SUMMARY FOR POLICY MAKERS

National Ecosystem Assessment

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

Ethiopian Biodiversity Institute

Addis Ababa, Ethiopia

2022

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A Message from the State Minister, Ministry of Agriculture

Regardless of the differences in socio-economic development and technological advancement, all human societies are dependent on the supply of ecosystem services. Due to the lack of responsible interaction with nature, however, the human race has modified the natural environment, maximizing benefits and in the long term, triggering harms to the natural environment, which in turn halts economic development. This has usually been manifested through degradation of forests, deterioration of arable lands, drying up of water bodies, alteration of climatic conditions, spreading of alien invasive species, loss of habitats and biodiversity, and frequent incidents of disease that ultimately worsens poverty and food insecurity. Over the last several decades, the world has witnessed such catastrophic phenomena in the various regions where human lives are inextricably linked to biodiversity resources.

Ethiopia is one of the biodiversity-rich countries where agriculture is the mainstay of its people's livelihood. There are various ecosystem types (woodland, wetland, moist evergreen Afromontane, sub-afroalpine, desert and semi-desert ecosystem, etc.) in Ethiopia harbouring large biodiversity resources. However, the biodiversity resources have been subjected to degradation mainly due to anthropogenic factors such as poverty, population-driven land conversion, and cultivation of marginal lands as well as natural drivers of change.

In order to tackle these challenges, therefore, it is quite indispensable to understand the status of biodiversity resources and predict future dynamic scenarios and generate evidence that would be used as inputs for policy and decisions making while setting priorities and correspondingly designing conservation development strategies. An initiative called "*National Ecosystem Assessment*" which aims at contributing towards this end has been implemented from 2017 to 2021 involving scholars from local institutions based on the conceptual and assessment frameworks of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). This project, which is the first in its kind, has been coordinated by the Ethiopian Biodiversity Institute and addressed the five broad categories of ecosystems, namely Mountain, Forest and Woodland, Aquatic and Wetland, Rangeland, and Agricultural ecosystems.

The technical support from the World Conservation Monitoring Center (UNEP-WCMC) and the financial support from the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety and Consumer Protection (BMUV) through the Biodiversity and Ecosystem Services Network (BES-Net) have been instrumental in accomplishing the assessment.

During the assessment processes, several stakeholders, mainly from relevant line ministries, universities, research institutions, non-governmental organizations, local communities and civic societies have been engaged at different stages. The assessment chapters were reviewed and evaluated for their credibility, reliability and legitimacy by scholars and key stakeholders through several consultative meetings held during the different stages of the study.

The final outputs of the assessment were organized in a form of a Composite Book, which consists of five chapters (of the aforementioned ecosystems) and a scenario chapter that shows the plausible future of the ecosystems, biodiversity, ecosystem services, and the implications for human wellbeing.

This Summary document intended for Policymakers (SPM) was produced with extracts of the key findings from the comprehensive outputs of the National Ecosystem Assessment so that they can clearly show the current state of knowledge and the existing gaps between the science-policy interface. The findings could serve as important inputs for prior informed decision making, policy formulation and analysis of the stereotypic scenarios of drivers of change of biodiversity and their subsequent impacts on human wellbeing. Using this opportunity, I, therefore, would like to thank the Ethiopian Biodiversity Institute for its all- rounded effort in making the assessment possible, the involved stakeholders for their active engagements during the assessment processes and international development partners for the technical assistance and financial support they provided. Lastly, I sincerely invite our stakeholders to thoroughly read this Summary for Policy Makers and thereby use the uptakes of the current assessment in mainstreaming biodiversity issues into their respective sector and sub-sectors plans.

Professor Eyasu Elias
Ministry of Agriculture

1. Key Messages

The Ethiopian National Ecosystem Assessment (NEA) came up with important key messages that will be instrumental in national policy processes and decision-making schemes. National ecosystem assessments are considered best choices in recent years to bring together different knowledge types and engage with a wide range of stakeholders in order to strengthen the credibility, legitimacy and relevance of biodiversity and ecosystems with their functions and services to humanity. Such assessments aim to address specific policy questions and assist empowering of the value of nature in decision-making including by undertaking elaborate analyses of scenario at the science-policy interface.

In this NEA summary for policymakers (SPM), the key messages are structured under a few main thematic headings that can transmit the core concepts by highlighting the biological significance and uniqueness of Ethiopian ecosystems, their functions and services, pressures and drivers of change and knowledge further hinting at areas with relevance to national policy and development. The SPM pinpoints the important roles of the indigenous and local knowledge (ILK) system for which the country is well noted. The ILK associated with agroecosystem and ecosystem services is anticipated to provide key policy directions and inputs. The ILK in custody of Ethiopia's ethnolinguistic communities is believed to positively contribute to the intellectual bases for conservation and sustainable development of ecosystem services in Ethiopia. This SPM is a synthesis made from each chapter of the Ethiopian NEA with the view to facilitating quick and clear understanding and a framework for action by policy and decision-making taking into account the policy direction along the findings and recommendations brought up through analysis and discussion of scenarios. More detailed information can be obtained from the executive summary, key findings and the full chapters dedicated to respective ecosystems and the scenarios chapter. The key messages synthesized from the chapters of the composite book are organized under five thematic headings describing: the contributions of biodiversity and ecosystem services to human life, their status and trends (A), pressures and drivers (B), comparative advantages (options and opportunities) and knowledge (C), contribution to growth and transformation (D), and policy and organizational matters (E).

A. **Ethiopia has natural assets of local, national, regional and global importance and uniqueness in its diverse ecosystems that facilitate the flow of ecosystem services contributing to quality of life provided it is closely monitored**

A1. Ethiopia needs to fully document the status and trends of its biodiversity and ecosystems to preserve and restore each ecosystem and maintain essential functions and services.

A2. Ethiopian ecosystems have components that harbour unique biodiversity. The five broad ecosystem categories spread out in two of the 36 Global Biodiversity Hotspots (the Eastern Afromontane and the Horn of Africa) that support a large number of endemic and unique animal and plant species.

A3. The rich avian diversity and the observed endemism in the various groups of organisms and the unique agroecosystem sub-types that layout in this Vavilovian centre of origin and/or diversity of crop species/varieties and livestock species/breeds are expressions of the uniqueness and abundance entrenched in groups of organisms. The latter is behind the agrobiodiversity-rich system with critical national significance and also with regional and global roles. The promotion of agrobiodiversity conservation and diversification, together with the enhancement of critically underutilized crops, are instrumental to sustainable food production in Ethiopia.

B. **Ethiopia's biodiversity and ecosystems face pressures driven by multiple factors**

B1. The ecosystems, in general, are affected by direct drivers such as anthropogenic factors, climate change, land-use/land cover changes or indirect drivers such as governance that allude to a range of institutions from local to national and international levels. Existing data gaps need addressing in respective ecosystems.

B2. Extensive land-use pressures and increased demand for resources and products result in degradation and exhibit declining trends due to on-going human-driven land-use/land cover changes that put continued pressures on ecosystems. Furthermore, degradation through excessive water abstraction, drainage agriculture, urbanization and associated pollution, introduction and expansion of invasive alien species and climate change; land

conversion by bush encroachment and the transformation of rangelands to other land-use types; and agricultural activities/practices expanding to new areas resulting in habitat changes have been threatening animal and plant species, by reducing their populations and associated gene pools. Climate change as one of the natural drivers has started negatively impacting ecosystem services to human wellbeing in all ecosystems.

B3. The spread of invasive alien species including the water hyacinth (*Eichhornia crassipes*) in water bodies, prosopis (*Prosopis juliflora*), parthenium (*Parthenium hysterophorus*) and lantana (*Lantana camara*) in rangelands, forests and woodlands and striga (*Striga hermonthica* plus some native species) weeds into agricultural landscapes has been affecting different ecosystems in Ethiopia. These invaders interfere with the production systems and pose major threats to biodiversity and ecosystem services. The fisheries industry, irrigation schemes, livestock watering, navigation and ecotourism and canals of hydroelectric power plants may lead to ecological imbalances and health hazards to humans, animals and environments.

C. **Comparative advantages (options/opportunities) and knowledge regarding conservation and sustainable utilization of biodiversity and ecosystem services in the light of Ethiopia's richness in biodiversity and associated ILK**

C1. Communities living in the various ecosystems have rich ILK that originated and has been used over the millennia, and now considered instrumental for managing biodiversity and ecosystems. The relevant ILK has to be tapped through scientific research, enhanced and applied. Though efforts to conserve biodiversity and maintain ecosystem services have continued for years, there is still a need for awareness-raising, recognizing and making effective use of the invaluable ILK, the traditional practices and the pearls of wisdom entrenched in cultures across the country.

C2. The government of Ethiopia has demonstrated commitment to agrobiodiversity conservation for better agroecosystem services through institutional capacity building and funding but more is needed to enhance the use of climate-smart ILK relevant to

agriculture and the ecological processes at all levels focusing on the gaps. Ethiopia has awareness-raising and education programmes, policies and planning frameworks that support conservation and sustainable management of agrobiodiversity and agroecosystem services. These are undertaken through mainstreaming agrobiodiversity and engaging local communities and farmers to enhance the age-old agrobiodiversity-enriched agroecological farming known for its environmentally friendly and sustainability merits. Further awareness-raising and generation of knowledge need to focus on the trade-offs between the provision of material goods and non-material ecosystem services. Gradual increase of community participation in agrobiodiversity management is noticeable but the need to develop and implement new approaches that recognize and work with farmer conservators on documentation, valorization and incorporation of ILK is high.

D. **Biodiversity wellbeing and healthy ecosystems are key for Ethiopia's growth and transformation drive and the Climate Resilient Green Economy Strategy**

D1. Implementation of existing and additional policies and laws related to biodiversity and environments can help to minimize pressures, enhance and improve ecosystems.

D2. The effectiveness of the national growth and transformation plans need relevant policies and clear action plans and implementation guidelines.

E. **Policies and strategies need to be put in place to meet national, regional and global targets and work towards the desired common future**

E1. Meeting the post-2020 Global Biodiversity Framework, that aims at accelerating the implementation of the pillar objectives of the Convention on Biological Diversity, by conducting a rapid review of its alignment with the Ethiopian National Biodiversity Strategy and Action Plan to be formulated. This framework will help to identify key areas that need to be updated and refined. The proposed framework and targets aim to engage key stakeholders in the review process with a wider social base in order to reduce obstacles in implementation. Continuous implementation of biodiversity goals

and targets and identification of opportunities for policy coherence and biodiversity mainstreaming across national policy as well as assessments of national monitoring systems, analyses of biodiversity and possible innovative mechanisms and bridging gaps.

E2. Ethiopia has formulated and implemented several forest and biodiversity-related policies, laws, regulations and guidelines to address the persistent challenges and for fulfilment of the economic and societal benefits expected from these sectors over the past several years. The National Biodiversity Strategy and Action Plan (NBSAP) 2015-2020 is an overarching framework for all stakeholders to value biodiversity and ecosystem services, reduce pressures on biodiversity and ecosystems, improve the status of biodiversity and ecosystem services, and ensure access to genetic resources and fair and equitable sharing of benefits arising from their uses. Ethiopia's Climate Resilient Green Economy (CRGE) Strategy and sustainable land management entail a mix of policies and instruments that together ensure nature conservation, ecological restoration and sustainable use, sustainable production (including food, materials and energy) and climate change adaptation. With effective implementation, the major drivers of biodiversity loss and nature deterioration can be addressed. International treaties and conventions related to forest management and biodiversity conservation have been adopted over the last two decades. Some of the policy and legal instruments of implementation are patchy to protect ecosystems; their implementation and enforcement are irregular, incomplete, and ineffective and deserve due attention.

E3. Absence of a comprehensive land-use policy; institutional instability combined with low implementation capacity; poor inter-sectoral coordination and lack of synergy between sectors; inadequacy of the forestry legal framework and weak law enforcement and unclear tenure and forest use rights need due consideration. A major gap in the forestry and biodiversity sectors that rendered existing policies ineffective is the lack of policy focus, which led to continued degradation and decline of ecosystem services and the integrity of unique biodiversity in many of the ecosystems and, therefore, there is a need for concerted management interventions for sustainable use of the natural resources and services; policy action needed to promote sustainable intensification in agriculture and

limiting excess population growth. Globally or regionally set relevant conventions, treaties and targets need to be implemented at the local and national levels.

