

## ECOSYSTEM SERVICES OF FOREST ECOSYSTEM IN NECHISAR NATIONAL PARK, ETHIOPIA: IDENTIFYING THE CHALLENGES AND CONSERVATION MEASURES

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**Abstract:** *The forest ecosystems in Ethiopia's Nechisar National Park are unique in special context of the ecosystem services extended to local population, tourist projects, restaurants, hotels, city dwellers and forest dwellers. There are four categories of ecosystem services provided by the forest ecosystems of Nechisar National Park. Anthropogenic activities inside forests exert immense pressure on the natural resources of the park. Rapid loss of the forest ecosystem of the park leads to losing all crucial ecosystem services. The challenges to the forest ecosystems of the park are posed by number of agents such as individuals, groups of individuals or institutions that directly convert forested lands to other uses. This review-based article not only identifies the factors responsible for the loss of ecosystem services but also suggests conservation strategies.*

**Key words:** Ecosystem service, Forest ecosystem, Nechisar National Park, Conservation

### Introduction

The national parks are the most extensive type of protected areas in Africa and globally. They are classified under category II of the World Conservation Union (IUCN) categories of protected areas. National parks are created to (1) protect the ecological integrity of one or more ecosystems for present and future generations; (2) exclude exploitation or occupation for the better conservation of the natural resources; and (3) provide spiritual, scientific, educational, recreational, and ecological opportunities, all of which must be environmentally and culturally compatible (Muhumuza and Balkwill, 2013). Nechisar National Park is also an IUCN category II protected area that was established in 1974 with the aim of conserving the vast diversity of wildlife and the scenic beauty of the area. It is located in Southern Nations Nationalities and People's Region (SNNPR) of Ethiopia and lies to the east of Arba Minch town at a distance of 510 km from the capital city Addis Ababa. The park covers 514 km<sup>2</sup> of territories including the 'Bridge of God' (an isthmus between lakes Abaya and Chamo). The park's elevation ranges from 1108 meter to 1650 meter.

Despite exceptional ecosystem services provided by Nechisar National Park, human interference has been influencing the conservation activities through accelerating the loss of habitat and biodiversity, which is eventually reducing the productivity of ecosystem services. The major challenges faced by the park are illegal settlements, overgrazing, agriculture expansion, alien invasive species, bush encroachment, uncontrolled fire, overfishing, deforestations, degradation of wildlife habitats, and weak infrastructure inside the park for the management activities such as monitoring, wildlife census and patrolling. The forest ecosystem services are often undervalued or are not given due attention by public decision-makers, investors, local communities, tourist accommodation providers, and others. Anthropogenic activities, particularly from Arba Minch town, therefore, exert immense pressures on the park's natural resources from the surrounding community. The loss of the forest ecosystem of the park leads to losing all

crucial ecosystem services that were obtained. This may further lead to difficult life in Arba Minch town. A limited number of studies have been carried out on the ecosystem services of Nechisar National Park, and on challenges the forest ecosystems of the park face. The present article will not only describe the ecosystem services provided by forests of Nechisar National Park, but also address the current challenges faced by the park. This will help the planners, decision makers, stakeholders, experts, investors, Arba Minch town dwellers and local communities for being aware of valuable services of the forest ecosystems. Moreover, this article will also focus on identifying the major challenges of the conservation of forest ecosystem of the park and will suggest potential measures to enhance the conservation.

