrients;
b. managing forest and grassland ecosystems for quality and quantity of water;
c. promoting green economy models;
d. converting monoculture forestry plantations to polyculture plantations;
e. managing human-wildlife conflicts; and
f. managing invasive alien species.

ii) ***Protection of Key Areas***

a. managing critical watersheds and upper catchment areas of rivers for hydrological functions;
b. managing biodiversity hotspots, protected areas and buffer zones;
c. minimizing human-wildlife conflicts;
d. Restoring and maintaining biological corridors between protected areas; and
e. Rehabilitating and restoring degraded ecosystems.

iii) ***Developing innovative mechanisms or institutions***

a. Developing/strengthening community-based natural resources management institutions;
b. Piloting clean development mechanism (CDM), clean and renewable sources of energy, ecosystem-based adaptation (EbA);
c. Developing market/financial incentives for better ecosystem management; and
d. Developing innovative models to link upstream and downstream areas for benefit and cost sharing in ecosystem management.

iv) ***Building local capacities for better ecosystem management***

v) ***Promoting regional cooperation for improved management of transboundary landscapes and ecosystems***

Framework for Ecosystem Management

The proposed framework for the management of ecosystems is shown in Figure 1. It presents a series of actions or steps required at various levels. It recommends four major steps after the identification of the area and formalization of a stakeholders' forum: (1) Outlining the biophysical and socioeconomic context of the ecosystem; (2) Defining the goals and objectives based on a shared vision and the impact indicators identified; (3) Designing ecosystem management strategies and plans; and (4) Implementing and adapting the ecosystem management plan. These four steps are part of a cycle, as indicated in the framework diagram, and they suggest the need for continuous learning and feedback to strengthen the management framework. Central to the management framework are: information management, influence policy and programmes, and innovation.

Programme Initiation

The initiation phase of a management programme includes three actions: (1) defining the management area; (2) establishment of a stakeholders' forum; and (3) coordinating agency. Delineation of the ecosystem and management boundaries must consider biophysical, economic and social attributes and should facilitate national strategies for planning and decision making. Similarly, it is important to consider the different and nested geographical and decision-making scales of stakeholders, including national priorities. For example, local stakeholders whose interests are at the local level may not wish to participate at the wider landscape level, assuming that their interests can be well addressed while doing landscape level assessment. It is important to note that assessment at multiple scales and wider geographical coverage promotes the inclusion of more interests.

Ecosystem management often starts with social mobilization- Communities interacting with the project staff about the impacts and management of invasive species in Khar, Far-western Nepal

Participatory management of ecosystems and services in any area begins with the identification of primary, secondary and tertiary stakeholders. These stakeholders or their representatives are then brought together on a common platform. Traditionally, the government agencies such as the departments of forests, rural development, irrigation, livestock and agriculture in the HKH countries have been working in silos without involving primary stakeholders. Thus, this framework seeks to create a stakeholders' forum and also decide the coordinating agency early on so as to make the planning process effective, participatory and iterative and thereby ensure the implementation of the ecosystem management plan.

Outlining the Biophysical and Socioeconomic Contexts (Step 1)

The HKH countries have different environmental regulations and legislations pertaining to the use of forests and natural resources. Likewise, within each country the customary laws and traditional rights for the use of basic resources differ from place to place. For example, in high altitude rangelands of the HKH, pastoral communities have been following their own set of rules and regulations for sharing pastures and maintaining ecosystem productivity. With changing socioeconomic conditions and land use, there is a need to revitalize the sustainable and participatory natural resource management practices. Management for ecosystem services needs to build on and strengthen existing institutional and cultural arrangements and practices for working with the natural environment. These could be informal or legal mechanisms for farming, forestry, water management or biodiversity conservation. The relevant stakeholders, from local people to government agencies, business sector, non-government organizations (NGOs), education and research bodies, and religious organizations, need to be identified and analysed. This should include gender and social inclusiveness in management and natural resource governance. Local stakeholders may be categorized in terms of livelihoods, such as subsistence or commercial farmers, herders or forest workers. Under this step five actions are required.