2. Background to the Key Messages

The Ethiopian National Ecosystem Assessment (NEA) is the first of its kind for Ethiopia in which attempts were made to elaborate a few guiding thematic questions focused around the contributions of biodiversity and ecosystem services, their status and trends, pressures and drivers, knowledge and awareness as well as policy and organizational matters. These were examined for each of the five broad ecosystem categories, namely (1) Mountain, (2) Forest and Woodland, (3) Aquatic and Wetland, (4) Rangeland and (5) Agricultural ecosystem for structuring and organizing the narrations of this assessment.

Ethiopia, the second most populous country in Africa, is located between 3°24' to 14°53'N latitude and 33°00' to 48°00'E longitude. Its 1.1 million km^2 total land area lies within the altitudinal range between 125 m b.s.l. and 4533 m a.s.l. Its diverse topographic features and associated environmental variations have resulted in varied habitats grouped into 12 vegetation types, commonly recognized as ecosystem types and sub-types (well established). In this Ethiopian ecosystem assessment, the discussion and analyses are focused around the five broad ecosystem categories. The estimated extent and coverage of each with descriptions is as presented in Table SPM 1 and the main features of each ecosystem are highlighted in Box SPM 1.

Table SPM 1. Estimated extent and coverage of the five major ecosystems of Ethiopia

Ecosystem Types	Area (in km^2)	Area (% of country's area)	Descriptive remarks
Mountain**	3000-6500	0.27-0.59	Covers all landmass that has risen significantly above sea level and the surrounding areas, forming altitudinal gradient defined vegetation zones of Afro-montane, Ericaceous and Afro-alpine
Forest and Woodland*	173,500 - 300,000	15.7-27	This ecosystem includes all forest lands and woodlands in all landscapes.
Aquatic and Wetland*	9318	0.844	Covers all wetlands and water bodies
Rangeland**	767, 000	69	Uncultivated land areas that provide forage and

			pasture for grazing and browsing animals. They are areas where natural rainfall variability is high, and climatic and other environmental conditions limit crop production
Agroecosystem**	105,974-242,880	9.6-22	Croplands that cover large areas in the highlands and mid-altitude areas, pastoral livelihood systems in the lowlands; are grouped into Cereal/grain crop-based, Perennial crop-based, Pastoral and agro-pastoral systems sub-types.

Note: some of the area coverage figures are taken from the chapters (*) and some are collected from other literature and extrapolated (**).

Box SPM 1: Highlights on the five major ecosystems of Ethiopia

The Mountain ecosystem, covering a very large area of land hosting important vegetation types with rich flora and fauna, has declined in recent years with regards to area and biodiversity quality and quantity. Most of the endemic flora and fauna of this ecosystem have been assigned critically endangered status by the IUCN Red List Criteria. The direct drivers of this change are land-use/d land cover changes and increased climate variability with population pressure constituting a major indirect driver. The steep slopes in the high altitude range are encroached by agricultural activities including crop cultivation and overgrazing by domestic animals. This ecosystem is highly vulnerable to the adverse impacts of climate change while limited research and documentation is focusing on the mountain biodiversity and ecosystem services.

The Forest and woodland ecosystem stretches over a vast area and comprises various vegetation types distributed in agroclimatic gradients that run from the lowland woodlands to the high mountain tropical forests, covering 15-27% of the total area of all ecosystems. Past trends showed that deforestation and forest degradation have been rampantly threatening the biodiversity therein. Protected areas, largely embedded within this ecosystem, are facing anthropogenic pressure and becoming more and more vulnerable as the natural habitats deteriorate and decline in floral and faunal diversity. This has hampered production and threatened human wellbeing, which is connected to the general lack of compliance with and paucity in implementing existing policies and enforcing laws and regulations. The direct drivers of degradation in this ecosystem are invoked by the underlying legal and institutional factors, including the absence of land-use policy, institutional instability, low capacity of institutions, substandard inter-sectoral coordination and lack of synergy between sectors, the inadequacy of the legal framework, weak law enforcement and unclear forest tenure and user rights.

The Aquatic and wetland ecosystem is a biodiversity hotspot in Ethiopia encompassing at least 10% of the Ethiopian floral diversity, providing habitat for at least 25% of the avifaunal diversity and hosting several other megafauna. However, the aquatic and wetland ecosystem in Ethiopia is rapidly declining due to degradation caused by excessive human activities. The direct causes are excessive water abstraction, habitat changes due to agricultural practices; drainage agriculture, rapid land-use changes, overgrazing, deforestation, urbanization and

climate change whereas population growth constitutes a major indirect driver. The biodiversity of this ecosystem is rapidly declining and the associated wild faunal and floral diversity is likely to decline. The ILK related to this ecosystem and the contribution towards conservation and sustainable use of resources therein would likely vanish. The major factors for degradation and loss of wetlands are population growth, unmanaged urban expansion and encroachment, international trade and agricultural investment and the absence of a national policy that recognizes the values and benefits of wetlands and aquatic resources. Climate change is expected to exacerbate the direct and indirect drivers.

The Rangeland ecosystem in Ethiopia, which has the largest land area coverage (69%) of the five major ecosystems, went through shrinkage since the 1960s due to extensive land-use changes. The management systems are gradually changing due to the expansion of enclosure systems leading to an increased degree of private ownership of communal grazing lands. This curtailed seasonal mobility between wet and dry season grazing areas and resulted in the loss of vegetation cover and increased severity of soil erosion due to continuous grazing. Climate change and increased human pressure are aggravating the deterioration of this ecosystem as seen in the increasing rate of soil erosion, loss of palatable grasses and rapid expansion of bush encroachment. Gradual sedentarization, crop cultivation and privatization of the communal rangelands in pastoral areas are leading to intra- and interethnic conflicts. The prevailing policies, governance systems and institutions emphasize poverty reduction; development efforts that focus on resource extraction aimed at short-term gains compromising long-term biodiversity conservation and sustainability. This has been progressively weakening the customary institutions leading to declines in rangeland biodiversity and ecosystem services.

Ethiopia's Agroecosystem, covers about 9.2-22% of the area occupied by all the ecosystems. Its agricultural biodiversity and the ecosystem services to human wellbeing are affected by natural and anthropologic drivers of change that include climate change, recurrent droughts, floods, acidification and related calamities. These are the main factors that result in disasters identified to have significant effects on biodiversity for food and agriculture. The agroecosystem is highly vulnerable to climate change and the spread of invasive alien species, which negatively affect crop and livestock production and productivity as well as human health. It is negatively affected by unsustainable utilization of resources either in the form of overexploitation or excessive use of nutrients with dire consequences of soil erosion, water depletion, acidification and salt accumulation. There is a growing need to increase production and productivity to provide food for the growing population and reduce poverty, while sustainably managing the agrobiodiversity and agroecosystem to ensure healthy human ecology and socioeconomic wellbeing and further scaling up to prosperity.

The country's topographic settings stretch over a high altitudinal range covering high mountains (Figure SPM 1), flat-topped plateaus, gorges, valley bottoms and aquatic and wetland environments. Rangelands and agricultural landscapes where larger population centres

occur and people engage in animal husbandry, crop cultivation and other livelihood systems are distributed within the wide agroclimatic and spatio-temporal settings of the country.

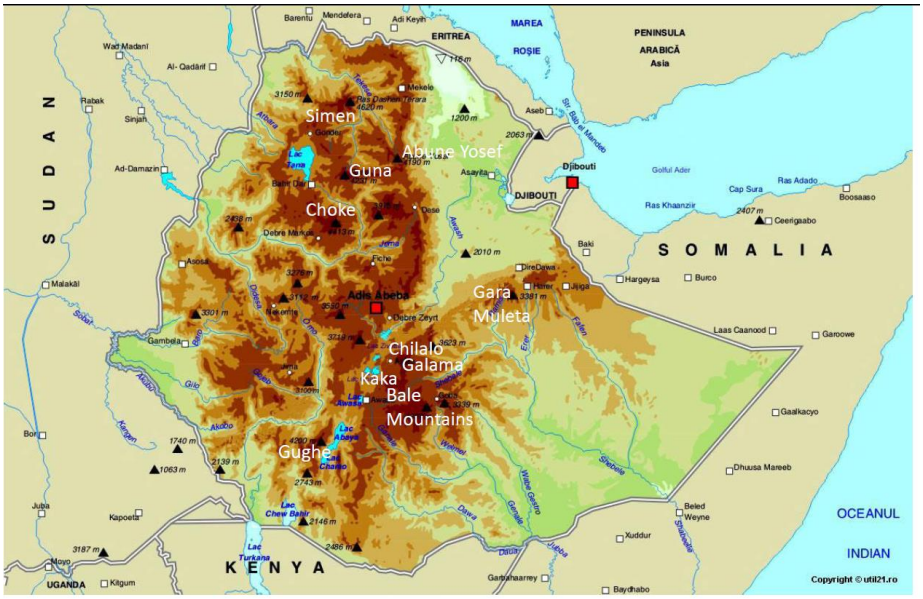

Figure SPM 1. Mountain ecosystem of Ethiopia [Modified from etiopia.jpg (1178×765) (util21.ro)]

This background section elaborates the key messages under the thematic headings; contributions of biodiversity and ecosystem services to human life, status and trends (A), pressures and drivers (B), comparative advantages (options and opportunities) and knowledge (C), contribution to growth and transformation (D) and policy and organizational matters (E).

A. Ethiopia has natural assets of local, national, regional and global importance and uniqueness in its diverse ecosystems that facilitate the flow of ecosystem services contributing to quality of life provided it is closely monitored {1, 2.1, 3.1, 4.1, 5.1, 6.1}.

A1. **Ethiopia is ecologically diverse with its chain of highland, midland and lowland systems that encompass familiar biomes, vegetation types and various ecosystems and agroecosystem sub-types with diverse flora, fauna and rich belowground and aboveground microbial diversity** (well established) {2.1.1, 2.1.2}.

A2. **The Ethiopian mountains are among the unique centres of biodiversity, housing diverse endemic fauna and flora inhabiting this most sensitive and fragile ecosystem** (established but incomplete*)* {2.1.6.1, 2.2.1, 2.3.4, 2.4.3}. Most of the Ethiopian mountains are well-known headwaters to major inland and transboundary rivers, holding great cultural values for connecting people with nature and serving the purposes of recreation and tourism in addition to the usual material goods and services. This ecosystem is highly vulnerable to the adverse impacts of climate change with little or no documentation in most cases.

A3. **Most of the endemic flora and fauna inhabiting isolated mountains of the country have been assigned critically endangered status by the IUCN Red List Criteria** (well established) {2.3.5}. The on-going changes are negatively impacting the rare and endemic plants (Figure SPM 2), animals (Figure SPM 3), keystone species, overall richness and ecosystem characteristics.

Figure SPM 2. Selected plant species (A: *Huernia macrocarpa* subsp. *macrocapa*, B: *Ceropegia sobolifera*) of Ethiopian mountain ecosystem known from single locality

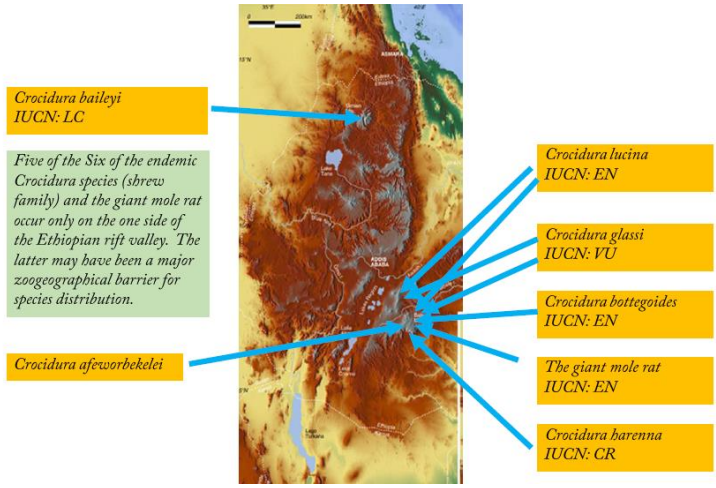

Figure SPM 3. Location of endemic small mammals of the Ethiopian mountain ecosystem

A4. **The forest and woodland ecosystem in Ethiopia stretches over a large area of the country and hosts the highest magnitude of biodiversity of all the Ethiopian ecosystems with considerable economic and ecological importance to Ethiopia and the global climate** (*established but incomplete)* {3.1}. However, the long history of human occupation and intensive land-use with continued degradation and deforestation have critically threatened the forest and woodland ecosystem and its once rich faunal and floral biodiversity (Figure SPM 4, Table SPM 2). The forest and woodland ecosystem needs implementation of appropriate conservation actions through afforestation programmes, restoration and rehabilitation actions ensuring the sustainability of the mode of utilization.