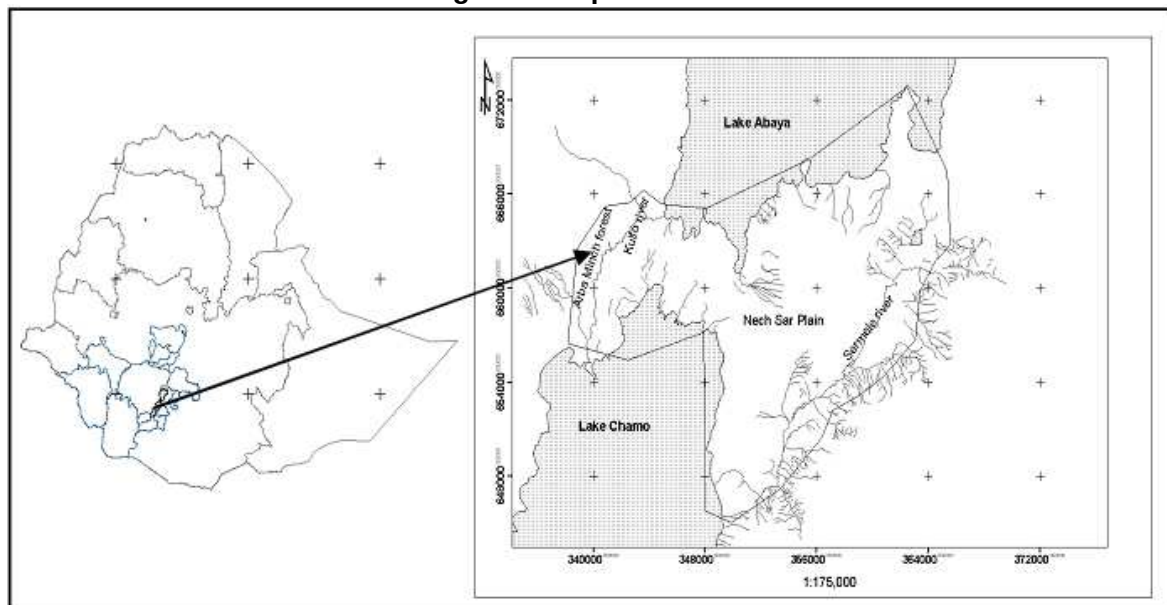
### Features of Nechisar National Park

Ethiopia is a country of great geographic diversity with wide altitudinal and physiographic variations. The wide range of ecological variation coupled with the corresponding diverse socio-culture has made the country one of the important diversity rich areas in the world (Tadesse, 2003; Alemayehu, Teketay and Powell, 2005). Nechisar National Park covers an area of 514 km<sup>2</sup>, of which 85 percent is land and 15 percent is water (lakes Chamo and Abaya). It lies within the floor of the East African Great Rift Valley, situated between 5°51'-6°10' N and 37°32'-37°48' E with an elevation ranging between 1108-1650 masl (Sintayehu, Afework and Mundantra, 2011). The Southern Nations, Nationalities and People's Region (SNNPR) of Ethiopia lies within the Somali-Massai Regional Center of endemism, one of the major floristic regions in Africa and falls within one of the IUCN's global biodiversity hotspots named the 'Horn of Africa' (Clark, 2010). Out of 2,500 plant species of this regional centre of endemism, around 800-1000 species are estimated to be found in SNNPR region (Samson, Tamrat and Alemayehu, 2010). The SNNPR has diverse wildlife species including terrestrial and aquatic, large and small mammals. Details of various faunal species are shown in Table 1.

**Table 01: Wildlife Resources of the SNNPR**

#	Wildlife Species	No. of Species in NSNP Region	No. of Species in Ethiopia	percent Species in NSNP Region compared with Ethiopia
1.	Mammals	> 91	279	33
2.	Birds	351	862	41
3.	Reptiles	33	201	16
4.	Amphibians	8s	63	13
5.	Fishes	16	150	10
6.	Plants	800-1000	6500-7000	12-14

