



Review Paper

Mountain forests: challenges and the management - A review

Hyunshik Moon¹ and Tamirat Solomon Dea^{1,2*}

¹Dept. of Forest Environmental Resources, Institute of Agriculture and Life Sciences, Gyeongsang National University, Jinju52825, South Korea

²Department of Natural Resources Management, Wolaita Sodo University, Wolaita Sodo 138, Ethiopia
tasolmame@gmail.com

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Abstract

Mountain forests are important for their production and protection values. They serve as a homes of important timber, wood and non-wood products in several countries and most importantly they serve in storing water and preventing erosion. They are also hotspots of biodiversity including common indigenous species that are used for different purposes in the society which are categorized as timber and non-timber forest products (NTFPs). Many of mountain forests are playing the role of carbon sinks to mitigate climate change. However, most of the world's mountain communities are strongly influenced by surrounding lowland and urban areas with regard to timber extraction, expansion of agricultural land to the fertile soils of the forest ecosystem with the addition of forest fire incidences. In a changing climate, human induced disturbances and lack of awareness are the major threats for the mountain ecosystems. Maintenance and new approaches for the management of the mountain ecosystems with the special attention and proper actions to save and maintain the productive, protective, socio cultural roles of mountain forests may be essential for maximum stability and integrity for the sustainability of the mountain forest ecosystems.

Keywords: Mountain forests, forest disturbance, participatory forest management.

Introduction

Mountain forests make up a third of all natural forest cover worldwide¹, are a living place to 12% of the global inhabitants, and include 28% of the world's forests². They are one of the most important ecosystems in the world as they provide numerous important ecological, hydrological, social, and economic values. Mountain forests are important homes of important timber, wood and non-wood products in several countries. For example, the major source of fuel energy for the people living around mountain in developing countries and to some extent in developed countries is wood. The collected fuel wood from mountain is used for cooking, heating, dry and prevent insect damage to stored crops, and purify water and/or sources of economy for both the collectors and the nearby settlements in the foothills of the mountain^{3,4}. It is commonly accepted that mountain forests especially assume various functions for society more and more, corresponding to the public utilities⁵, protection of the soils, supply of products for human lives and infrastructures, the purification of air and water, activities linked with tourism and recreation (including hunting), and rural development (through grazing and timber production). Mountain forests are also central elements in natural patrimony and cultural heritage⁶.

Generally, mountains are primarily hotspots of biodiversity^{7,8} and common indigenous species that are used for different purposes in the society which are categorized used as a timber and non-timber forest products (NTFPs). This is due to their

vertical expansion which creates different climatic conditions only short distances apart⁸. And also mountains are global centres of biodiversity; 25 of the 34 global biodiversity hotspots are wholly or partially in mountains⁹.

However, most of the world's mountain communities are strongly damaged by surrounding lowland and urban areas with regard to timber extraction, watershed management and, often, recreation^{3,10}, and most importantly expansion of agricultural land to the fertile soils of the forest ecosystem is one of the top most problems challenging the mountain forests and diversities around especially in developing countries. This is because of the question of how much or what fraction of deforestation (emissions) in a country is caused by a specific driver (i.e. expansion of agriculture versus infrastructure) cannot be answered for many developing countries¹¹. Even though the mountain ecosystems are very important for life on the earth, attention given to the environment is less than to which it's supposed to be that is evidenced by scarcity of references and reports from the scientific community in comparison to works on other forest ecosystems. This article is intended to click on the gaps and so that scientists and other concerning stakeholders could give more attention in research and scientific works to manage the mountain forest ecosystems.

Mountain Forests as a Landscape Resources

In the UN General Assembly¹² the Agenda 2030, the importance of mountain ecosystems is clearly recognized in the category

life on land Sustainable Development Goal (SDG 15), set as a goal for management by the goal targeting to achieve by the year 2020, “to ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements” (goal 15.1), and more specifically “by the year 2030, to ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development” (goal 15.4).

The importance of mountain forests is clearly stated by different reports and findings from countries of different continents^{13,6,9,12,8,14}, but the capacity of mountain ecosystems to provide key services is however at risk^{15,13}. Therefore, as a landscape resource mountain forests need integrated management system as integrated forests resource management (IFRM) is an approach of managing forest resources sustainably by helping forest users, managers, and other stakeholders to achieve their different goals by willfully taking into account, and aiming to reconcile and synergize, their various interests, attitudes, and actions.