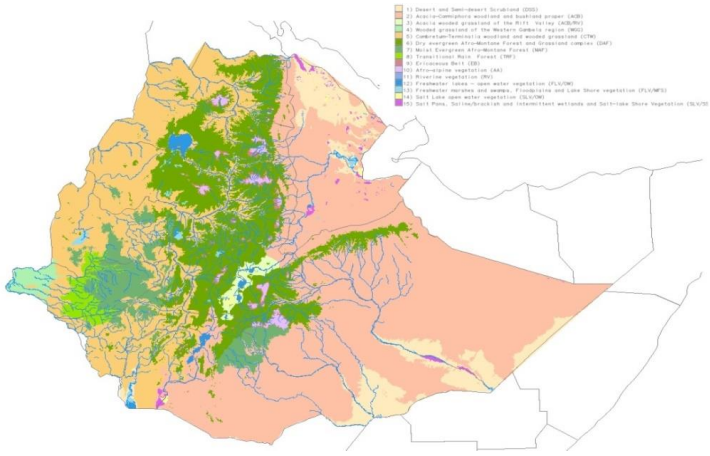

Figure SPM 4. Atlas of potential vegetation types in Ethiopia excluding the newly described vegetation types (Intermediate evergreen Afromontane Forest and Transitional Semi-evergreen Bushland)

Table SPM 2. Salient features and similarities of vegetation types having forests and woodlands

Vegetation types	Biological characteristics			Physical characteristics
	Vegetation characteristics	Family	Species	
1. Dry Afro-montane Forest and Grassland complex (DAF)	Canopy dominated by *Podocarpus falcatus, Juniperus procera* and *Olea europaea* subsp. *cuspidata* Comprises Afro-montane woodland and wooded grassland with *Acacia abyssinica, A. negri*[1], *A. pilispina, A. bavazanoi* and *A. montigena.*	Cupressaceae Podocarpaceae Fabaceae	 *Podocarpus falcatus* *Acacia abyssinica, A. negeri, A. pilispina, A. bavazanoi* and *A. montigena.*	DAF occurs from 1800 – 3200 m asl. Its spatial distribution includes: Oromia Region (Shewa, Arsi, northern Bale and western Hararge), Amhara Region (Shewa, Gojam, Welo and Gonder), Tigray Region (Tigray) and SNNP Region (Sidamo and Gamo Gofa).
2. Moist Evergreen	Canopy dominated by *Pouteria adolfi-*	Sapotaceae	*Pouteria adolfi-friderici*	MAF occurs from1500 – 2600 m asl

[1] Some of these species are endemic to the highlands of Ethiopia

Vegetation types	Biological characteristics			Physical characteristics
	Vegetation characteristics	Family	Species	
Afro-montane Forest (MAF)	*friderici, Olea welwitchii, Albizia gummifera* and *Albizia schimperiana*			Its geographic distributions include southwestern part of the Ethiopian Highlands mainly in Oromia, SNNPR and Gambella (some parts of Godere Forest) and on the southern slopes of the Bale Mountains in Oromia Region (Harenna Forest).
		Oleaceae	*Olea welwitchii*	
		Fabaceae	*Albizia gummifera* and *A. schimperiana*	
3. Intermediate Evergreen Moist Afro-montane Forest (IAF)	Share certain characteristics of MAF and DAF	Fabaceae	*Albizia gummifera, A. schimperiana*	It occurs in intermediate climate from 1500 – 2800 m asl
	Closed evergreen strata of one of more *of Albizia gummifera, A. schimperiana* and *Celtis africana, Prunus africana*			Its spatial extent includes West Gojam Zone (Bahirdar Zuria, Zege Peninsula); Gondar (western Farta on the west-facing slope of Mt. Guna); Awi Zone (most parts of Awi); Metekel Zone (on the plateau of eastern Wenbera, on the massive Mt. Belaya of Dangur, and smaller areas in Bullen and Mandura)
		Ulmaceae	*Celtis africana*	
		Rosaceae	*Prunus africana*	
4. Transitional Forest (TRF)		Sapotaceae	*Manilkara butugi Pouteria altissima Pouteria alnifolia*	TRF is found in the western parts of Ethiopia in Oromia (Wellega and Illubabor), Gambella (Godere and Abobo Forests) and in SNNPR (Kafa, Bench-Skeko and Sheka).
		Logianaceae	*Anthocleista schweinfurthii*	

Vegetation types	Biological characteristics			Physical characteristics
	Vegetation characteristics	Family	Species	
			Strychnos mitis	
		Moraceae	*Ficus mucuso*	
			F. exasperata	
			Milicia excelsa	
			Morus mesozygia	
			Trilepisium madagascariense	
		Apocynaceae	*Alstonia boonei*	
		Euphorbiaceae	*Croton sylvaticus*	
		Ulmaceae	*Celtis toka*	
			C. zenkeri	
			C. gomphophylla	
		Ebenaceae	*Diospyros abyssinica*	
		Sapindaceae	*Zanha golungensis*	
			Lecaniodiscus fraxinifolius	
		Meliaceae	*Trichilia dregeana*	
		Rutaceae	*Zanthoxylum leprieurii*	
		Fabaceae	*Albizia schimperiana*	
			A. grandibracteata	
5. Riverine Forest (RF)		Ulmaceae	*Trema orientalis*	This vegetation type occurs along several major systems of rivers and tributaries such as Abay (Blue Nile), Awash, Baro, Omo, *Oncoba spinosa* Tekeze and Wabi Shebele Their tributaries have riverine forests in areas below approximately 1800 metres altitude Riverine forest vegetation is highly variable in structure and density, and the floristic composition is dependent on altitude and geographical location
		Flacourtiaceae	*Oncoba spinosa*	
		Annonaceae	*Uvaria* sp.	
6. *Acacia – Commiphora* Woodland	Characteristic species are drought resistant trees and shrubs, i.e., with deciduous or	Fabaceae	*Acacia bussei*	It occurs in the northern, eastern, central and southern part of the country mainly in
			A. drepanolobium	
			A. hamulosa	
			A. ogadensis	

Vegetation types	Biological characteristics			Physical characteristics
	Vegetation characteristics	Family	Species	
and Bushland (ACB)	small, evergreen leaves		*A. prasinata* (endemic)	Oromia, Afar, Harari, Somali, and SNNPR
		Burseraceae	*Boswellia microphylla* *B. neglecta,* *Commiphora alaticaulis* *C. albiflora* *C. ancistrophora,* *C. boiviniana* *C. boranensis*	
		Balanitaceae	*Balanites aegyptiaca* *B. Rotundifolia*	
		Capparidaceae	*Boscia minimifolia* *Cadaba ruspolii* *C. rotundifolia* *Capparis tomentosa*	
		Combretaceae	*Combretum aculeatum Terminalia orbicularis*	
7. *Combretum – Terminalia* Woodland and wooded Grassland	Characteristic species have small to moderate-sized trees with fairly large deciduous leaves	Burseraceae	*Boswellia papyrifera*	It altitude ranges from 500 – 1900 m asl It occurs in the Tekeze valley, western parts of Benshangul- Gumuz and North to the village of Gelego and south of Metema
		Araliaceae	*Cussonia arborea*	
		Combretaceae	*Anogeissus leiocarpa* *Combretum Vitex doniana adenogonium* *C. hartmannianum* (near endemic) *C. mole* *C. rochetianum* (near endemic) *C. collinum, Terminalia laxiflora* *T. macroptera* *T. schimperiana*	
		Fabaceae	*Lonchocarpus laxiflorus* *Pterocarpus lucens* *Dalbergia melanoxylon* *Piliostigma thonningii*	
		Balanitaceae	*Balanites aegyptiaca*	
		Bignoniaceae	*Stereospermum kunthianum*	
		Anacardiaceae	*Lannea barteri*	

Vegetation types	Biological characteristics			Physical characteristics
	Vegetation characteristics	Family	Species	
			L. fruticose	
			L. schimperi and *L. schweinfurthii*	
			Ozoroa insignis, O. pulcherrima	
			Sclerocarya birrea subsp. *Birrea*	
		Lamiaceae	*Vitex doniana*	
		Fabaceae	*Acacia hockii*	
		Tiliaceae	*Grewia mollis*	
		Bombacaceae	*Adansonia digitata*	
8. Wooded Grassland of the Western Gambella Region (WGG)		Fabaceae	*Acacia seyal*	It occurs between 450-500 m asl
			A. nilotica	Dominant vegetation in western Gambella Region.
		Arecaceae	*Hyphaene thebaica*	
			Borassus aethiopum	

A5. **Ethiopia is endowed with substantial aquatic resources in its lakes, reservoirs and rivers with a total area of about 7444 km^2 (0.07% of the country) occupied by water bodies that include 11 major freshwater lakes, nine major alkaline lakes and 12 major wetlands, which together occupy about 1.5-2.0% of the country's landmass**. Growing number of reservoirs have been constructed including the GERD with an area of 1874 km^2 upon attaining full capacity. Fourteen major rivers crisscross the country, which is largely classified as a dryland area despite being the source of major inland and transboundary rivers including the world's longest river (the Nile). A growing number of human-made reservoirs are adding to the surface water storage potential (well-established) {4.1.3, 4.2}.

A6. **The Ethiopian aquatic and wetland ecosystem is a biodiversity hotspot accounting for about 10% of the total floral diversity, providing habitats for about 25% of the avifaunal diversity and diverse megafauna** (well established) {4.2.4}**.** This ecosystem provides key economic and cultural values that enhance the quality of life in addition to the provision of water and land critical for agriculture, albeit the lack of adequate empirical data on number of pollinators and their contribution to the national economy.

A7.The aquatic and wetland ecosystem contributes to improving food security and surplus production so long as sustainable management is made the norm. The services and values that accrue to the people of Ethiopia from this ecosystem play key roles in the cultural manifestations as well as affirmation of beliefs and identity of communities adding to the major material goods, functions and services (well established) { 4.2.1, 4.2.3. The role of wetlands as kidneys for the aquatic system and adjoining drylands with benefits to nature and humanity coupled with their economic and biodiversity potentials are assets yet to be fully understood and recognized in development ventures

A8. **The rangeland ecosystem in Ethiopia occurs widely, holds important biodiversity and provides key ecosystem services through the provision of feed, food, medicine, energy, gum and incense among others; and safeguards environmental health** (well established) {5.2.2, 5.4.1.2, 5.4.2, 5.5.2, 5.5.3}**.** A major resource supplier in this ecosystem is livestock husbandry, which also contributes to soil nutrient cycling but may lead to land degradation and biodiversity loss in the absence of sustainable management. Vegetation in rangelands contributes to carbon storage, climate stability, air and water purification and control of the erosive forces. The habitats, together with the plants and animals, constitute important living sites for large herbivores, carnivores and other wildlife, and also sceneries that are highly valued as tourist attraction centres.

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A9. The rangeland ecosystem has roles of maintaining the social identity, heritage values of the cultural landscapes and provision of nature's spiritual services. Land-use/land cover (LULC) changes in rangelands show the observable substantial changes made since the 1960s. (well established) {5.3.2.2}. Many pastoral areas show increasingly fenced rangelands/grazing enclosures, an evident change in tenure with the growing shift from traditional communal grazing lands to private holding and curtailment of seasonal mobility between wet and dry season grazing areas. These changes led to the loss of vegetation cover aggravating soil erosion in wet season grazing areas. Anthropogenic pressures on rangelands coupled with changing climate have led to the deterioration of the ecosystem, increasing soil erosion, loss of palatable grasses and

legumes, and increased bush encroachment for which watershed management is considered an important option (Figure SPM 5).

Figure SPM 5. Watershed management through the application of biodegradable geotextile for the rehabilitation of degraded land in Lake Tana catchment

A10. The agroecosystem in Ethiopia stretches over 32 major agroclimatic/agroecological zones with diversity in agricultural practices and farming complexes. (established but incomplete) {6.1}. Fourteen distinct production-based agricultural systems, clustered into three major systems (pastoral and agropastoral, cereal/grain crop-based or seed farming-based, perennial crop-based), have varying designations and agrobiodiversity contents and status showing the robustness of the Ethiopian agrobiodiversity resources (Figure SPM 6). They are widely distributed within the agroecological zones providing multiple agroecosystem functions to people and nature.