**Figure 1: Map of the Park**



## **Context of Ecosystem Services**

What is 'ecosystem service'? In a broad sense, 'ecosystem service' refers to the range of conditions and processes through which natural ecosystems, and the species that they contain, help sustain and fulfill human life (Daily, 1997 as cited in Jodi *et al.*, 2005). The four broad categories of forest ecosystem services are: (1) provisioning, such as the production of food and water; (2) regulating, such as the control of climate, flood and diseases; (3) supporting/habitat, such as nutrient cycles and crop pollination; and (4) cultural, such as spiritual and recreational benefits. Healthy ecosystems supply us with food, freshwater, clean air, and a stable climate. They protect us from disease and disaster and allow us to make choices about our way of life (MEA, 2007). Haines-Young and Potschin (2009) also reiterate that all humans are dependent on the ecosystem services. Despite the invention of many synthetic materials, nature still provides the stuff of life: trees bring us wood and paper, clothing is made from plant and animal fiber, and many life-saving medicines are derived from plants. Less visible but equally important are the complex natural systems that filter our air and water, regulate the climate, and protect us from disease and natural disasters. Forests maintain air and water quality, reduce landslides and floods, and play a key role in stabilizing climate pattern.

Ecosystem services are sometimes confused with biodiversity. Biodiversity or life on earth, including the variability among living organisms within species, between species, and between ecosystems is not itself an ecosystem service. Rather, biodiversity serves as the foundation for all ecosystem services. Both wild and managed ecosystems contribute to biodiversity. The value some people place on biodiversity for its own value is captured under the cultural ecosystem services of 'ethical' and 'existence' value (Janet *et al.*, 2008). Forests support as much as 90 percent of terrestrial biodiversity (Brooks *et al.*, 2006). The world's forests are also globally important carbon stores and sinks and provide a wide variety of other ecosystem services for people, such as protection of fisheries, watersheds and soils, apart from being source of raw materials, e.g. non-timber products (Gullison *et al.*, 2007).

## **Classification of the Ecosystem Services**

There are three international classification systems that are available to classify ecosystem services: Millennium Ecosystem Assessment (MEA), The Economics of Ecosystems and Biodiversity (TEEB) and Common International Classification of the Ecosystem Services (CICES). The MEA was the first large scale ecosystem assessment and it provides a framework that has been adopted and further refined by TEEB and CICES. The MEA organizes ecosystem services into four well known groups: provisioning, regulating, cultural and supporting services. The TEEB proposes a typology of 22 ecosystem services divided in 4 main categories, mainly following the MEA classification: provisioning, regulating, habitat and cultural and amenity services. An important difference that TEEB adopted was the omission of supporting services, which are seen in TEEB as a subset of ecological processes. Instead, habitat services have been identified as a separate category to highlight the importance of ecosystems to provide habitat for migratory species (e.g. as nurseries) and gene pool 'protectors'. CICES builds on the existing classifications but focuses on the ecosystem service dimension. In the CICES system, the services are either provided by living organisms (biota) or by a combination of living organisms and abiotic processes (EU, 2013). The correspondence between these classifications is illustrated in Annex 1. According to Haines-Young and Potschin (2011), the main difference between CICES and TEEB classifications is in the treatment of 'habitat services'. While TEEB identifies them as a distinct grouping at the highest level, CICES regards them as part of a broader 'regulating and maintenance' theme. The CICES includes the 3 familiar 'service themes' that are nested as 9 principle classes of services; 23 'service groups' and 59 'service types'. The CICES classification is illustrated in Annex 2.

Hence, no universally accepted typologies of ecosystem services presently exist, although the MEA framework is still widely applied. Notwithstanding the difficulties of defining what exactly an ecosystem service is, many authors have attempted to provide a typologies or checklists. These typologies, both pre- and post-date of the MEA, vary considerably in their approach and level of sophistication (Haines-Young and Potschin, 2009).