Determining the status of ecosystem services supply and ecosystem functioning

The suite of ecosystem services currently supplied by the ecosystems in the management area need to be identified and their status and trends determined. The list of ecosystem services in Annex 1 can be a starting point for this analysis, and other classifications and categorizations of ecosystem services may also be used, especially to incorporate local and indigenous interpretations. The current ecosystem functioning that supplies these services needs to be described. The components of core ecosystem processes, structure and interactions provide a framework for this. The reasons behind past or existing trends in ecosystem service supply should be briefly documented. The results of these analyses need not be extremely detailed, but sufficient to inform the management objectives and strategies.

Information would also be needed on the unintentional, direct impacts of activities external to the ecosystem location on ecosystem services and functioning, such as agriculture in upstream areas, construction of roads and hydropower plants, or establishing protected areas. For each ecosystem service, seek evidence of trends in their supply and use, and the reasons for any change. At this stage of the assessment, it is sufficient to simply categorize trends as rapidly or slowly increasing or decreasing, or as stable. The time period on which this categorization is based should be recorded, e.g., over the last 5 years or 20 years.

Identifying economic influences on ecosystem management capacity

In the face of the rapid socioeconomic changes and growing influence of a market economy in the HKH, it is imperative to analyse the economic issues that affect the local ecosystem management capacity. Invariably, communities living in remote localities are disadvantaged due to a lack of incentives for sustainable use of natural resources, distant markets, poor access, and inadequate mechanisms for benefit sharing associated with the use of bio-resources. It is necessary to understand the economic context in which the stakeholders in the defined management area are living and working. The focus of the analysis at this stage should be the economic forces that promote or diminish people's capacity to manage their environment, building on the previous step in the framework.

Identifying the demand for ecosystem services and their importance for people

For each group of stakeholders, assess the current importance of the identified ecosystem services as essential, important, or slightly important, and the reason for the rating. The importance of the ecosystem service should be assessed in terms of its current use and supply (availability) to the group. Consideration should be given to any likely changes in the future demand for ecosystem services, such as population growth or migration. This information will help define the vision and objectives of ecosystem management.

Determining the vulnerability of ecosystem service supply to climate change and other threats

Climate change poses an increasing challenge to the sustainable supply of ecosystem services in the HKH. Methods are being developed and tested for Ecosystem-based Adaptation (EbA) to climate change, as a means of reducing people's vulnerability to the negative effects of climate change. To plan and implement ecosystem management, information should be obtained on the impact of current and likely future climatic hazards and trends in the supply of ecosystem services, along with information on people's livelihoods. Understanding and properly describing the ecosystem functioning for the supply of important ecosystem services will help identify climate parameters that are most significant for these services. Ideally, information can then be gathered on possible trends in these climate parameters, to assess the vulnerability of ecosystem services supply to any such change.

Other threats to the supply of important ecosystem services could be invasive alien species, pests and diseases, or pollution. Such threats may also need to be identified and assessed for their potential impact and probability of occurrence.

Identifying economic influences on the demand and supply of ecosystem services

It is relatively easy to value provisioning ecosystem services, such as water, food, medicine and timber, because they are physical goods that can be traded. However, many non-market services (e.g., intrinsic and aesthetic values, hydrological, nutrient cycling, climate regulation, and cultural) are difficult to value in absolute terms. Although tools are being developed for economic valuation of ecosystem services (Kumar, 2010; Rasul et al., 2011), such tools are yet to be adapted and tested in the context of the HKH. Managing ecosystems to supply commercially traded (tangible) provisioning services is a major goal of rural communities, and this may take place at the expense of the supply of other types of ecosystem services. Ecosystem management planning should be based on information on markets and relevant policies that influence the demand and supply of many ecosystem services.

Defining Vision and Goals for Ecosystem Services Supply and Functioning (Step 2)

The key stakeholders in the management area should produce a description of their broad vision of the supply of ecosystem services that they want to have and would work towards achieving. This vision will guide the definition of more specific goals for specific locations or areas under management. The goals for ecosystem service supply need to be accompanied with a description of the necessary ecosystem functioning for these services. For each goal, indicators should be developed to measure progress in its achievement, and these indicators can be included in long-term monitoring plans.