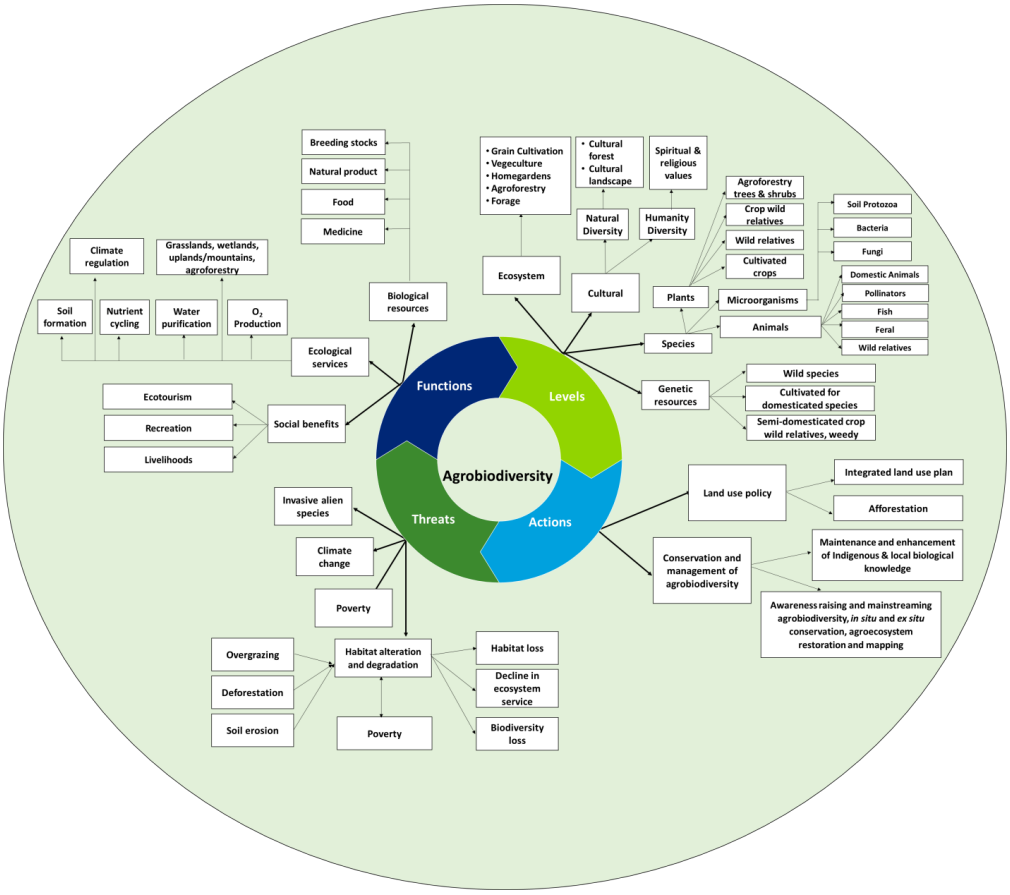


Figure SPM 6. Agroecosystem functions, services, threats and needs as a function of agrobiodiversity

B. Ethiopia's biodiversity and ecosystems face pressures driven by multiple factors

B1. Not enough biodiversity conservation has been done in the forest and woodland ecosystem as well as in mountains, rangelands and wetlands and this is hindering national efforts to halt deforestation and achieve the country's ambitious plan for fast-track sustainable development. (well established) {3.3.1, 3.5.2, 3.7.1, 3.7.2}. Translation of policy and legal provisions relevant to the forest and woodland biodiversity and ecosystem services into implementation instruments through regulations, directives and guidelines needs to be reinforced by actions. Freely accessible, accurate and up-to-date comprehensive legal and spatial information and records about the forest and woodland biodiversity ought to be

maintained centrally at regional and federal levels and this must be enshrined by law. Likewise, the mountain ecosystem has entered a declining phase as manifested by shrinkage of coverage due to on-going human-driven land-use and land cover changes with increasing vulnerability to climate change, further aggravated by increasing livestock populations and encroachment by agriculture and settlement and their interlinkages.

B2. The types of crops cultivated in the different localities of Ethiopia are determined by agroecological conditions of the sites, and cultural preferences of the people living in the areas (well established). For thousands of years, Ethiopian farmers have been engaged in crop domestication and breeding efforts to select species and varieties that adapt to the local climate and meet their needs. However, recent data interpreted as probably being caused by climate change effects shows that the bioclimate envelope model for coffee (*Coffea arabica*) appeared to be shifting to the northwest direction {6.2.1, 6.3.1}. This provides evidence for changes in agroecological conditions including warming on the Ethiopian high altitude areas to which coffee maybe extra sensitive (Figure SPM 7).

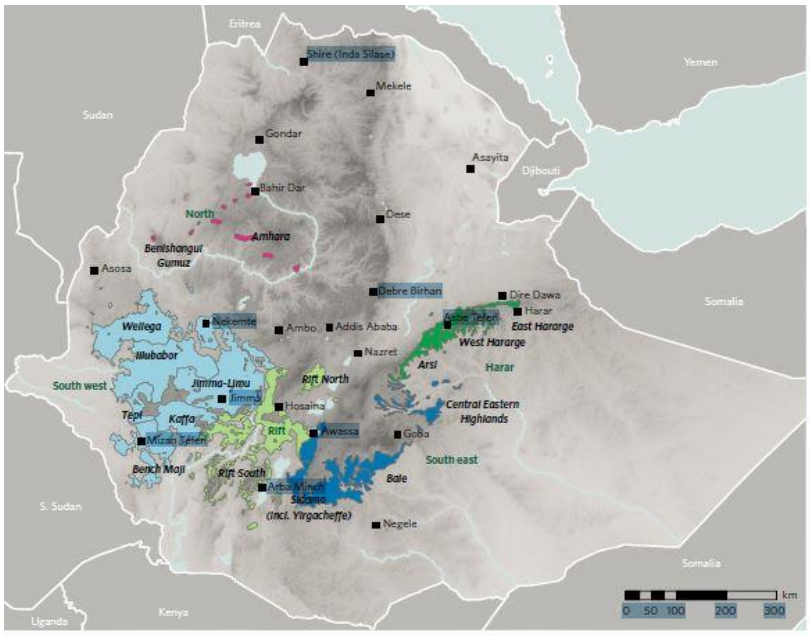


Figure SPM 7. Coffee producing areas expanding northwards in Ethiopia (recent research)

B3. Ethiopia is rapidly losing its natural water bodies and wetlands due to over abstraction, pollution, and changes in land-use and habitats, aggravated by other calamities such as climate change, resulting in water scarcity, increased vulnerability to drought, floods and loss of livelihoods (well established) {4.3.2, 4.4.1, 4.4.2}. The biodiversity of this ecosystem is rapidly declining as the negative impacts threaten the wild flora, fauna and the ILK system. There are growing socio-economic demands to wetland ecosystem services where direct drivers causing resource degradation include over-abstraction, alien or other invasive plants, overgrazing and dominance of non-palatable forage plants (Figure SPM 8) and reducing size of water bodies as illustrated by measuring the trend in spatial extent of Lake Abijata (Figure SPM 9).

Figure SPM 8. Livestock on overgrazed grazing-land

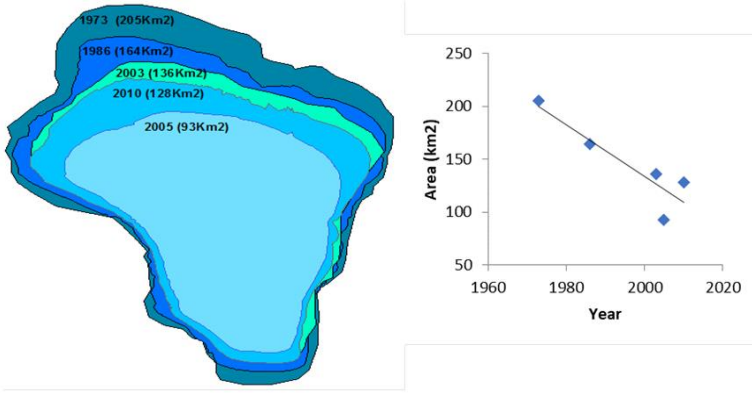


Figure SPM 9. Trend in spatial extent of Lake Abijata

B4**. Low level of public awareness prevails in the face of growing threats to aquatic and wetland areas. The legislative and organizational reforms have played their roles in reducing environmental challenges although their impacts to reverse damages are contested.** (well established) {4.3.2, 4.5.1}. The laws, policies and associated instruments lack implementation tools and practitioners are confronting with unclear and overlapping mandates (established) On the other hand, some issues pertinent to the aquatic and wetland ecosystem are included in policy frameworks of other ecosystems The existing legal instruments are patchy and irregular leading to incomplete implementation, ineffective compliance and enforcement. These instruments are insufficient to protect the aquatic and wetland areas of the country thus calling for further interventions. Ongoing activities geared to developing regulations that help to delineate wetlands, buffer zones and for mounting awareness-raising drives are expected to redress some of the observed gaps.

B5. The shift towards sedentarization, crop cultivation and privatization of communal rangelands trigger conflicts over grazing and water resources with boundary claims (well established) {5.3.2.2}. The major direct drivers of change in biodiversity and ecosystem services of rangelands are climate change and variability, inappropriate extension services and management, land-use changes, overexploitation, privatization and/or sedentarization, bush encroachment and population pressure with constrained mobility. Policy, governance and formal institutions indirectly contribute to the weakening of customary institutions leading to changes in the status of biodiversity and ecosystem services. Continued degradation of the rangeland ecosystem is leading to loss of the associated ILK and is shifting livelihoods. Customary institutions that have traditionally been governing the rangelands are breaking down as government institutions grow to dominance. Government programmes of pastoral areas emphasize poverty reduction and development, focusing on resource extractions for short-term gains. The biophysical, socio-economic and political conditions in recent decades are also threatening the roles and strengths of the traditional institutions and practices.

B6. Lack of clarity in rangeland policy and development direction, limited knowledge and attention to the pastoral ILK and institutions, and prevailing governance systems are causes for degradation linked mainly to inappropriate decision-making and misappropriation of resources (established but incomplete) {5.1, 5.6.4.1, 5.6.5}. There exists no dedicated organization responsible for rangeland development and this is coupled with the absence of a clear policy framework that recognizes and empowers customary institutions and ILK for resource governance, conflict management and other methods of traditional protection applicable to rangelands. This situation has led to the deterioration of biodiversity and ecosystem services of rangelands (Figure SPM 10). The land-use and land cover changes in all the ecosystems (Figure SPM 11) are areas that need attention to evaluate and monitor the magnitude and severity of changes, the drivers causing change and also to chart out the remedial action plans.

Figure SPM 10. Status of vegetation degradation in the Borana rangeland of southern Ethiopia

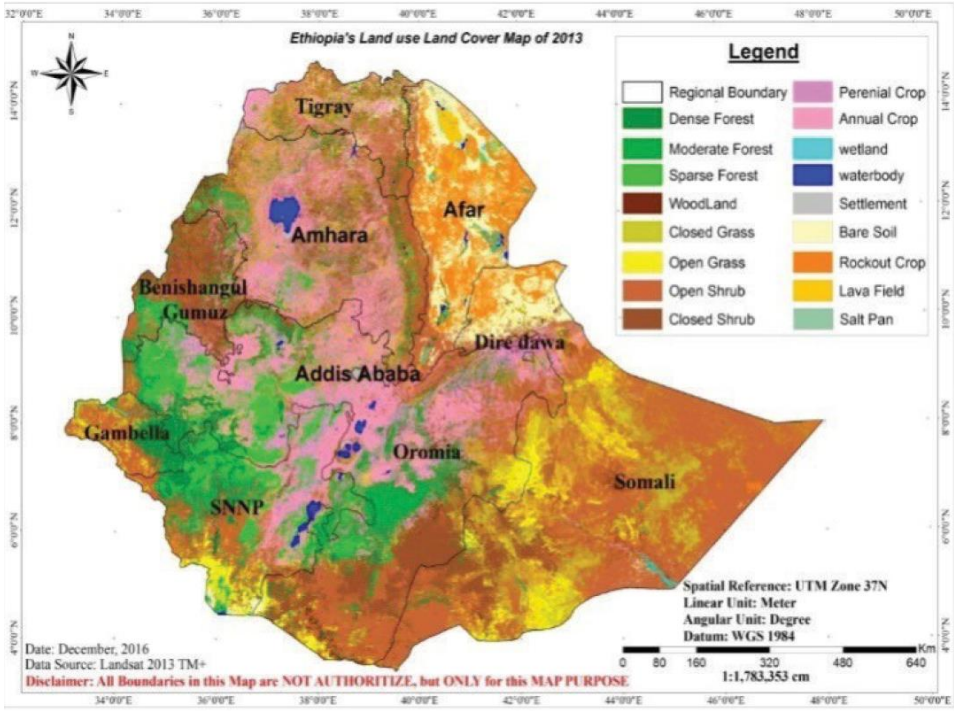


Figure SPM 11. Land-use land-cover of Ethiopia

C. **Comparative advantages (options/opportunities) and knowledge regarding conservation and sustainable utilization of biodiversity and ecosystem services in the light of Ethiopia's richness in biodiversity and associated ILK**

C1. Biodiversity wellbeing and ecosystem health are critical for Ethiopia's growth and transformation framework in agriculture, the Climate Resilient Green Economy Strategy and in rural development and other sectors. Indigenous and local communities living inside and around the Ethiopian mountains and other ecosystems have developed millennia-long rich ILK system on the uses of a variety of plant species for traditional medicine and conservation of biodiversity resources. The National Policy on Biodiversity Conservation and Research and other environmental conservation and sustainable development-related policies and strategies do not pay any special attention to the mountain ecosystem as a unique environment of outstanding ecosystem services (established but incomplete) {2.6, 3.7.1, 4.6, 5.6.4.1, 5.6.5, 6.6.1}. This assessment sends

an important signal to the Ethiopian Biodiversity Institute and all concerned institutions to dispense special consideration to the important biodiversity and ecosystem services of the country's mountains.