### **Ecosystem Services of Nechisar National Park**

The forest ecosystem of Nechisar National Park is the “lung” of Arba Minch town and its vicinities. It regulates the local weather and climatic conditions. It also adds aesthetic values. This forest satisfies the spiritual, recreation and aesthetic needs. It serves as cultural asset and the “green home” for diversified wild fauna and flora with exceptional nutrient cycles and energy flows. The forests of the park provide various ecosystem services like: 1) provisioning services (food, water, timber, fuel wood, fodder, grass, charcoal, medicinal plants, game, fruits, drinking water), 2) regulatory services (air quality regulation, fresh air provision, rainfall, flood prevention, drought prevention, pollination, carbon sequestration, waste decomposition, maintenance of soil fertility, pest and disease control, etc.), 3) habitat services for wild fauna like Burchell’s zebra, grant’s gazelle, greater kudu, lesser kudu, common bushbuck, hippopotamus, lion, leopard, Nile crocodile, Anubis baboon, Vervet monkey, Columbus monkey, diki dik, hyena, pelicans, flamingos, etc., and 4) cultural services like recreation, ecotourism, bird watching, forest walking, mountain climbing, trekking, aesthetic value and spiritual relaxation. According to Aramde *et al.* (2014), the vegetation in the park comprises forests, grasslands, shrub lands and thickets, woodlands and the riparian forest. There are also the savannahs, mountain habitats and spectacular landscapes. Hence, it has a variety of habitats that supports the vast diversity of wildlife and provides a number of crucial ecosystem services for the human wellbeing. The forest ecosystem of Nechisar National Park is believed to be unique in its vegetation formation from which the forty springs (called as God’s Hall) emanate<sup>1</sup>.

### **General Challenges to Forest Ecosystems**

In spite of obvious values of forests, anthropogenic activities are causing unprecedented threats to forest ecosystems (Chavan, 2013). Throughout the world, the destruction of natural forests for timber, cropland, fuel wood, urbanization, development projects and commercial industry have had a profound impact on rural communities and wild fauna and flora. The deterioration of the Earth’s extensive forests has exposed critical watersheds, thereby, accelerating topsoil erosion and sedimentation of rivers and reservoirs, and exacerbating floods. Simultaneously, the excessive deforestation has overtaxed the land’s natural resilience and the capacity to regenerate and sustain its productive functions (Poffenberger, 1996).

In East African countries, the forests play a major role in the economies by providing a variety of goods and services. The total forest cover of East Africa is estimated to be 85.6 million ha or about 21 percent of the land area of the sub-region (FAO, 2003). However, most of the population is concentrated in the limited high-productivity activities and the intense land use pressures are a major factor contributing to land degradation and other environmental problems such as soil erosion and downstream siltation. The annual rate of deforestation in East Africa between 1990 and 2000 was estimated to be 0.51 million ha or about 10 percent of the annual deforestation rate for all of Africa (FAO, 2003). Today, the forest resources of East Africa are steadily disappearing and those that are left are being degraded. The growing demand for land, expanding commercial activities, resettlement, wildfire, overgrazing, subsistence cultivation, encroachment and inadequate efforts to implement sustainable management have contributed to deforestation (FAO, 2003). The forest land occupies approximately 2.9 percent of Ethiopia’s total landmass. Currently, forest degradation and depletion are commonplace in the country. By early 1950s the forests occupied about 16 percent of the total land area, by 1980s the forests occupied only 3.6 percent, and by year 2000 the coverage of forests was 2.9 percent (Mogaka *et al.*, 2001). The current annual loss of highland forest area has been estimated to be between 150,000 ha to 200,000 ha (Bongers and Tennigkeit, 2010; Mogaka *et al.*, 2001).

### **Challenges to Nechisar National Park**

Historically, humans have modified natural ecosystems emphasizing on those species that yield direct benefits (e.g. agricultural commodities), generally overlooking the unseen but essential ecosystem services (DEWHA, 2009). In the last 50 years, people have modified forest ecosystems more rapidly and extensively than in any comparable period of human history (MEA, 2007). DEWHA (2009) also describes that forest ecosystem services have not been easy to

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<sup>1</sup><http://allafrica.com/stories/201510192783.html>

observe until they cease to flow; hence, they have not been formally counted in economic systems, or the effects of their loss have been counted as 'externalities.' However, when these externalities become a significant cost burden to society, such as restoring degraded forest ecosystem, it becomes a priority to understand and value forest ecosystem services and to integrate them into economic frameworks. The challenges to the forest ecosystems are the results of anthropogenic actions by a number of agents. Agents are individuals, groups of individuals or institutions that directly convert forested lands to other uses or that intervene in forests without necessarily causing deforestation but substantially reducing their productive capacity. Agents include shifted cultivators, private and government logging companies, mining and oil and farming corporations, forest concessionaires and ranchers. These agents clear forest lands or selectively exploit forests for agricultural expansion, to subsist, for mining, to obtain forest products and fuel wood (Arnoldo, 2000).