The vision statement and goals should build on and incorporate existing management and policy objectives, from local plans and agreements to national policy frameworks and international conventions and agreements such as the SDGs.

The process of setting goals for specific locations will entail making some trade-off decisions between the supplies of different types of ecosystem services. For example, increasing the supply of many provisioning services may involve simplifying the ecosystem structure and consequently reducing regulating and cultural ecosystem services. Trade-offs in services supply may also exist between different stakeholders, including urban and downstream beneficiaries of the ecosystem. Such trade-off decision making is as much a social and institutional process as it is a technical one, and so its success depends on the existing institutional and governance capacity for ecosystem management decision making. The availability of suitable and reliable information from the previous steps and activities in the Framework for Ecosystem Management will be necessary to inform this decision making.

Local communities discussing the management plan along with different line departments in Himkhola, Pithoragarh, India

Formulating Strategies and Plans for Adaptive Management for Ecosystem Services (Step 3)

Formulation of short and long term management strategies for achieving the goals related to ecosystem services supply requires in-depth stakeholder consultation and thorough analysis of environmental, socioeconomic and cultural issues. For each management area and its ecosystem, strategies and plans need to be developed that build on existing practices and knowledge, with a focus on ways to enhance ecosystem functioning and people's management capacity to supply ecosystem services. This planning may include ways to address the major issues affecting the desired structure and functioning of ecosystems, taking into account stakeholder priorities. For each issue there may be one or more strategies depending on national legislation and customary laws. The management strategies should include establishing linkages with development initiatives, capacity building of community based organizations in participatory natural resource management and biodiversity conservation, appropriate technology, best practices for restoration and rehabilitation of degraded ecosystems, and developing economic incentives. Formulation of management strategies would require answers to several basic questions pertaining to sectoral linkages, and incentive mechanisms for sustaining ecosystem services. Some of the relevant questions are given in Annex 2.

Management decisions depend on the availability of options. Each option carries certain risk and uncertainty. As ecosystem patterns themselves are not completely predictable, it is important to assess associated risks and uncertainty in any ecosystem management prescription. There are a number of methodologies and tools to assess these risks and uncertainty and identify indicators for early warning of problems.

The strategies, once agreed by the stakeholders, should be made more detailed with site-specific and zone-wise action plans with a view to climate, gender, and equitable benefit sharing. To restore degraded ecosystems, the inherent properties of ecosystems in terms of species richness and various other parameters should be taken into consideration (Figure 1).

Figure 1: **Suggested framework for the management of ecosystems in the HKH**

Implementing management plans with monitoring and learning for adaptive management (Step 4)

Ecosystem management plans are implemented most directly by the local people who live on and use the land and water resources. The ownership and implementation of the plans should also be the responsibility of relevant institutions at the local to national level. The role of a coordinating agency in promoting ecosystem management may evolve from initiating the ecosystem management planning process to supporting its implementation, and then withdrawing after locals have gained sufficient capacity.

Ecosystem management should be adaptive in order to be effective. This means proactively gathering information on the results of the management practice, learning from its success and failures, identifying and addressing early-warning signs of problems, and learning more about the ecosystem and socioeconomic conditions and how to work with them. Adaptive management thus entails monitoring selected indicators on the functioning of the ecosystem, the results of management actions and the socioeconomic context. The results of this monitoring will inform decision making for future management. The gathering of information on the indicators should be part of the long-term

ecosystem monitoring plan. Without monitoring, it is not possible to gauge the progress made towards achieving the management objective. To support the partners in ecosystem monitoring, a Framework for Long-Term Environmental and Socio-ecological Monitoring (LTESM) has been developed by ICIMOD (Chettri et al., 2015). The LTESM framework should be used as a document that complements this **FIEM**.

The following inter-linked actions need to be carried out for effective implementation of the ecosystem management plans.