Challenges of Mountain Forests

Forest Disturbance as a Major Issue: Mountains are fragile and often remote regions, whose human population are often highly vulnerable to environmental, economic and social changes at all scales from local to global¹⁶. Due to the slope and natural settings, diversities included, increasing interests of societies for recreation purposes, the mountain environments and forest ecosystem are exposed for changes; specifically disturbances.

A disturbance is a discrete event (volcanic eruption, fire, browsing, tree fall, branch break, etc.) that changes the species composition, the looks (physiognomy/structure) and/or physiological processes and resources, such as light, temperature and nutrients, in any vegetation system^{17,18}. As ecosystems are dynamic entities, variable across both space and time, and these patterns of variability in ecosystem development are modulated by events or processes known as “disturbances”¹⁹.

Land conversion specifically due to agricultural expansion is widely believed to be one of the main causes of deforestation. In Froliking et al.¹⁷ stated that fire, windstorms, logging, and shifting cultivation are dominant disturbances; minor contributors are land conversion, flooding, landslides, and avalanches. However, the influence of land conversion on forest ecosystem is not simple especially in the developing world, as in most developing economies the decline in forest and woodlands is mainly the result of land conversion, in particular agricultural expansion for crop production^{20, 21}. It was stated that the influence of agriculture in the global deforestation is

significant; by considering the importance of both agriculture and forests for the livelihood of human and sustainability of life on the earth, there is an exigent need to build a positive interaction in between these two land uses²².

The perception of disturbances has evolved over time but continues to vary geographically. Sometimes disturbances are seen as beneficial ecological processes and sometimes as catastrophes that threaten the ecosystems they affect. Often they cause substantial concern among the public and policy makers, a concern that is reported or promoted by the popular press²³. In Geldenhuys et al.¹⁸ stated that disturbances at different scales are a natural part of all types of vegetation, and also of natural forests and woodlands. They have a benefit for natural processes like distribution of seeds, transportation of seeds from the sources origin to other environment via different agents like wind, water, animals and birds and also in contrary, they can influence the entire ecosystem depending on the way they happen with mismanagement.

In many regions over the past centuries human activities have strongly influenced forest dynamics, especially following natural disturbances, thus limiting our understanding of natural ecological processes, particularly in densely-settled regions²⁴. Analysis of the disturbance regime of a forest can be of great value for understanding patterns of structure and composition, as well as being important for defining appropriate management interventions²⁵. Characterizing the disturbance regime typically involves assessing the severity, timing, and spatial distribution of the different types of disturbance affecting the forest. It is useful to note the difference between the intensity and severity of disturbance. And also every action in the forest ecosystem specifically in mountain forest ecosystem needs care to avoid the distinct effect on the forest environment.

Climate Change: Our understanding of the magnitude and ecological implications of climatic variation in space and time has greatly developed over the past decades²⁶. Climate change is one of the major disturbing factor which affects the amount and values of forest resources. The impact of climate change on the forest resources is in multidimensional means; such as fluctuation of seasons, altering the frequency, duration, and timing of fire and drought, increasing the intensity of disease incidence, and timing of fire, drought, invasive species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides^{27- 29}.

Understanding the extent and impact of each disturbance resulted from climate change on the forest provides a background for examining ways to cope with the impacts of climate change²⁷. Forest disturbances, both anthropogenic and natural, influence forest systems by affecting their composition, structure, growth, development and functional processes.

With a predicted global temperature increase of 2.0–4.5°C until the end of the century³⁰, climate change is expected to affect

density and diversity of forest resources and its influence is sever for mountain forests. For instance Harald et al.³¹ stated that in mountain ecosystems, numerous causes are of crucial importance that may be nearly negligible elsewhere. Examples include determination of slope angle and aspect for the influence of energy stability, role of the steep slopes on downhill or water flows, impacts of root systems on slope maintenance, the relationship in between high topographic and biotic heterogeneity, the role of forest vegetation on steep slopes for keeping ecosystems, human and infrastructure from natural threats such as avalanches and rock fall.

Changes on climatic conditions strongly alter forest dynamics, particularly disturbance and species assembly, complicating the prediction of the future contribution of forests to climate regulation³².

Table-1: Challenges of Mountain forests and the potential impacts.