In particular context of Nechisar National Park, the following pertinent challenges are described as below:

### **Lack of Awareness and Coordination among Stakeholders**

The contribution of forest ecosystem services to human wellbeing is usually undervalued due to lack of awareness which is resulting in the use of the resources in a way that undermines the provision of such services. Decision makers and the general people often influence forest ecosystem in Nechisar National Park through their actions as a result of lack of awareness of forest ecosystem and biodiversity values. This arises from the lack of effective communication mechanisms to raise awareness of forest ecosystem services and its values. At national level too, the forest ecosystem services issues were not well integrated into the formal education system. Promotion and appreciation of community knowledge associated with forest ecosystem services and biodiversity, its local uses and management that should also be used as an informal education (EBI, 2014). Similarly, DEWHA (2009) also describes that despite their enormous services, forest ecosystems continue to be destroyed in this park. Lack of hard data regarding the actual services of forest ecosystems hampers the incorporation of services into government decision making. Moreover, there is a lack of proper implementation and monitoring mechanisms both in specific cases and in the overall assessment of the status of forest ecosystem conservation and their sustainable use. Huge efforts are needed to strengthen coordination and to raise awareness of stakeholders, including the public, concerning biodiversity conservation, sustainable utilization and development (EBI, 2014).

### **Lack of Recognition of the Forest Ecosystem Services**

Human well-being utterly depends on nature. Despite the inextricable connections, forests have frequently been seen in isolation. Decision makers may be focused on reducing poverty, increasing food production, strengthening resilience to climate change, or producing energy. The development projects and policies intended to meet these goals often go forward unwittingly at the expense of forest ecosystem (Janet *et al.*, 2008). EBI (2009) also states that conserving forest ecosystem requires strong political commitment and an understanding of the value of natural resources. It appears that the latter is totally lacking in regard to managing the Nechisar National Park. As a result, inadequate consideration is being given to conservation of forest ecosystem in the park. Projects and investments are either oriented to short term development goals and, even when they consider forest ecosystem and biodiversity conservation, they are poorly implemented. Jodi *et al.* (2005) express that the full social and environmental benefit of forest ecosystem services and the full cost of their degradation are not translated in a way that will ensure optimal decisions for both the economy and the environment. That is one reason why ecosystem services in national parks remain neglected in mainstream paradigm of development.

### **Population Growth**

Uncontrolled population growth puts undue pressures on all the natural resources particularly on forest ecosystem. With increasing population growth there is an increase in resource consumption, which causes expansion and intensification of land use, overutilization of biological resources and overexploitation of forest ecosystem services (EBI, 2014). At present the rapid population growth of Arba Minch town is related to immigration of people coupled with the higher

demand of fuel wood and construction materials. It brings pressure to bear on the forest ecosystems in Nechisar National Park. Besides, the park's forests serve as source of food, feed and fodder, environmental and social services to the community (Lemlem and Fasil, 2006; Aramide, Tsegaye and Pananjay, 2012).