Communities in the Khar VDC of Far-western Nepal using Ageratina adenophora, an invasive plant, for making bio-briquettes and compost

Developing biophysical ecosystem management practices to supply ecosystem services

To obtain a suite of ecosystem services from an area, people often carry out a series of physical management practices to alter or maintain ecosystem functioning to supply these services. In most situations, this will look like versions of existing agriculture, livestock management, forestry or water management. Before implementing these actions, their influence on ecosystem functioning will be taken into consideration. In some situations, new technologies, farming and livestock management practices, or new species may be introduced. Preferably, in an adaptive management approach, small-scale trials of new methods, technologies and species will be carried out in order to develop the necessary skills and modifications beforehand and gain confidence about the intended results.

Developing governance capacity for ecosystem management, including gender mainstreaming

Effective implementation of ecosystem management plans requires well-established institutions and mechanisms for decision making and management of people, financial resources and information. Actions are needed to strengthen governance capacity, as well as to promote gender mainstreaming and equitable benefit sharing. Management and governance capacity includes enhancing inter-sectoral coordination, and may well require promoting reforms in natural resource governance.

Developing economic instruments to promote desired ecosystem services supply

As the economic context of ecosystem management can have a major influence on the choice and success of management objectives, there is a need to develop economic instruments to promote the supply of desired ecosystem services. This can also help us design pro-poor incentive mechanisms that are fair and equitable.

Scaling up learning and influence policy development

Pioneering and successful examples of ecosystem management need to be widely disseminated so as to achieve region-wide impact in the HKH. A policy review is also needed to strengthen democratic processes and convergence of various stakeholders to pursue the long-term conservation and development goals. In this context, governments need to review and strengthen the mandates of existing conservation agencies for the management of ecosystems in coordination with other line agencies, technical institutions, civil society and community based organizations. Evidence gathered from ecosystem management initiatives, including their limitations due to unfavourable policy contexts, can provide the basis for developing policy and monitoring its impacts.

Geospatial solutions for ecosystem management

Recent advances in remote-sensing technology and geographic information systems (GIS) have presented ecologists and resource managers with a crucial tool for ecosystem management. The potential for synergies between ecosystem conservation-focused research and remote sensing has actually been acknowledged by both disciplines for some time, and there is clear interest among researchers, practitioners, and data providers to better understand how remote sensing can benefit ecosystem management (Pettorreli et al., 2014). Multi-temporal multi-scale satellite datasets provide a synoptic view and can help the researchers to understand the status and functioning of the ecosystems in the HKH at various spatial scales e.g., species to landscape level. These tools can provide crucial information on biophysical attributes of ecosystems through plant phenology and productivity, threats such as invasive plants, diseases, and disturbances such as forest fires for effective ecosystem planning and management. Some of the existing applications at ICIMOD are mentioned below:

Participatory GIS for resource mapping: Participatory GIS is being widely used for resource mapping in most areas in the HKH. Communities find the three-dimensional view of their area far more exciting compared to a normal 2D map. They can visualize their landscape, which in a way helps in effective resource mapping. This technique is used in the field to generate data on agricultural patterns, people's perceptions on past land use change, springshed research, value chain mapping, digitization of community forest boundaries, etc.

GIS for Ecosystem services: Mapping status, source-sink-flow, beneficiaries, and vulnerabilities remote sensing and GIS have proved advantageous in mapping the source and sink of ecosystem services as they provide a better understanding of the flow of the services and the location of the beneficiaries. Remote sensing datasets dating as far back as the 1970s can help us understand the trends in the dynamics of the services. These tools with future climate datasets provide insights on the vulnerability of these services to climate change, which in turn will be important for the planning and management of these ecosystems. Recent modelling techniques such as ARIES-Artificial Intelligence for Ecosystem Services, Co$ting nature etc. are capable of using GIS layers for assessing the source-sink-beneficiary linkages in ecosystem services.

Mapping cultural services: A step towards conservation and responsible heritage tourism

In a recent exercise, ICIMOD in collaboration with Sichuan University, China created a geodatabase of 208 culturally significant sites along the Kailash Kora (circumambulation route around Kailash Sacred Mountain), which includes the name, description, location of the site, and threats. Similar work has been done to map cultural sites from India and Nepal. The work aims to to understand the cultural significance, comparative importance, threats, and valuation of cultural services that can help in the nomination of Kailash Sacred Landscape as a UNESCO world heritage site.