C2. **The Ethiopian agroecosystem has various forms of uniqueness as it evolved within a Vavilovian centre of origin and/or diversity of crop and livestock species/varieties and breeds under diverse socio-cultural settings in a biodiversity-rich country that falls within two of the global biodiversity hotspots** (well established) {6.1}. The country has wide and unique agroclimatic regimes (Table SPM 4) providing major ecosystem services that benefit people in Ethiopia and beyond. The agricultural systems are elaborate having been shaped by millennia of perfection of the ILK for sustaining the biophysical, socio-economic and cultural assets of communities. The information provided in this table (Table SPM 4) will allow agroecosystem zone-specific planning of conservation and development and thus useful for policymakers and field implementers.

Table SPM 3. Agroecological zones of Ethiopia placed in the traditional agroclimatic zones with their altitudinal ranges, average annual temperature, rainfall, total area and percentages

Traditional Agroclimatic Zones	Altitude (m.a.s.l)	Mean annual Temperature (^{0}C)	Mean annual rainfall (mm)	Major Agroecological Zone according to Recent Classification (EIAR 2011)		Total area (ha)	Percent-age
				Symbol of AEZ	Name of AEZ		
***Bereha* (hot arid)**	< 500	>27.5	< 300	A1	Hot arid lowland plains	12,202,265	10.79
				SA1	Hot semi-arid lowlands	449,789	0.40
***Kolla* (warm semi-arid)**	500 - 1500	20.0 – 27.5	300-900	A2	Warm arid lowland plains	22,356,361	19.76
				M1	Hot moist lowlands	672,104	0.59
				M2	Warm moist lowlands	17,109,776	15.12
				PH1	Hot per-humid lowlands	13,088	0.01
				SA2	Warm semi-arid lowlands	3,114,607	2.75
				SH1	Hot sub-humid lowlands	1,893,410	1.67
				SM2	Warm sub-moist lowlands	10,890,128	9.63
***Woina dega* (cool sub-**	1500-2300	16.0 - 20.0	900-2200	A3	Tepid arid mid highlands	488,143	0.43
				M3	Tepid moist mid highlands	9,101,288	8.05

Traditional Agroclimatic Zones	Altitude (m.a.s.l)	Mean annual Temperature (^{0}C)	Mean annual rainfall (mm)	Major Agroecological Zone according to Recent Classification (EIAR 2011)		Total area (ha)	Percent-age
				Symbol of AEZ	Name of AEZ		
humid)				H2	Warm humid lowlands	2,592,647	2.29
				H3	Tepid humid mid highlands	3,001,630	2.65
				PH2	Warm per-humid lowlands	765,390	0.68
				PH3	Tepid per-humid mid highland	152,281	0.13
				SA3	Tepid semi-arid mid highlands	218,624	0.19
				SH2	Warm sub-humid lowlands	8,046,859	7.11
				SH3	Tepid sub-humid mid highlands	7,504,025	6.63
				SM1	Hot sub-moist lowlands	637,276	0.56
				SM3	Tepid sub-moist mid highlands	5,850,115	5.17
				SM4	Cool sub-moist mid highlands	1,314,156	1.16
***Dega* (Cool and humid)**	2300-3200	11.5 – 16.0	900-1400	H4	Cool humid mid highlands	926,331	0.82
				M4	Cool moist mid highlands	1,963,109	1.74
				SH4	Cool sub-humid mid highlands	589,049	0.52
				H5	Cold humid sub-afro-alpine to afro- alpine	62,620	0.06
***Wurch* (Cold and moist)**	3200-3700	< 11.5	900-1400	H6	Very cold humid sub-afro-alpine	50,577	0.04
				M5	Cold moist sub-afro-alpine to afro-alpine	78,829	0.07
				M6	Very cold moist sub-afro-alpine to afro-alpine	15,246	0.01
				SH5	Cold sub-humid sub-afro-alpine to afro-alpine	68,815	0.06

Traditional Agroclimatic Zones	Altitude (m.a.s.l)	Mean annual Temperature (^{0}C)	Mean annual rainfall (mm)	Major Agroecological Zone according to Recent Classification (EIAR 2011)		Total area (ha)	Percent-age
				Symbol of AEZ	Name of AEZ		
				SH6	Very cold sub-humid sub-afro to afro- alpine	34,889	0.03
				SM5	Cold sub-moist mid highlands	76,819	0.07
				SM6	Very cold sub-moist highlands	18,021	0.02
Qure or high *Wurch* **(very cold highland)**	>3700	< 11.5	>1400		Very cold sub-moist highlands (usually lumped with *Wurch* and no separate measurements of its own)		
				WB	Water body	870,795	0.77
					Total	113,129,062	100.00

C3.**Crop and livestock varieties/landraces and breeds that are contributing to humanity's welfare are declining and the many wild useful plant species and orphan crops that could improve food security and livelihood systems of the people remain underutilized and vulnerable** (established but incomplete){ 6.3.1, 6.3.2}. In addition to the wide production gaps in some of the major crops, wider knowledge and yield gaps prevail more in the cases of the underutilized species including the orphan crops. There are several orphan crops and uncultivated useful plants that require increased conservation actions. Traditional agricultural practices have built-in agrobiodiversity conservation and livelihood support systems but the time-tested ILK on agroecological farming and polyculture practices are underutilized and underdeveloped. Adequate documentation, valorization and sustainable effective socio-economic and technological transformation efforts are lacking.

C4. **In recent decades, an increasing level of awareness and knowledge about contributions, status and management of agrobiodiversity and agroecosystem services is observed** (established but incomplete) {6.5.4}. The government of Ethiopia has demonstrated commitment to agrobiodiversity conservation for better agroecosystem services through institutional capacity building and funding but more is needed to enhance the use of climate-smart ILK relevant to agriculture and the ecological processes at all levels given the prevailing gaps *(established but incomplete)* {6.5.2, 6.5.3}. Ethiopia has awareness-raising and education programmes, policies and planning frameworks that support conservation and sustainable management of agrobiodiversity and agroecosystem services. These are undertaken through mainstreaming agrobiodiversity and engaging local communities and farmers to enhance agrobiodiversity-enriched farming. Awareness raising and generation of knowledge need to focus on the trade-offs between the provision of material goods and non-material ecosystem services. Gradual increase of community participation in agrobiodiversity management is noticeable but the need to develop and implement new approaches that recognize and work with farmer conservators on documentation, valorization and incorporation of ILK is highly in demand.

D. **Biodiversity wellbeing and healthy ecosystems are key for Ethiopia's growth and transformation drive**

Ethiopia has been attempting to implement ambitious plans and initiatives (The Growth and Transformation Plan earlier, and the Ten-Years Perspective Plan currently, Climate Resilient Green Economy Strategy, the Home-grown Economic Reform Programme) with implications to biodiversity and ecosystem services; and the ideas put forward in this assessment will be useful for their proper implementation without compromising the biodiversity resource base.

D1. **Implementation of policies and laws related to biodiversity and environments can help to minimize pressures on ecosystems and enhance and improve their wellbeing and contributions.**

D2. **The effectiveness of the national growth and transformation plans need relevant policies and clear action plans that pertain to each of the assessed ecosystem and clear implementation guidelines targeting each ecosystem and its sub-types.**

E. **Policies and strategies need to be put in place to meet national, regional and global targets to work towards the desired common future**

E1. The Ethiopian government has long realized the importance of forests and woodlands as demonstrated by designation and safeguarding of a protected area system, though most of the protected areas are under huge pressure due to inadequate protection, partly because most of them are viewed by some affiliated authorities as areas set aside for the protection of game and associated wild animals (well established, incomplete) {3.1, 3.2.1, 3.6.1}. Direct and indirect anthropogenic and natural causes and drivers negatively impact the biodiversity and the services of this ecosystem. If the current trend is left unchecked, the biodiversity of the country's relatively pristine environments of the forests and woodlands will indisputably continue to decline and the associated livelihood systems will further deteriorate. Introduction and promotion of environmental marketing schemes that involve water, biodiversity, carbon and other resources as well as valorization of new forest products will be critical to enhancing forest and woodland conservation and sustainable utilization.

E2. **Policies and institutional arrangements relevant to biodiversity and ecosystem services of the forest and woodland ecosystem and their impacts show a huge gap between policy design and implementation on the one hand and legal frameworks on the other** (established but incomplete) {3.3.1, 3.5.2, 3.7.1,3.7.2}. Efforts made so far have focused on developing policies and strategies while little has been done on strengthening institutional arrangements, implementation at field levels and enforcement of laws. Frequent shifting of institutional mandates and working relations need to be minimized for stability and deliverance of outputs.

E3. The rangeland sector needs strong institutional stature or alignment with the most relevant and mandated ministry (established but incomplete) {5.6.7}. Adequate research evaluating the effectiveness of policies, governance systems and institutional settings that can harmonize government plans with the interests of pastoral communities need to be put in place. The challenges could be addressed through the provision of training, awareness-raising, implementation of outreach programmes, developing knowledge management system suitable for diverse stakeholders. Research undertakings related to biodiversity and ecosystem services where consideration of the knowhow on payment for ecosystem services (PES) that would engage and empower local communities need to be designed. The evolution of a pastoral-friendly rangeland policy can pave the way towards building resilient livelihoods while maintaining the cultural, historical and economic characteristics of the system. A clear pastoral land tenure system and land-use policy frameworks are necessary to sustain the productivity and viability of this ecosystem.

E4. The agroecosystem, which is of critical role in the wellbeing of Ethiopians, is threatened by natural and anthropogenic drivers resulting in the loss of agrobiodiversity and essential ecosystem services (well established) {6.4.1, 6.4.2}. Elements of climate change, recurrent droughts, floods and invasive alien species add to vulnerability of the agroecosystem in Ethiopia. Overexploitation of soil and water resources further compounded by acidification and salt accumulation heighten Ethiopia's major challenges in food production and productivity and efforts to reduce poverty, maximize agroecosystem services and maintain healthy human ecology and socio-economic wellbeing.

E5. **Ethiopia has put in place a number of polices and planning frameworks that slowly better support the conservation and sustainable management of biodiversity and agroecosystem services** (established but incomplete) {6.6.1} The National Biodiversity Strategy and Action Plan (NBSAP) 2015-2020 is an overarching framework on biodiversity for all stakeholders to value biodiversity and ecosystem services, reduce the pressures on biodiversity and ecosystems, improve the status of biodiversity and ecosystem services, and ensure access to genetic resources and fair and equitable sharing of benefits arising from their use. Seed policy, Plant Breeders Right and Access to Genetic Resources and Community

Knowledge, and Community Rights are also typical governance mechanisms for the generation and distribution of agrobiodiversity through market and non-market practices (Figure SPM 12), as well as combined traditional and new cultural practices.