### **Poverty**

Poverty is situations in which people depend directly upon consumption of forest ecosystem services or other natural resources for survival. Poor farmers, fishermen, pastoralists and others extract from the forest ecosystem to support their livelihoods (EBI, 2014). The population in the fringe areas of Nechisar National Park is largely poor, and the dependence of people on forests' ecosystem services is well evident (EBI, 2009). Hence, usually the poor people are forced to harm forest ecosystem to expand their agricultural land and to collect forest products (Jodiet *al.*, 2005). Poverty, food insufficiency and insecurity contribute much to habitat loss and fragmentation as a result of deforestation and cultivation. Sumit *et al.* (2011) states that poverty and over population is believed to be the main causes of loss of forest ecosystem in the park areas. Even though poverty and overpopulation are undeniably responsible for much of the damage to forest ecosystem, it is not an exclusive problem to Third World countries. An individual in an industrialized country is likely to consume much of the world's resources as compared to a person in a poor country. The linkage of poverty and overexploitation of resources in poor countries with the affluent lifestyles in developed world is well understood.

### **Deforestation**

Deforestation is the removal of a forest or stand of trees where the land is thereafter converted to a non-forestry use. It also refers to indiscriminate cutting or over-harvesting of trees for fuel wood, commercial activities, charcoal making, pulp, or to clear the land for agriculture, ranching, logging, construction, or development activities such as construction of railway, highway, dam, industries, mining and alike (Ojekunle, 2014). Along with the fast population growth and the development of Arba Minch town, there is a high demand for fuel wood and timber by the urban dwellers and big institutions. For all these institutions and households, the only source of heat and light energy, and construction of houses, fences and roofing, is park's forests. According to EBI (2009), absence of schemes for benefit sharing in most parks, including Nechisar National Park is causing negative impacts due to minimizing the sense of ownership within the local communities. In other words, the lack of benefit sharing schemes has, to some extent, produced negative attitudes towards forest ecosystems in the park area.

### **Inadequate Valuation of Forest Ecosystem Services**

Forest ecosystem provides local and global unmarketable/non-priced benefits like carbon sequestration, ecotourism and recreation to the human well-being. Any loss of these benefits must be considered as costs. Nevertheless, the failure of markets to account for non-priced benefits and costs in various circumstances, has to be an important underlying source for the challenges of forest ecosystem services (Arnoldo, 2000). Market and economic policy failures, such as perverse subsidies, absence of markets for the forest ecosystem services are the major challenge which leads to forest ecosystem degradation and loss (Jodiet *al.*, 2005). In addition, even when a value credibly estimated for the forest ecosystem, it is often an externality—a cost accruing to society at large, rather than to the individuals or companies responsible—so there is little incentive for those actors to care for the forest ecosystem in question. These market failures are common drivers of the huge forest ecosystem losses of the past half century (DEWHA, 2009). Though this principle is common for all parks, it acutely befits on Nechisar National Park.

### **Potential Measures to Conservation of Nechisar National Park**

#### **Enhancing Public Awareness of Forest Ecosystem Services**

Considering the issues and problems in Nechisar National Park, raising awareness of the people living in vicinity of park and the decision makers should be integrated in most of the activities related to forest ecosystem services and its values. Public awareness raising activities can be done by organizing annual events such as International Day for Biological Diversity, Earth Day, Tree Day, World Environment Day, Green Award Programs and Annual Tree Planting programmes. Such activities may be organized and carried out by governmental and non-

governmental organizations. Besides, knowledge acquired/gained through research, carried out by various institutions in the areas of forest ecosystem services, can be communicated using different media outlets, and such information may be used to devise plan to conserve and sustainably utilize forest ecosystem services.

### **Enhancing Stakeholders' Participation in Forest Ecosystem Conservation**

Ways to reduce challenges on the forest ecosystem must go hand in hand with improving the welfare of communities at the forest frontiers. There is no clear strategy of involving stakeholders in the conservation of forests of Nechisar National Park. Conservation strategies require cooperation and goodwill of communities and other stakeholders who are directly dependent on the forests of park. The strategies should be such that they should, on the one hand, recognize the critical roles of national, state and conservation sectors; and, on the other hand, they should empower the civil society and the private sector to take a proactive role in reducing challenges, often working in conjunction with government.