Assessment of climate change vulnerability and adaptation planning of forest ecosystems: Climate projection datasets with satellite derived variables on forest status and functioning can be used to assess the impacts of climate change on forests. In addition, GIS layers of the dependence of local communities on forests could be overlaid on the vulnerability maps to understand the supply-demand function in a future time period. A study along these lines for the whole of Nepal is currently being undertaken at ICIMOD.

Some of the web applications developed using geospatial datasets are:

- http://geoportal.icimod.org
- http://apps.geoportal.icimod.org/chalccv
- http://apps.geoportal.icimod.org/redd-dss/SiteIdentification.aspx

Concluding Remarks

This framework provides a common language for ICIMOD and its partners in the regional member countries to develop ecosystem management planning, implementation and monitoring activities across the transboundary landscapes. The Framework emphasizes management for ecosystem services and promotes an ecosystem approach to natural resources management. It is expected that a common understanding of the terminologies, principles and steps for ecosystem planning and management will help facilitate communication and exchanges among the partners, enhance the partners' capacity for ecosystem management and improve the environment and wellbeing of people in the HKH.

The users shall be reminded that this skeletal framework only introduces the general steps that all ecosystem management activities shall follow but the steps shall be sequenced and made more detailed according to specific contexts. It is also important to mention that not all the principles elaborated in the framework shall be adopted equally in each and every case. The focus and application should be context specific.

To support the partners in the use of this framework, ICIMOD has developed an operational manual on planning management for ecosystem services, which will be published and distributed to partners for application. For the same purpose, it is envisaged that manuals or tools on related subjects, e.g., participatory planning, gender mainstreaming, will be further developed in the coming years.

A productive farm ecosystem of walnut trees, grapes and cereal crops, well adapted to market economy in western Yunnan, China

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Annex 1: Indicative List of Ecosystem Services

Source: the WRI Ecosystem Services Review for Impact Assessment (ESR for IA) Dependence Scoping Tool Version 1.1 http://www.wri.org/publication/ecosystem-services-review-for-impact-assessment

The ecosystem services categories shown here are based on the classification developed for the Millennium Ecosystem Assessment (MEA 2005), which is still the most widely used classification. The four categories of ecosystem services are provisioning, regulating, cultural and supporting services. There are some overlaps and inter-relationships between these categories.

The provisioning ecosystem services, as physical goods and products from ecosystems, are the easiest to identify and quantify. Farming for provisioning ecosystem services and harvesting of natural products are often the objective of many livelihood strategies. Many farming and land management activities alter the structure and processes of ecosystems for the supply of provisioning ecosystem services.

> ***Supporting*** *ecosystem services are the ecosystem processes (e.g., conversion of the sun's energy to organic matter by plants) that are necessary for the supply of the other ecosystem services categories. This Framework recommends that we do not separately list supporting ecosystem services, but describe them as necessary ecosystem functioning for the other identified ecosystem services.*

Regulating ecosystem services are the benefits obtained from an ecosystem's influence on natural processes, such as regulation of water flows and flooding by vegetation . The functioning, or supply, of many regulating ecosystem services greatly influences the supply of many provisioning ecosystem services.

Cultural ecosystem services are the non-material benefits obtained from ecosystems. The 'supply' of cultural ecosystem services depends on people's interactions with the physical structure of the ecosystem. This could include intellectual, health, cultural and spiritual values derived from ecosystem services through farming and harvesting wild products.

The Millennium Ecosystem Assessment also included the category of supporting ecosystem services. These are ecosystem processes (e.g., conversion of the sun's energy to organic matter by plants) that are necessary for the supply of other ecosystem services. This Framework recommends defining supporting ecosystem services as processes necessary for the functioning of other ecosystem services rather than listing them as a separate category.