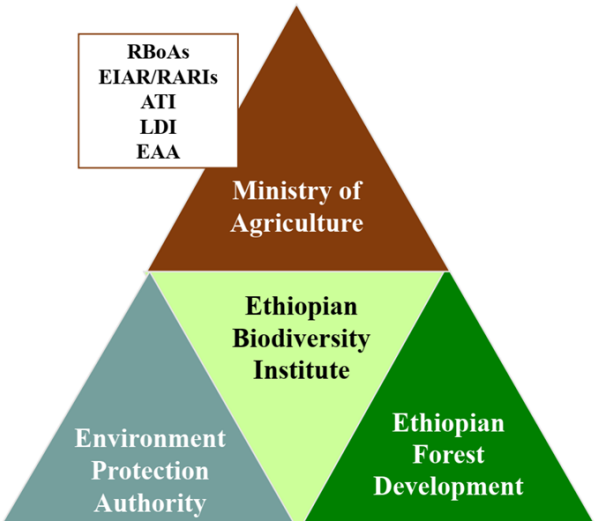


Figure SPM 12. Institutional arrangements for agroecosystem protection and management (ATI: Agricultural Transformation Institute, EIAR: Ethiopian Institute of Agricultural Research, RARIs: Regional Agricultural Research Institutes, RBoAs: Regional Bureaus of Agriculture, LDI: Livestock Development Institute, EAA: Ethiopia Agriculture Authority)

3. Analysis of drivers of change, trends in biodiversity & ecosystems and goods and services

The Ethiopian National Ecosystem Assessment was initiated with the aims to developing an up-to-date critical synthesis of knowledge on biodiversity and ecosystem services and the linkages with people and to address the country's needs for intervention of specific policy questions. As part of the assessment, analyses of scenarios was undertaken to get insights about plausible future developments and strategic decision lines and actions thereof. Scenario analysis is an important tool for exploring alternative futures in socioeconomic and socio-political pathways, trends in major drivers of change in ecosystems and the consequent long-term impacts on biodiversity, ecosystem services and human wellbeing. The scenario analysis undertaken is

mostly based on information from the assessments given in the five ecosystems, the review of available literature and collective/group expert judgment as described in the framework below.

4. A framework for scenario analysis

Scenario analysis has already become a standard procedure and a recommended practice in ecosystem assessments. Outcomes of scenario analysis can lead to the evolution of new policies, strategies and actions and can further guide the development of a comprehensive roadmap for Ethiopian ecosystems and ecosystem services. These analyses can be used to concretize issues and engage on science informed strategic plans and actions. The policies to be developed must target the major changes, drivers of changes and the trends in biodiversity and services rendered by ecosystems. The environmental crisis, the recurrent drought, the climate variability, the food insecurity dilemma that Ethiopia experienced in the past as well as the national, regional and global significance of the Ethiopian ecoregion and its highly valued biodiversity and genetic resources including the endemic and rare taxa and the highly valued genetic resources entrenched in its local domesticates including coffee (*Coffea arabica*), *Teff* (*Eragrostis tef*), *Enset* (*Ensete ventricosum*) and many farmers' varieties/landraces of major crops and breeds of livestock strongly justify the urgency of such an increased attention.

Scenario archetypes are important policy instruments to guide informed decision making. They are neither predictions nor projections of indicators but plausible futures formulated from expert assumptions on the future directions of the drivers of change being dependent on existing literature knowledge. Scenario archetypes provide the opportunity to organize and synthesize the pool of diverse information from scenarios and modelling studies of future projections on direct and indirect drivers of changes in biodiversity and ecosystems. Scenario archetypes are group of scenarios defined by specific assumptions, storylines and characteristics on drivers that determine plausible future outcomes. Past studies on scenarios and modelling works are important inputs. However, in these assessments, except for climate projections and land-use/land cover changes, scenario studies are very much limited mainly because modelling works on future dynamics of biodiversity and ecosystems in Ethiopia are scanty.

It is only recently that local-scale modelling of habitat quality change and ecosystem services change started to appear in the literature. Except on few of the known species of plants and animals, the impact of the direct and indirect drivers on the flora and fauna of the majority of the ecosystems are lacking. Scenario analysis on the vegetation, climate, population dynamics, land-use/land cover changes are not readily available for most ecosystems. National scale scenario analysis results are rarely found in the literature. Expert knowledge on the application of scenario modelling, spatial and multi-temporal projections and understanding of the global and regional scenario groups is essential for building scenario archetypes. Generally, there is limited knowledge on the future projections of key drivers of change in biodiversity and ecosystems, on the future dynamics of ecosystems, on the extent of the loss of biodiversity in most ecosystems and on the ecosystem goods and services.

Thus, an expert-driven exploratory scenario development approach was adopted as it was considered suitable since the objective is to find how the direct and indirect drivers of change will shape the future biodiversity and ecosystem services in the country. To this end, a 'what if' approach was motivated and changes in biodiversity and ecosystem services under different projected futures of nature and society interactions were scrutinized. The impacts of the drivers on biodiversity and ecosystem services under the different scenarios are summarized considering some key guiding questions (described under five scenario archetypes) and these refer to the trends in socioeconomic development over the past few decades; the food first plan that aims at fast economic growth and improving the living standards; the green growth path across all sectors of the economy; socioeconomic and policy reforms in the country and the possible effects of the increasing trends towards regional integration. Scenario archetypes are groups of general patterns of future developments that help to summarize and harmonize large amount of information in individual sets of scenarios. This approach is being widely applied in assessments at global, regional and national scales.

The archetype considered suitable for defining the Ethiopian situation are the business-as-usual, food first fast track economic growth, the green growth, policy reform and regional integration models. The scenario archetypes and the storylines exhibit different assumptions and plausible futures on the drivers of change in biodiversity and ecosystem services. The expected outcomes

under the five scenario archetypes are discussed considering the drivers of change, biodiversity and ecosystems and ecosystem goods and services. The link between scenario archetypes, the underlying factors, indirect and direct drivers and the cause and impact relationships, as they apply to scenario analysis of trends in biodiversity and ecosystem services, are schematically shown in Figure SPM 13; and detailed impacts of these factors are summarized in Box SPM 2.

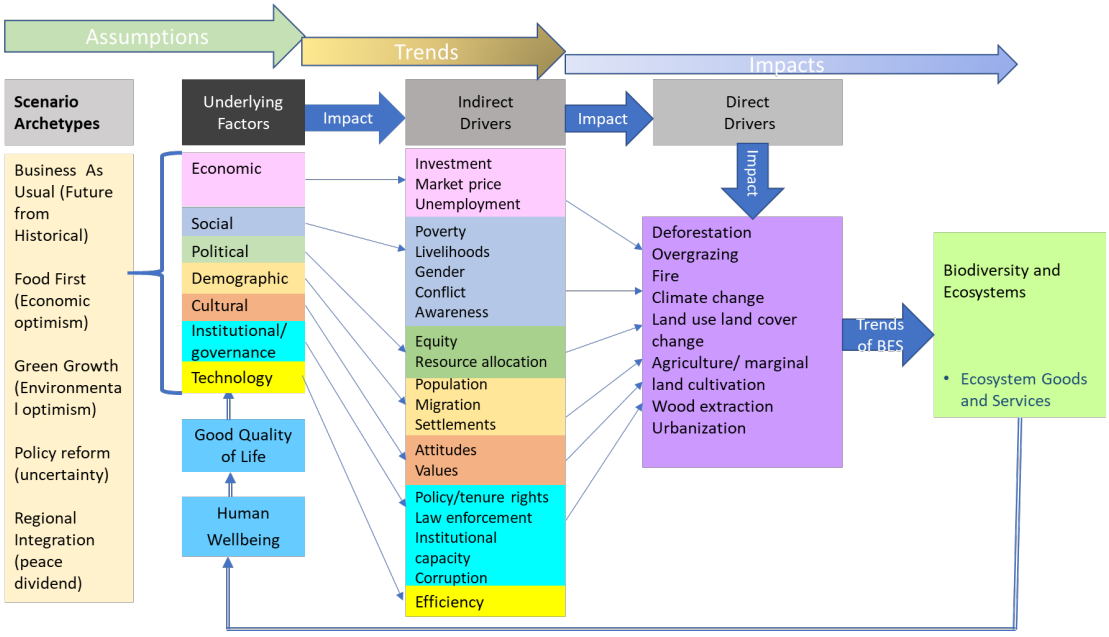


Figure SPM 13. A conceptual framework for the analysis of scenarios (plausible futures) on biodiversity and ecosystem services in Ethiopia

5. Drivers of change under the five scenario archetypes

Biodiversity and ecosystem services in Ethiopia are impacted by a multitude of drivers of change and the scenario analysis helped to categorically identify many of them grouped into underlying factors, indirect and direct drivers with their impacts and relationships (Figure SPM 13). The major drivers of changes discussed in details are population, urbanization (settlements), land-use/land cover change, economic policy and institutions and climate change. Scenario analysis based on ecosystem assessment outcomes and expert judgment generated plausible future trends in the direct and indirect drivers of change in biodiversity and ecosystem services; and the possible changes anticipated in each scenario archetype are examined. Population is an indirect

driver and continues to increase without the influence of the scenario archetypes and will rapidly grow in the business-as-usual scenario because of the pervasive poverty and its catalytic effect. In the rest of the scenarios, population will take a path of steady growth. Urbanization is projected to show a sharp rise in the business-as-usual and food first scenarios mainly because of the uncontrolled rural-urban migration. Although green growth *per se* does not promote urbanization, economic progress and adherence to environmental standards may lead to sprouting of urban centers. Land-use/land cover change continues unabated in the business-as-usual, food first and policy reform scenarios as a combined effect of increasing population, agricultural expansion and urbanization. The regional integration scenario may not necessarily drive or slowdown land-use/land cover change at national and regional levels. The green growth scenario will positively drive nature conservation, strict implementation of policies and laws, land restoration and afforestation/reforestation of barren/abandoned lands. Increasing growth in urban green networks, nature reserves, protected areas are positive land-use changes implicating positive future impacts. This leads to positive contribution to climate change as it reduces greenhouse gases emissions and maximizes sequestration. Policies and institutions under the business-as-usual, food first and policy reform scenarios are weak, not observed and not implemented, and hence a negative decline is imagined and the same trend looms for climate change. In the green growth scenario, the reverse holds true and hence, a positive increase in policy implementation and in greenhouse gases emission reduction. The role of regional integration on climate change remains grey for research.

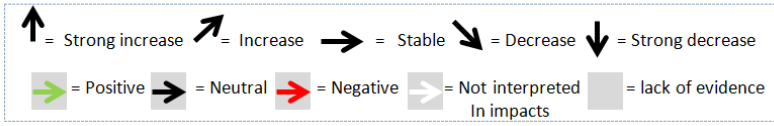
Each of the five major drivers listed above were examined under the five scenario archetypes (business-as-usual, the food first, the green growth, the policy reform and regional integration options) and their corresponding changes and possible effects on biodiversity and ecosystem services elaborated. Under each scenario, each driver of change has and will impact biodiversity and ecosystems and the ecosystem goods and services. If socioeconomic development trends that went on in Ethiopia over the past few decades (business-as-usual) continue into the future, the drivers of change will continue operating and biodiversity resources and ecosystem services will further decline. If fast economic growth that focuses on food first and food self-sufficiency aimed at improving the living standards of the population is prioritized, drivers of change will go on operating in the same way and the major ecosystems will continue to decline further in area

coverage, biodiversity and ecosystem services. If the green growth replaces the business-as-usual modality, the drivers will be managed and the biodiversity and ecosystems will be conserved and services thereof maintained. The provisioning services such as food and fibre will increase and food security will be ensured at the national as well as the household levels. This will likely lead to increased local production and improved access to food through purchases as household income increases and other ecosystem service go into the restoration phase. The food first and the policy reform pathways will not be able to manage the drivers resulting in the decline of biodiversity and ecosystem services while regional integration may control some of the drivers and improve the situation with biodiversity and ecosystems.

Most drivers are likely to have negative impacts under most of the scenarios while a few have positive influences. Ethiopia's population has increased steadily over the years and if left to continue, the total projected figure is expected to exceed 205 million by 2050. With this huge population, land-use change, urbanization, climate change and other factors will act together and biodiversity and ecosystems and their services to people are bound to suffer. Under the business-as-usual and the food first scenario archetypes, the effects of urbanization, land-use/land cover change and climate change as well as population growth and economic policies and institutions, to limited extents, are likely to amplify and result in negative impacts. All the drivers of change are likely to have positive effects on biodiversity and ecosystem services under the green growth path and relatively similar trends can be expected under the regional integration archetype. The green growth path and the business-as-usual are on the extreme ends of the scale as the former can address the drivers effectively but the latter fails short of proper response. The trend analysis output of drivers of change under the five scenario archetypes is presented in Table SPM 3.