### **Strengthening Investment in Research, Training and Education**

Undoubtedly, there is lack of knowledge and information among the common people about forest ecosystem services. Forest managers and policy makers serving for Nechisar National Park need to be comprehensively educated, and they need to appreciate the complexity of the interacting ecological, economic, social, cultural and political factors. Hence, training and education of stakeholders help people understand forest ecosystem services and its challenges. It can help reduce adverse effects and challenges on the forest ecosystem services. Besides, it can encourage appropriate action to minimize challenges on the forest ecosystems.

### **Generating Significant Contribution from Stakeholders**

Generating stakeholders' contribution is crucial for sustainable forest ecosystem management since it realizes ecological, economic and social sustainability. Management for forest ecosystem services without the involvement and contribution of stakeholders is not economically and socially sustainable. Achieving ecological sustainability means that the ecological values of the forest must not be degraded rather improved in Nechisar National Park. Stakeholders' contribution will enhance biodiversity conservation, minimize soil erosion, boost up soil fertility, and increase water quality through maintaining forest ecosystem health (Chomitzet *et al.*, 2007).

### **Strengthening the Role of Government and Non-Government Institutions**

Strong and stable government agencies managing the Nechisar National Park are essential to slow down the challenges to the forest ecosystem services. Sumit *et al.* (2011) stated that environmental NGOs' contribution towards conservation management has been enormous. They have the advantage over government organizations and large international organizations because they are not constrained by government to government bureaucracy and inertia. They are better equipped to bypass corruption and they are very effective at getting to the people.

### **Enforcement of Policy, Legislative and Regulatory Measures and its Compliance**

A wide variety of policy statements and legislative and regulatory measures have been established to protect forests, but they need to be effectively enforced. New modifications or adjustments are, of course, needed for site specific conditions. Laws, policy and legislation should be such that they encourage local people and institutional participation in forestry management and conservation along with safeguarding indigenous people's traditional rights and tenure with rightful sharing of benefits. Many formal and informal enforcement or compliance mechanisms can be used to overcome forest ecosystem challenges and to prevent deforestation. All these recommendations also apply in case of Nechisar National Park.

### **Conclusion**

The ecosystem services provided by forest ecosystems of Nechisar National Park of Ethiopia support the livelihood and life of a series of stakeholders. Arba Minch town completely depends for various needs on the forests of the park. The anthropogenic pressure and degradation threats on the natural resources of park's forest ecosystems are observed causing acute pressure on the ecosystem services of forests. It will lead to fast loss of habitats and health of

ecosystems. Various strategies for conservation have been suggested for the management of the Nechisar National Park. The park administration must take serious measures to halt the degradation process by involving and engaging not only the local populations but also the stakeholders like restaurant owners, hotel owners, tour operators, water users, fuel wood collectors, timber merchants, stone quarries, and so on. Multilateral participatory processes need to be pursued with utmost seriousness.

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### Annex 1: Ecosystem Services Categories in MEA, TEEB and CICES