Provisioning services: The goods and products obtained from ecosystems	
Food from crops, livestock, capture fisheries, aquaculture, and wild foods	• Cultivated plants or agricultural produce harvested by people for human or animal consumption as food *Examples:* Grains, vegetables, fruit • Animals raised for domestic or commercial consumption or use *Examples:* Chicken, pigs, cattle • Wild fish captured through trawling and other non-farming methods *Examples:* Cod, crabs, tuna • Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for harvesting purposes *Examples:* Shrimp, oysters, salmon • Edible plant and animal species gathered or captured in the wild *Examples:* Fruit and nuts, fungi, bushmeat

Biological raw materials from timber and other wood products, fibres and resins, animal skins, sand, and ornamental resources	• Products made from trees harvested from natural forest ecosystems, plantations, or non-forested lands. *Examples:* Industrial roundwood, wood pulp, paper, construction materials • Nonwood and nonfuel fibres and resins *Examples:* Cotton, hemp, and silk, twine and rope, natural rubber • Processed skins of cattle, deer, pig, snakes, sting rays, or other animals *Examples:* Leather, rawhide, and cordwain • Sand formed from coral and shells *Examples:* White sand from coral and white shells, coloured sand from shells • Products derived from ecosystems that serve aesthetic purposes *Examples:* Tagua nut, wild flowers, coral jewellery
Biomass fuel	• Biological material derived from living or recently living organisms –both plant and animal – that serve as a source of energy *Examples:* Fuelwood, charcoal, grain for ethanol production, dung
Freshwater	• Inland bodies of water, groundwater, rainwater, and surface waters for household, industrial, and agricultural uses *Examples:* Freshwater for drinking, cleaning, cooling, industrial processes, electricity generation, or mode of transportation
Genetic resources	• Genes and genetic information used for animal breeding, plant improvement, and biotechnology *Example:* Genes used to increase crop resistance to disease
Biochemicals, natural medicines, and pharmaceuticals	• Medicines, biocides, food additives, and other biological materials derived from ecosystems for commercial or domestic use *Examples:* Echinacea, ginseng, garlic; paclitaxel as a basis for cancer drugs; tree extracts used for pest control
Regulating services: The benefits obtained from an ecosystem's natural processes	
Regulation of air quality	• Influence ecosystems have on air quality by emitting chemicals to the atmosphere (i.e., serving as a 'source') or by extracting chemicals from the atmosphere (i.e., serving as a 'sink'). *Examples:* Lakes serve as a sink for industrial emissions of sulfur compounds; vegetation fires emit particulates, ground-level ozone, and volatile organic compounds
Regulation of local, regional, and/ or global climate	• Global: Influence ecosystems have on the global climate by emitting greenhouse gases or aerosols to the atmosphere or by absorbing greenhouse gases or aerosols from the atmosphere. *Examples:* Forests capture and store carbon dioxide; cattle and rice paddies emit methane • Regional, local: Influence ecosystems have on local or regional temperature, precipitation, and other climatic factors *Example:* Forests can impact regional rainfall levels, mountains have an effect on rainfall patterns
Regulation of water timing and flows	• Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem or landscape. *Examples:* Permeable soil facilitates aquifer recharge; river floodplains and wetlands retain water–which can decrease flooding during runoff peaks–reducing the need for engineered flood control infrastructure.
Erosion control	• Role vegetative cover plays in soil retention *Examples:* Vegetation such as grass and trees prevents soil loss due to wind and rain; forests on slopes hold soil in place, thereby preventing landslides.