Table SPM 4. Trends in drivers (indirect and direct) of biodiversity and ecosystem services and the changes anticipated under each plausible scenario archetype

Scenario archetypes	Drivers of Change in BES				
	Population growth	Urbanization (Settlements)	Land Use Land Cover Change	Policies and institutions	Climate change
Business as usual (Future from Historical)	↑	↑	↗	↘	↗
Food first (Economic optimism)	↗	↑	↗	↘	↗
Green Growth (Environmental optimism)	↗	↗	↗	↑	↗
Policy Reform (unstable economy)	↗	↗	↑	↓	↑
Regional Integration	→	↗	→	↗	



Box SPM 2: Drivers of change on biodiversity and ecosystem services under the five scenario archetypes

Ethiopia's **population** has been increasing steadily over the years emerging as the second most populous country in Africa, currently estimated to around 114 million and projected to 160 million by 2035 and may exceed 205 million by 2050. Increase in population size suggests declining trends in per capita availability of arable land, grazing land, potable water since more people require more resources. Forests and other habitats will be disturbed or destroyed to construct homes and settlements including towns, businesses and roads for domestic energy production to accommodate needs of the growing population. As population increases, more land is used for agricultural activities to grow crops and support livestock and decline in species and the number of wild animals may lead to extinction as human expansion encroaches into their habitats and limits their mobility and geographic spread and serious implications to biodiversity and ecosystem services.

The level of **urbanization** in Ethiopia is low, as the least urbanized country in of sub-Saharan Africa, but the rate of urban population increase is relatively high being projected to constitute about 22.8% of the total population by 2022 being driven by natural growth, rural to urban migration (0expected to rise) and emergence of new towns. Job creation in urban areas lifts the pressure exerted on natural resources, the environment and biodiversity in the rural landscapes. Urbanization impacts biodiversity and ecosystem services both directly (habitat loss and degradation, modified land cover and other physical transformations) and indirectly (changes in water and nutrient availability, increases in water and air pollution, and increases in competition from non-native species). The most evidently affected ecosystem service by the expanding urban centres is the regulatory hydrological service and pollutants may drive away some biodiversity and modify ecosystems. Urban expansion may have both negative and positive impacts on biodiversity and ecosystem services.

The greatest driver of declines in nature and biodiversity is **land-use/land cover change** affecting biodiversity, the functioning of ecosystems and the services they provide. The major form of global land-use/land cover change is agricultural expansion for cropping, plantations, and animal rearing, which results in loss of biodiversity and declining ecosystem services. This driver alters types and magnitude of ecosystem services provided being varied for different ecosystems. Forests provide higher services in terms of habitat for species, timber production, carbon stock and water regulation than croplands. Wetlands provide higher services of water provision and regulation than croplands and grazing lands. Land-use/land cover change therefore causes gains in some ecosystem services and losses in others. This suggests that trade-off and synergies exist between different services associated with land-use/land cover changes. Provision of one ecosystem service gets reduced as a consequence of increased use of another ecosystem service as when forests or grasslands are converted into farmland, the provision of food will increase while capacity for carbon sequestration will reduce. Synergy may occur when two ecosystem services are enhanced as in hydrological regulation by forests reduces sediment load of runoff. The pattern of land-use change observed in Ethiopia over the past decades is a decrease in forest cover, wetland areas and grazing lands and increase in cultivated lands and settlements

Economic policy and institutions are major underlying drivers of change in biodiversity and ecosystem services and their collective root causes are economic growth, markets, technology and governance. Economic growth

generates negative externalities in the form of habitat destruction and environmental pollution and in turn, degradation of biodiversity and ecosystem services. Higher rates of economic growth are generally associated with greater biodiversity decline as individuals, companies and governments tend to use biodiversity in an unsustainable manner. Governance is an important factor in biodiversity loss expressed in terms of political will, the quality of relevant policies and legislation and organizational capacities for biodiversity conservation. Biodiversity loss increases where biodiversity policy goals are unclear, legal frameworks are inadequate, law enforcement activities are weak, involvement of stakeholders in biodiversity conservation is absent or inadequate and a general lack of commitment to sustainable management exists. Ethiopia has several policies, legislation, standards and plans that are relevant for biodiversity conservation and works with development partners.

Climate change is a possible driver of biodiversity and ecosystem services in Ethiopia as evidence of increase in mean annual temperature by about 0.28°C per decade over the last 40-50 years indicates. Ethiopia is one of the most vulnerable countries to the adverse impacts of climate change. By most measures, exposure and sensitivity are high and adaptive capacity is low in Ethiopia and this is attributable to the ecological setting and level of socioeconomic development of the country. High natural climate variability, a large highland area with rugged terrain and steep slopes, and a vast lowland area with arid, semi-arid, and dry sub-humid climates characterize Ethiopia. The major areas of concern for Ethiopia are human health, agriculture, food security, water resources, energy and infrastructure. The cumulative effect of the multidimensional impacts of climate change is loss of biodiversity and ecosystem services, which are vitally important for human wellbeing.

6. Biodiversity and ecosystems under the five scenario archetypes

Ethiopia has embarked upon fundamental economic, socio-political and institutional reforms since 2018 pursuing home-grown economic reforms and conducted macro-economic changes including major fiscal and monetary policies. The Growth and Transformation Plan has been replaced with the ten-year development perspective plan. These reforms helped to negotiate with international lenders on debt restructuring and other options. Trade laws, electoral laws, penal laws, civil society and terrorism prevention laws have been either revised or replaced. The reform has helped to reshape both the social and economic landscapes. To the broader mass, an increased level of economic and political optimism was created. However, the reform did not go without snags as some small differences grew to conflicts ending up dislocating people. The overall impacts of the witnessed recent developments on the environment will linger for several years to come and the social strain may diminish the efforts to arrest natural resource degradation. The rural low-income population would likely resort to natural resources for immediate needs and to sustain livelihoods unless corrective measures are taken quickly.

Rehabilitation and reconstruction efforts will demand use of available natural resources, particularly forest resources aggravating negative consequences of land-use/land cover change. Table SPM 5 indicates that only the green growth scenario has an upward direction for biodiversity and ecosystem services while downward trend for all the others. Strategies and action plans focused to these problems and gaps in knowledge and research need to be considered among the top priority engagements to minimize the challenges.

Trends of changes in the five broad ecosystem categories of Ethiopia (Mountain, Forest and woodland, Aquatic and wetland, Rangeland and Agroecosystem) have been analyzed under the five scenario archetypes. As indicated by the analysis, under the green growth scenario improvements in the status of the five ecosystems and biodiversity therein has been envisaged; while in the other scenario archetypes a declining trend has been visualized in all the ecosystems. The details on the expected status of biodiversity and ecosystems under the scenario archetypes are summarized in Box SPM 3.

Table SPM 5. Changes in biodiversity and ecosystems under the five scenario archetypes

Ecosystems	Scenario Archetypes									
	Business As Usual		Food First		Green Growth		Policy Reform		Regional Integration	
	Biodiversity	Ecosystem services	Biodiversity	Ecosystem services	Biodiversity	Ecosystem services	Biodiversity	Ecosystem services	Biodiversity	Ecosystem services
Mountain	↘	↘	↘	↘	↗	↗	↘	↘		
Forest & Woodland	↘	↘	↘	↘	↗	↗	↘	↘	↕	↕
Aquatic and wetland	↘	↘	↘	↘	→	↗	↘	↘		
Rangeland	↘	↘	↘	↘	→	↗	↘	↘	→	→
Agrocosystem	↘	↘	↕	↕		↗	↘	↘	↕	↕

↗ = Increase ↘ = Decrease → = Stable ↕ = Variable = lack of evidence

Box SPM 3: Biodiversity and ecosystem change under the five scenario archetypes

Under the **business-as-usual** scenario or viewing the future from historical stance, it is projected that the loss of biodiversity resources and ecosystem services is bound to be significant in Ethiopia's future (Table SPM 5). The current climate variability is likely to increase in intensity and frequency of extreme events affecting fragile ecosystems in the dry lowlands such as the low potential cereal cropping agroecosystem sub-type. Population growth would likely continue as the main driver of land-use/land cover change and urbanization would likewise increase. The protected areas will continue to be encroached by local communities in response to the growing shortage of cultivable and grazing lands.

The **food first** or the rapid economic growth model that targets food self-sufficiency driven by investments in all economic sectors by the private sector and public-sector investments. This brings weak conservation policy implementation and enforcement of environmental protection laws where the utilitarian view of nature dominates over the environmental. The economic growth scenario shares many features of the business-as-usual model but different in the extent of focus on economic growth for food self-sufficiency and job creation where self-reliance is prioritized over other values and agriculture will expand to cultivable areas and a significant proportion of the total production will come from large scale commercial agriculture. This leaves long-term environmental sustainability to the background leading to biodiversity and ecosystems decline while water and air pollution emerge as major problems in urban areas and greenhouse gases emissions increase.

The **green growth** scenario assumes Ethiopia will successfully follow a growth path as outlined in the current national climate resilient green economy strategy, which aims at achieving net zero emissions through interlinked approaches of reducing emissions of greenhouse gases and enhancing carbon sinks. Climate resilience strategies are under implementation for agriculture, forestry, water and energy with a national adaptation plan. Sustainable land management, mass mobilization for watershed management of soil and water conserve are underway. The 'green legacy' initiative contributed to planting of billions of trees across the country and is growing to an annual activity. The country aims for land degradation neutrality in line with the global goal to restore 350 million hectares of degraded and deforested landscapes by 2030. Public awareness on ecosystem services will be lifted as management becomes a continuous engagement and environmental issues get covered in school curricula and society recognizes biodiversity and ecosystems as providers of irreplaceable services to generations.

The **policy reform** scenario may likely be associated with high level of uncertainty and compromised implementation of the rule of law, which makes enforcement of environmental laws, pollution control and regulatory measures loose. Environmental decline in major ecosystems lead to negative impacts on biodiversity resources. Forest, mountain and wetland ecosystems will suffer the most.

7. Ecosystem good and services under the five scenario archetypes

Ecosystems are the sources of freshwater, food and fibre, energy and timber, medicinal organisms and ornamental materials that are vital to human wellbeing. These are the material services provided by nature from ecosystems and known as ecosystem services. The four ecosystem services (provisioning; regulating; supporting and cultural) are visualized under the five scenario archetypes (Table SPM 6), which showed declining trends in all cases except the green growth model where an upward trend is shown but an irregular trend in the case of regional integration. Ecosystem goods and services, considering each of the four types, are summarized in some details under the five scenario archetypes in Box SPM 4.

Table SPM 6. Changes in ecosystem goods and services under five scenarios

Ecosystem goods and service (material, regulating and non-material services)		Scenario archetypes				
		Business as usual	Food First	Green Growth	Policy Reform	Regional Integration
Provisioning services	Food/feed/fiber	↘	↗	↗	↘	↘
	Fresh Water	↘	↘	↗	↘	↘
	Energy/fuel/timber	↘	↘	↗	↘	↗
	Medicine/Ornamental	↘	↘	↗	↘	
	Genetic/ variety	↘	↘	→	↘	◆
Regulating Services	Climate	↘	→	↗	↘	↗
	Air quality	↘	→	↗	↘	→
	Erosion control	↘	↘	↗	↘	
	Water flow	↘	↕	↗	↘	↘
	Natural hazard control	↕	↕	↗		
Supporting services	Material cycle (nutrient, water)	↘	↘	↗	→	
	Soil formation and retention	↘	→	↗	↘	
	Biomass production (NPP)	↘	↗	↗	↘	↗
	Habitat for flora and fauna	↘	↘	↗	↘	↗
	Production of oxygen	↘	↕	↗		
Cultural services	Spiritual/ religious	→	→	↗	→	→
	Aesthetic/ scenic	↘	↘	↗	↘	↗
	Educational/ ILK	↘	↕	◆	↘	
	Heritage/ Historical/ diversity	↘	→	◆	→	↗
	Recreational/ Eco-Tourism	↘	→	↗	↘	↗

↗ = Increase ↘ = Decrease → = Stable ↕ = Variable = lack of evidence

Box SPM 4: Ecosystem goods and services (provisioning, regulating, supporting & cultural) under the five scenario archetypes

The **business-as-usual** scenario is characterized by continued population growth, variable and slow-growing agricultural production, slow growth in industrial production, rapid and unplanned urbanization mainly driven by push factors from rural areas, high exposure and sensitivity to climate change, and weak capacity to coordinate and enforce environmental policies and laws of the country. Poverty and food insecurity remain major socioeconomic challenges that lead to biodiversity and ecosystem decline and per capita availability of environmental resources. The effects of the scenario on the provisioning services of ecosystems are reduced per capita availability of agricultural land, fresh water resource, wood and increased rarity of medicinal organisms. Population growth and climate change are the key drivers causing decline in the provisioning services under this scenario, while poor implementation of policies and laws or absence of policies like land-use policy add to the problem.