<i>MEA Categories</i>	<i>TEEB Categories</i>	<i>Type</i>	<i>CICES Categories</i>
Food (fodder)	Food	Provisioning services	Biomass (Nutrition)
Freshwater	Water		Biomass (Materials from plants, algae and animals for agricultural use)
Fiber, timber	Raw Materials		Water (for drinking purposes) [Nutrition]
Genetic resources	Genetic resources		Water (for non-drinking purposes) [Materials]
Biochemicals	Medicinal resources		Biomass (fibers and other materials from plants, algae and animals for direct use and processing)
Ornamental resources	Ornamental resources		Biomass (genetic materials from all biota)
			Biomass (fibers and other materials from plants, algae and animals for direct use and processing)
			Biomass (fibers and other materials from plants, algae and animals for direct use and processing)
			Biomass based energy sources
			Mechanical energy (animal based)
Air quality regulation	Air quality regulation	Regulating services (TEEB)	[Mediation of] gaseous/air flows
Water purification and water treatment	Waste treatment (water purification)	Regulating and supporting services (MEA)	Mediation [of waste, toxics and other nuisances] by biota
Water regulation	Regulation of water flows Moderation of extreme events		Mediation [of waste, toxics and other nuisances] by ecosystems
Erosion regulation	Erosion prevention	Regulating and maintenance services (CICES)	Mediation of liquid flows
Climate regulation	Climate regulation		Mediation of mass flows
Soil formation (supporting service)	Maintenance of soil fertility		Atmospheric composition and climate regulation
Pollination	Pollination		Soil formation and composition
Pest regulation	Biological control		Lifecycle maintenance, habitat and gene pool protection
Disease regulation			Pest and disease control
Primary production	Maintenance of life cycles of migratory species (incl. nursery service)		Lifecycle maintenance, habitat and gene pool protection
Nutrient cycling (supporting services)			Soil formation and composition
			Maintenance of water conditions
	Maintenance of genetic diversity (especially in gene pool protection)		Lifecycle maintenance, habitat and gene pool protection
Spiritual and religious values	Spiritual experience	Cultural services	Spiritual and/or emblematic
Aesthetic values	Aesthetic information		Intellectual and representational interactions
Cultural diversity	Inspiration for culture, art and design		Intellectual and representational interactions
Recreation and ecotourism	Recreation and tourism		Spiritual and/or emblematic
Knowledge	Information for		Physical and experiential interactions
			Intellectual and representational

MEA Categories	TEEB Categories	Type	CICES Categories
systems and educational values	cognitive development		interactions Other cultural outputs (existence, bequest)
MEA provides a classification that is globally recognized and used in sub global assessments.	TEEB provides an updated classification, based on the MEA, which is used in ongoing national TEEB studies		CICES provides a hierarchical system, building on the MEA and TEEB classifications.

Source: EU (2013).

### Annex 2: The CICES Classification

Themes	Service Class	Service Groups	Service Types
Provisioning Services	Nutrition	Terrestrial plant and animal foodstuffs	Commercial cropping
			Subsistence cropping
			Commercial animal production
			Subsistence animal production
			Harvesting wild plants and animals for food
		Freshwater plant and animal foodstuffs	Commercial fishing (wild populations)
			Subsistence fishing
			Aquaculture
			Harvesting fresh water plants for food
		Marine plant and animal foodstuffs	Commercial fishing (wild populations)
			Subsistence fishing
			Aquaculture
		Potable water	Harvesting marine plants for food
	Water purification		
	Materials	Biotic materials	Non-food plant fibers
			Non-food animal fibers
			Ornamental resources
			Genetic resources
			Medicinal resources
		Abiotic materials	Mineral resources
Energy			Renewable biofuels
			Renewable abiotic energy
Regulating and Maintenance Services	Regulation of wastes	Bioremediation	Plant based resources
			Animal based resources
		Dilution and sequestration	Wind
			Hydro
	Flow regulation	Air flow regulation	Solar
			Tidal
		Water flow regulation	Thermal
			Remediation using plants
		Mass flow regulation	Remediation using micro-organisms
			Dilution
	Regulation of physical environment	Atmospheric regulation	Filtration
			Sequestration and absorption
Water quality		Windbreaks, shelter belts	
		Ventilation	
Water quality	Water flow regulation	Attenuation of runoff and discharge rates	
	Water purification and oxygenation		

Themes	Service Class	Service Groups	Service Types
		regulation	Cooling water
		Pedogenesis and soil quality regulation	Maintenance of soil fertility
			Maintenance of soil structure
	Regulation of biotic environment	Lifecycle maintenance & habitat protection	Pollination
			Seed dispersal
		Pest and disease control	Biological control mechanisms
		Gene pool protection	Maintaining nursery populations
Cultural Services	Symbolic	Aesthetic, Heritage	Landscape character
			Cultural landscapes
		Spiritual	Wilderness, naturalness
			Sacred places or species
	Intellectual and Experiential	Recreation and community activities	Charismatic or iconic wildlife or habitats
			Prey for hunting or collecting
		Information & knowledge	Scientific
Educational			

Source: Haines-Young and Potschin (2011)