Challenges of mountain forests	Potential Impacts	Sources
Poverty challenge	Reducing production and results in dependency on the mountain forests,	33, 34
Climate change challenge	By changing the climatic parameters; particularly temperature and precipitation	2, 29
The fragile nature of ecosystem	Complexity of topography, greatly enhanced direct runoff and erosion	2,34
Agricultural expansion	Deforestation and conversion of land use system	35, 11
Dependency of lowland people	Unsustainable extraction of wide range of goods and services	33, 37

Management and Maintenance Mechanism for Mountain Forests

Participatory Forest Management (PFM) for Mountain Forests: Mountain forests have a high potential for securing livelihoods by providing opportunities other than timber use because of their beautiful scenery and the associated ecosystem functions^{14,2,6}, and they are among the most important ecosystems as they support numerous ecological, hydrological, climatic, social, and economic functions. Mountain ecosystems can only continue to provide all these services in a rapidly changing world if sustainable forest management is implemented and ecosystem services and benefits are considered in forest management at local, landscape and regional scales. The sustainable management of mountain forest can be achieved by the approaches by considering the relationship in between ecosystem and social processes. One of the best method that can be used to manage the forest resources is participatory forest management (PFM).

Participatory Forest Management (PFM) is a technique to manage forests and improve the livelihoods of societies who depend and use from them in the process¹⁶. As mountain forest ecosystems provide a wide range of direct and indirect contributions to the people who live in the mountains and surrounding areas³⁸, including nearly 50% of the world’s freshwater for direct consumption, agriculture, and energy³⁹, are originated from mountain forest ecosystems, and mountain tourism accounts for 15-20% of the world’s tourism industry, totaling an estimated \$US70-90 billion per year. Therefore, the areas are typically exposed to multiple disturbances, damages and hazards. Extreme events such as storms, landslides, avalanches and rock falls may become more common and intense in mountain areas²⁹ beside to anthropogenic impacts resulting in major changes in the ecosystem.

The socio cultural values of mountain forests as to the definition given in Uta et al.⁴⁰, Bernue’s et al.⁴¹; MEA⁴² are nonmaterial benefits from mountain forest ecosystems, which includes recreational facilities and tourism, aesthetic appreciation, inspiration, a sense of place and educational value³⁸. However, the socio cultural values of mountain forests results a serious problem on mountain forests mainly forest fire, invasive species, and damage on some specific species and so on.

Trends and experiences over the last decade appear to confirm the general assumption that PFM, when well facilitated, can lead to recovery and/or maintenance of forest quality⁴³, and also Aklilu et al.,⁴⁴ expressed that participatory management was more successful than government management in making forestry sustainable. On the same ways expressed about as there were increases in basal area and volume in sites managed under both joint and community-based forest management, and declines in both of these variables in forests under government or open access management⁴⁵. Therefore, inclusiveness; PFM is a key management method to include the users in management so as to share the responsibility of management with the user group or society.

Maintenance Mechanism for Mountain Forests: Can the use of continuous cover forestry alone maintain mountain forests? Traditional rural activities, such as agriculture, fuel wood collection, charcoal production, livestock grazing and forestry, together with expansion of infrastructures, and tourism and recreation are the major challenges for the mountain communities. Even though there is a difference from place to place and countries to countries based on the socio-economic and awareness context of each country, such activities are nowadays either declining or in full expansion. Therefore, protection is of vital importance to human populations and activities.

Physical soil and water conservation technologies are the best mechanisms for managing mountain forests. Soil erosion may cause severe loss of topsoil where organic matter and vital nutrients needed by tress for survival. As the land degradation

leads to the deterioration of soil quality⁴⁶, the physical soil and water conservation technologies plays a great role in protection of the soil erosion. For instant, the studies by Kebede et al.; Joas,^{47, 48} revealed that the use of soil conservation interventions such as traditional stone bunds, terracing and diversion ditches in contributed a significant effect on the reduction of land degradation. More than 80% of land degradation is due to soil erosion; out of which 56% is due to the water-induced soil erosion⁴⁹, therefore, the physical structures are mechanisms to protect the erosion problem.

Conclusion

The coverage of mountain forests of the world’s land surface is about 900, which is about 20 percent of forest coverage in the world. Although there is difference in gaining of resources from mountain ecosystems based on the developmental level of countries, the mountain ecosystem provides a great support to human beings. The followings are the categories of benefits from mountains forest ecosystems to human beings (Figure-1).

Mountain forests are subject to many forces of changes, in different ways including expansion of agriculture, forest fire,

climate change, and mismanagement. Mountain forests are particularly endangered and many mountain forests have been almost completely destroyed. They are threatened by climate change, because of their steep slopes and changing climates and weather conditions, they are fragile ecosystems and also by human use that challenges mainly in the form of disturbances. Forest disturbances, both anthropogenic and natural, influence forest systems by affecting their composition, structure, growth, development and functional processes.