Water purification and waste treatment	• Role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water; assimilation and detoxification of compounds through soil and subsoil processes. *Examples:* Wetlands remove harmful pollutants from water by trapping metals and organic materials; soil microbes cause the degradation of organic waste, rendering it less harmful.
Regulation of diseases	• Influence ecosystems have on the incidence and abundance of human pathogens *Example:* Intact forests reduce the occurrence of standing water–a breeding area for mosquitoes–and thereby reduce the prevalence of malaria.
Regulation of soil quality	• Role ecosystems play in sustaining soil's biological activity, diversity, and productivity; in regulating and partitioning water and solute flow; and in storing and recycling nutrients and gases *Example:* Some organisms aid in the decomposition of organic matter, increasing soil nutrient levels; some organisms aerate soil, improve soil chemistry, and increase moisture retention; animal waste can be used as soil fertilizer.
Regulation of pests	• Influence ecosystems have on the prevalence of crop and livestock pests and diseases. *Example:* Predators from nearby forests–such as bats, toads, snakes–consume crop pests
Pollination	• Role ecosystems play in transferring pollen from male to female flower parts. *Example:* Bees from nearby forests pollinate crops.
Regulation of natural hazards	• Capacity of ecosystems to reduce the damage caused by natural disasters such as hurricanes and to maintain natural fire frequency and intensity. *Examples:* Mangrove forests and coral reefs protect coastlines from storm surges; biological decomposition processes reduce potential fuel for wildfires.
Cultural services: The non-material benefits obtained from ecosystems	
Recreation and ecotourism	• Recreational pleasure people derive from natural or cultivated ecosystems *Examples:* Hiking, camping, bird watching, scuba diving, and safari trips
Ethical and spiritual values	• Spiritual, religious, aesthetic, intrinsic, "existential" or other values people attach to ecosystems, landscapes, or species *Examples:* Spiritual fulfilment derived from sacred lands and rivers; belief that all species are worth protecting regardless of their utility to people –"biodiversity for biodiversity's sake"
Educational and inspirational values	• Information derived from ecosystems used for intellectual development, culture, art, design, and innovation *Examples:* The structure of tree leaves has inspired technological improvements in solar power cells; school field trips to nature reserves and parks aid in teaching scientific concepts and research skills.
Supporting services: The natural processes that maintain the other ecosystem services	
Habitat	• Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances *Examples:* Native plants in gardens and fields provide pollinators with food and structure for reproduction; rivers and estuaries provide nurseries for fish reproduction and juvenile development.
Nutrient cycling	• Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems *Examples:* Transfer of nitrogen from plants to soil, from soil to oceans, from oceans to the atmosphere, and from the atmosphere to plants; soil deposition by rivers.
Primary production	• Formation of biological material by plants through photosynthesis and nutrient assimilation *Examples:* Algae transform sunlight and nutrients into biomass, thereby forming the base of the food chain in aquatic ecosystems.
Water cycling	• Flow of water through ecosystems in its solid, liquid, or gaseous forms *Examples:* Transfer of water from soil to plants, plants to air, and air to rain

Annex 2: Key Research Questions for Formulation of Strategies for Ecosystem Management

Key Research Questions for Formulation of Ecosystem Management Strategies

1. What are the strategic measures for balancing biodiversity conservation with rural livelihoods so as to sustain ecosystem services?
2. What are the policies and practices pertaining to local resource use in and around protected areas and what are the best practices for minimizing people-wildlife conflicts and for ensuring equitable sharing of benefits from bio-resources in the given area?
3. What are the best governance mechanisms that could be adopted to address the key drivers of ecosystem change?
4. How to ensure community participation in management and conservation of natural resources for sustainable supply of goods and services?
5. What are the innovative watershed management practices that can be developed and adopted to enhance adaptation to change, restore ecological functions and bridge upstream-downstream linkages in an integrated way?
6. How to build upon the traditional knowledge and customary practices related to rangeland and livestock management for coping with climatic impacts?
7. What are the cost-effective ways to restore degraded wetlands and high altitude peatlands for both carbon sequestration and livelihood improvement?
8. What are key policy instruments that promote participation of local communities in conservation and management of ecosystems and implementation of integrated management ecosystem management strategies?
9. How to improve synergy between customary institutions and the state policies to ensure biodiversity conservation, equitable benefit sharing, and alleviate poverty among the mountain farmers?
10. What could be the appropriate methodology for the valuation of mountain ecosystem goods and services for improving sustainable management of natural resources and developing responsible land use policies?
11. How can we design and mainstream incentive mechanisms that are fair and equitable to both beneficiaries and providers of ecosystem services to ensure the sustainability of ecosystem management?

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