The **food first** scenario would likely ensure food security at the national and household levels due to anticipated increase of local production and improved access. Demand for resources such as water increases for the rising population and for the agricultural, industrial, urban and domestic uses. The rapid economic growth and urbanization may lead to pollution of water and ambient air. Expansion of large scale irrigated agriculture particularly in the lowlands may negatively affect pastoral livelihood systems. Indigenous knowledge and practices become marginalized or even lost. A 'grow first and clean up later' attitude by the state to environmental sustainability contributes to declines in genetic variety and replacement of indigenous species and landraces by improved varieties and monocultures, change in ornamental materials provision is indeterminable, availability of medicinal organisms declines due to conversion of the natural landscape into a human-managed one.

In the **green growth** path, environmental sustainability will always assume an important national priority position and hence all environment-related policies, strategies and programmes are effectively implemented leading to the achievement of policy goals and targets. The country is expected to meet the net zero emission and the land degradation neutrality objectives, and climate change impacts will be mitigated through nature-based solutions and other adaptation measures. Sustainable intensification of agricultural production, meeting increased food demands, energy needs will be fulfilled primarily from the renewable sources of hydropower, wind, solar and geothermal sources as the country's vast potential will have been developed. This path will enhance availability of the provisioning ecosystem services of food, feed, freshwater, energy and medicinal/ornamental materials, and thus trends will be upward maintaining a stable pool of genetic variety.

The **policy reform** scenario will speed up loss of provisioning services and uncertainty may not bring sustained peace thus leading to declining accountability with compromised implementation of the rule of law. This will lead to unmanaged urban expansion, rising conversion of natural ecosystems into managed landscapes. Species with medicinal values and the wild gene reserves will diminish with the destruction of the natural ecosystems decreasing the supply of timber and fuel wood. Shifting to use of crop residue and cow dung for fuel compromises nutrient return and further reduces yield. Economic stagnation reduces investment on sustainable land management and the agroecosystem loses its production potential through increased erosion, nutrient mining and invasive species.

Expansive agriculture undermines the role of critical catchments as sources of fresh water.

Under the **business-as-usual** scenario, the regulating ecosystem services (regulation of climate, air quality, water flow, soil erosion, natural hazards and pollination functions) will be compromised by population growth, dependence on small scale agriculture, urbanization, climate change and weak enforcement of environmental policies and laws with limited spatial coverage of sustainable biodiversity and ecosystem management practices. Thus, there would be reduced carbon storage capacity, air quality and climate regulation due to land-use/land cover change, deforestation, expansion of small scale agriculture into marginal areas, cultivation of wetlands and overgrazing in rangeland ecosystem.

The **food first** scenario leads to the decline in the regulating services of ecosystems because the over-riding national priority is economic growth to ensure food security, job creation, poverty elimination and transition to the middle-income group. The 'grow now and clean up later' attitude will relegate environmental sustainability issues as secondary to economic growth. Agriculture expands into higher elevations at the expense of natural vegetative covers as increasing temperature shifts limit crop cultivation. Inorganic fertilizer and herbicide applications will increase.

The **green growth** is in favour of the regulating services of ecosystems with areas under forest and tree cover increasing, protected areas and rangelands sustainably managed, sustainable land management is adopted throughout the agroecosystem, and dairy and ranch farming use modern technologies and management practices. Commercial agriculture adheres to strict environmental standards. The guiding principle for agriculture in general is sustainable intensification of production systems. Effective agricultural management enhances carbon sequestration through soil conservation, or by introducing trees as agroforestry systems.

The **policy reform** modality leads to absence of stable economy under which ecosystems and their functions are heavily disturbed due to increased degree of anthropogenic pressure. The regulating services are hampered in this scenario by carbon release, deforestation and habitat modifications that increase release of greenhouse gases and induce changes in micro-climates. Biological activities of micro-fauna will be interrupted minimizing the climate regulating role. The air and water infiltration role of ecosystems is weakened from poor management of liquid and solid wastes. Reduced investment on sustainable land management in upper catchments disrupts water flow and causes downstream flooding.

The **business-as-usual** scenario will produce negative effects on all supporting services. Expansion of agriculture to marginal lands continues to drive deforestation and soil degradation in major ecosystems. Land degradation, biodiversity loss, habitat fragmentation and climate change remain major challenges to cause declines in the habitat provisioning, biomass production, soil formation, and nutrient cycling services of ecosystems. The water cycling service is affected by the change in land use land cover of watersheds; surface runoff increases, transpiration and infiltration decrease, and seasonality of stream flows and groundwater levels increase. The production of atmospheric oxygen through photosynthesis, which is an important supporting service, is negatively affected by the reduced forest and tree cover and urban expansion, although the human impact is over an extremely long time and at

the global scale.

The overriding policy priority under the **food first** scenario is economic growth, which is expected to put the country in the group of middle-income countries, food security being ensured, agricultural production significantly increased with expansion of cultivated lands into the highland and lowland areas with use of yield-enhancing modern inputs and the industrial sector becoming a major employer. As the focus is on economic growth, unsustainable exploitation of environmental resources shall prevail and deterioration in diversity and richness of biodiversity, natural vegetation cover, and water and air quality. The different supporting services of ecosystems are affected differently as biomass production increases, habitat provisioning and water and nutrient cycling functions get reduced, while the changes in production of oxygen and soil formation remain variable.

The supporting services are enhanced under the **green growth** storyline where policies and plans for environmental sustainability in general and conservation of biodiversity and ecosystems in particular will be effectively implemented. Significant increase in area coverage of forests, agroforestry systems, protected areas and aquatic and wetland ecosystem will be achieved. Soil and water conservation measures will be implemented across cultivated lands and rangelands shall be effectively managed. The supporting services will increase in biomass production; soil formation and retention will be enhanced with species diversity and richness. The positive influence of forest and vegetation cover on water cycle will improve the productive flow of water through ecosystems. The production of oxygen is maximized due to total increase in vegetation cover across all ecosystems including in urban areas.

The supporting services will be lost in many of the ecosystems under the **policy reform** scenario. Habitats will be lost when vegetation in forests, woodlands and rangelands get degraded or converted to farmlands due to institutional and policy failures. Loss of biomass and organic matter in agroecosystem affects soil micro-organisms and disrupts soil formation processes. Soil holding functions are reduced due to increased deforestation, erosion and sedimentation. In Ethiopia, the forestry and agriculture sector governance and laws have been formed and reformed over decades but the results are increased deterioration of protected areas and the ecosystem services they provide.

Under the **business-as-usual** scenario, the spiritual/religious functions of ecosystems remain stable as people continue to use them for cultural services, which are the non-material benefits received through spiritual enrichment, cognitive development, recreation and aesthetic experience. Ancient civilizations have left drawings of environmental elements (animals, plants or landforms), which indicates the significance of ecosystems in the development of human creativity and cultural advancement. Aesthetic experience or recreation through nature-based tourism has economic values and it is increasingly recognized as having positive impacts on physical and mental health of people. Despite declined quality of biodiversity and ecosystems, places of spiritual value maintain their social and symbolic values to local communities. The aesthetic, educational and heritage values are reduced with loss of biodiversity and degradation of ecosystems.

The **food first** scenario involves large scale modification of the natural landscape and its replacement by managed landscape. The focus is on economic growth and use of modern technologies. Indigenous knowledge and practices become marginalized or lost. Environmental sustainability is compromised. Urban expansion lacks appropriate

planning, and hence green spaces and public parks cover limited areas. The aesthetic and educational/ILK values of ecosystems are reduced, the spiritual and heritage values remain stable, and recreational use is increased.

The **green growth** path involves sustainable utilization and management of environmental resources and enhanced the cultural services of ecosystems. Forests, springs, lakes and wetlands considered to be sacred places by local communities in different parts of the country will be protected and continue to provide their spiritual and religious functions and as a result cultural and religious diversity of the country will be maintained at a stable state. Effective management of protected areas and public parks in urban settlements will improve biodiversity and ecosystem conditions and this, in turn, increases local and international tourists visiting natural attractions, making the sector an important source of employment and income generation.

The Policy reform scenario is where ecosystems continue to provide cultural services to society. Regardless of the severity of degradation, sacred sites and religious heritages will continue to remain sacred and protected by people allowing such services remain stable in the ecosystems. However, the aesthetic and educational services including the indigenous and local knowledge will be eroded along with the degradation of the ecosystems. In forest and woodland, aquatic and wetland, and rangeland ecosystems, the ecotourism values will decline under this scenario.

In general, the scenario analysis has brought forth major conclusions to take forward. Five major direct and indirect drivers of change have been identified: population growth, urbanization (settlement), land-use/land cover change, economic policies and institutions and climate change. It is further shown that under the business-as-usual and the food first scenario archetypes, urbanization, land-use/land cover change, climate change and to a limited extent population growth and economic policies and institutions may likely aggravate the existing situation and lead to negative consequences on biodiversity and ecosystem services. In the green growth and relatively so in the regional integration archetypes, drivers will come under control and will not have negative impacts on biodiversity and ecosystem services; thus favourable situation is expected in Ethiopia under the green growth.

Regional integration as evident from recent developments is a plausible future that visions a region/sub-region with a high degree of interconnectedness and interdependencies built upon a multitude of factors. Sustained peace and security, mutual trust, collective vision and policy harmonization for joint actions and growth are at the root of the African/East African integration idea. Such regional/sub-regional integration when combined with on-going efforts by countries can make positive environmental responses that could trigger ecosystem restoration and control of biodiversity loss opening up opportunities for increased interaction and heightened flow of

goods and labour among countries. This leads to an increased level of interdependencies, tolerance, mutual trust and physical connectivity that enhances and facilitates movement of people and wildlife. On the other hand, integration may also bring negative outcomes connected with development that may lead to land fragmentation with possible negative impacts in the forest and woodland ecosystem, the rangeland ecosystem and the agroecosystem in particular.

The studied scenario archetypes point to the future social, political and economic situations expected that may determine the underlying factors with anticipated negative or positive outcomes of the drivers of change in biodiversity and ecosystem services. Despite Ethiopia's economic progress in the recent past, poverty remains a major driving factor for natural resource degradation. Expansion of cultivation to marginal lands continues to drive deforestation and land degradation in major ecosystems and vegetation zones. The decision-making process can work on policies that can deter the negative outcomes and promote and support the positive outcome to achieve the desired outcomes of living in harmony with nature and reaping multiple ecosystem goods and services from all ecosystems, dubbed as high or low potential. If implemented as anticipated, the green growth path will enhance the availability of the provisioning ecosystem services of food, feed, fresh water, energy and medicinal/ornamental plants and thus will be accompanied by upward trends that maintain a stable pool of genetic variability. Other services will also be enhanced. Since it is highly unlikely to abandon the existing scenario, it may be necessary to think of a hybrid scenario archetype where the green growth gradually expands and the business-as-usual goes on shrinking until the former takes over completely within a specified time frame; and this is the much desired healthy and ideal future for Ethiopia.

The outcomes of the Ethiopian Ecosystem Assessment must be viewed within the guiding principles of the nature futures framework that visualizes linkages of nature with nature, nature with society and nature with culture. To realize this, Ethiopia needs a long vision towards achieving transformative changes in various sectors wherein biodiversity and ecosystem services take the very central position. This goes in line with the fact that Ethiopia is a biodiversity-rich agrarian country whose economy and socio-cultural lives are linked to nature/biodiversity. To get all the benefits that Mother Nature can provide to people, society must, on its part, work for nature. These interlinkages are critical for humanity to achieve the goal of a more sustainable and

prosperous future that is deeply embedded in a thriving nature. The route towards achieving this goal depends on how close society can heave science to the policy arena. A science-policy platform is a tool for engaging in transformative changes that the land and the people crave at this time in history.

Since changes that modern societies inevitably bring upon natural and human-managed ecosystems are unavoidable where people and livestock exist, they are always followed by some kind of changes and there is a need for new policies, plans, arrangement options and collaborations. Copping with such changes requires appropriate and effective impact assessment, evaluation and monitoring mechanisms. The Ethiopian National Ecosystem Assessment and its outputs send wake-up calls to plan and implement conservation and sustainable use interventions with care, not only to save and improve lives and environments but also bring balanced prosperity in dynamic environments. The national policy issues need to be well synchronized and aligned with the relevant regional/sub-regional and global goals and targets such as the Post-2020 Global Biodiversity Framework, the 2050 Vision for Biodiversity that fosters “Living in harmony with nature”, and the African Agenda 2063 Goals on Biodiversity conservation, genetic resources and ecosystems. As Ethiopia has already been working on many of these goals and targets, the way forward can accelerate without much ado.

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