Forest management of the mountain should be designed and implemented to solve the problems of forest overuse which leads to degradation. Because, mountain forest degradation could result environmental complications such as soil erosion, landslides, rock falls, extreme water runoff or reduction in the capacity of water storage, the drying of springs and the loss of biodiversity; that directly put a negative influences on livelihoods and even cause loss of life. Therefore, special attention and adequate measures to save and maintain the productive, protective, socio cultural functions of mountain forests maybe required for maximum stability and integrity.

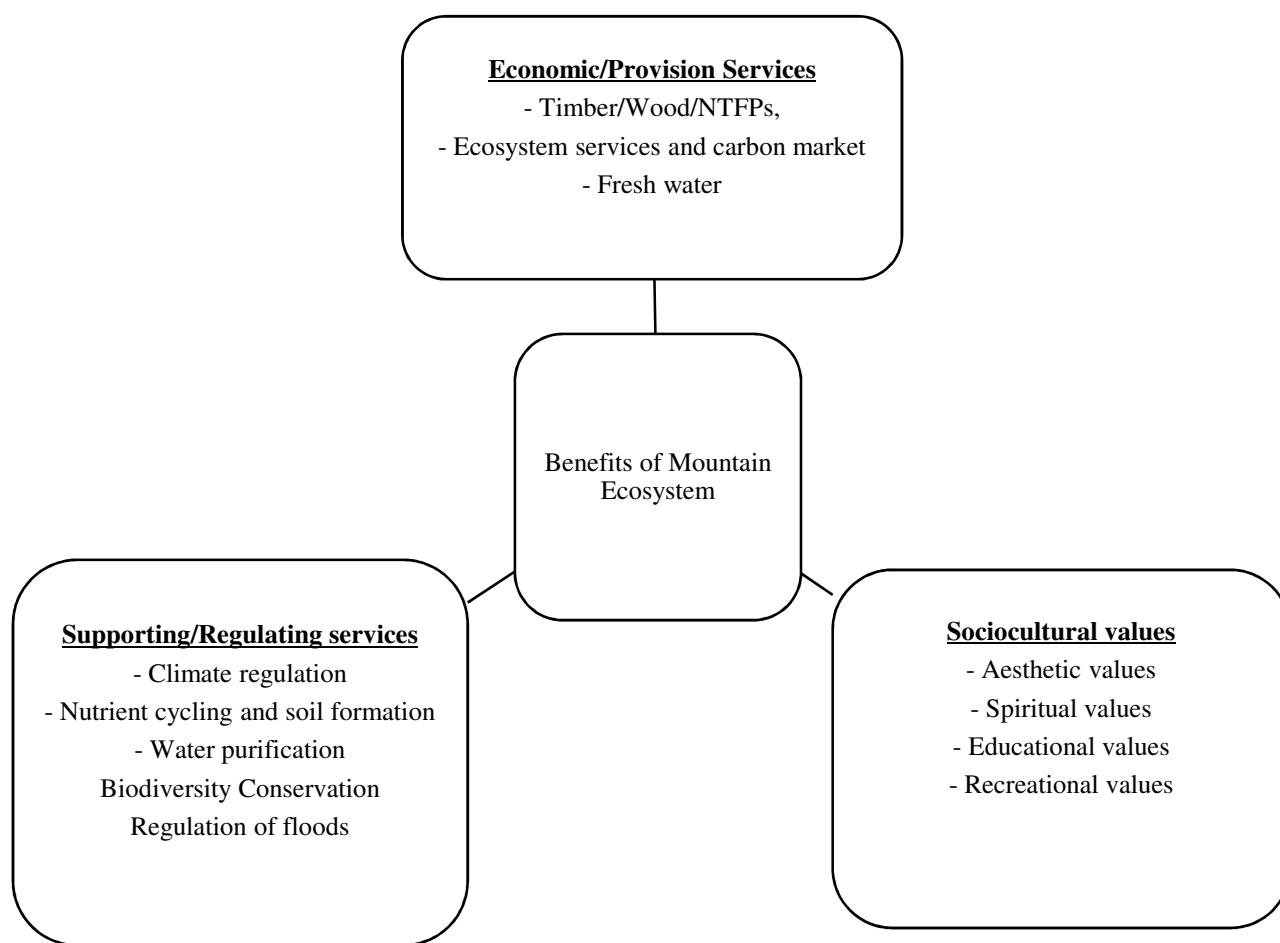


Figure-1: Importance of mountain ecosystems, compiled from different sources^{42,38,50,51}.

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