ambition for biodiversity

BIODEV 2030

NATIONAL BIODIVERSITY THREAT ASSESSMENT:

RANKING MAJOR THREATS IMPACTING ETHIOPIA'S BIODIVERSITY

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Abbreviations and Acronyms

AZE	Alliance for Zero Extinction
CBD	Convention on Biological Diversity
CMP	Conservation Measures Partnership
CR	Critically Endangered
CRGE	Climate Resilient Green Economy(Ethiopia's national blue print for climate action)
DD	Data Deficient
EBI	Ethiopian Biodiversity Institute
EbTA	Expert-based Threat Assessment
EN	Endangered
EWCA	Ethiopian Wildlife Conservation Authority
GTP	Growth and Transformation Plan
IBA	Important Bird Areas
IBAT	Integrated Biodiversity Assessment Tool
IBC	Institute of Biodiversity Conservation
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
LC	Least Concern
NA	Not Assessed
NBSAP	National Biodiversity Strategy and Action Plan
NDP	National Development Plan
NP	National Park
NPFA	National Priority Forest Area
NT	Near Threatened
PA	Protected Area
RLI	Red List Index
RLTS	Red List of Threatened Species
STAR	Species Threat Abatement and Species Restoration
UNESCO	UN Economic, Social, and Cultural Organization
WDPA	World Database on Protected Areas

Executive Summary and Recommendations

INTRODUCTION: The BIODEV2030 project aims to accelerate the mainstreaming of biodiversity into economic sectors which are key to biodiversity (BIO-) and development (-DEV), to 'bend the curve' of biodiversity decline and promote more sustainable and resilient economies. Ethiopia is among the 8 pilot countries where BIODEV2030 is implemented by the IUCN. This two-year project shall create the conditions for a national dialogue involving stakeholders around strategic economic sectors, relevant to the national economy and biodiversity. This dialogue will aim to initiate and facilitate tangible voluntary national and sectorial commitments to reduce pressures on biodiversity over the next decade. Such voluntary contributions will be a big step towards building ambitious common goals to halt the decline of biodiversity by 2030 and restore biodiversity by 2050. The objectives of this study were to assess the state of biodiversity in Ethiopia, identify, classify and rank the threats to Ethiopia's biodiversity from anthropogenic activities, and identify economic sectors associated with the main threats to Ethiopia's biodiversity for engagement with the BIODEV2030 project in Ethiopia.

METHODOLOGY: Target biodiversity components (taxonomic groups) for the assessment of status & trends and threats and approaches followed are presented on Table 1. First, an online search was conducted for peer-reviewed literature, policy documents, IUCN Red List data, other scientific data and sectorial reports relating to biodiversity and threatening processes in Ethiopia (see section 2.2.2 for details). This information was used to assess biodiversity status & trends and threats for the Target taxonomic groups and ecosystems. Then, we evaluated/reviewed the initially proposed STAR analysis conducted by IUCN and revised/re-analysed it. Third, primary data on biodiversity threats were collected using both Expert- and non-Expert-based Threat Assessment Tools. Fourth, the severity of biodiversity threat categories identified through literature review, STAR analysis and expert- and non-expert-based assessment were assessed. Finally, we used results of the threat analysis to identify and recommend sectors contributing most to biodiversity decline in Ethiopia, as well as at three selected sites, and that need urgent measures in terms of abating threats (incompatible economic activities) and restoring of habitats. STAR analysis was conducted for three taxonomic groups for which adequate data were available: amphibians, birds and mammals.

RESULTS: We identified and described 17 ecosystems types, comprising of 14 terrestrial ecosystem realm, 2 terrestrial-freshwater realm (i.e., Riparian and wetland ecosystem types), and 1 freshwater realm ecosystem (i.e., Aquatic ecosystem). The Red List Index (RLI) for Ethiopia for three taxonomic groups (mammals, birds and amphibians) show a constant trend over time, indicating that the overall extinction risk for species in Ethiopia is unchanged over the period of the last 25 years (1995–2020). However, the RLI of species survival in Ethiopia is low (0.85) which indicates that the status of biodiversity is degraded and should be enhanced. The number of protected areas of Ethiopia has been increasing over time, from about 6% in 1970s to 12% in 2019 and 12.14% in 2022. However, available data do not allow to accurately assess the extent to which these protected areas cover key biodiversity areas (KBAs), representative ecosystems and conservation concern species.

Despite the increasing number in protected areas, many flora and fauna species are threatened and experiencing severe population declines, while the status of several species has been remained unknown. For example, Ethiopia has 314 mammal species, including 57 (18.5% of the total mammal species) endemic species. Out of the 314 mammal species, populations of 74 (23.5%) species are experiencing declining trend and 39 (12.4%) are currently globally threatened, including 16 threatened and 4 near threatened endemic species. Similarly, about a quarter (214 species) of the total bird species occurring in Ethiopia are experiencing decreasing population trend and 36 species are globally threatened. Of the 253 reptile species known from Ethiopia, 26 (10%) are endemic to the country. Only five of the total species are known to be threatened, all of which are endemic and experiencing population declines. Of the 78 amphibian species occurring in Ethiopia, half (39) of the species are endemic and 18 of them are globally threatened.

The total STAR score for Ethiopia is 206,544. Habitat Restoration (STAR R) component of the STAR metric represents 94% of the total score, which is, by far, higher than the country's score for Threat Abatement component (STAR T; 6%). This could indicate that restoration actions should be prioritized in Ethiopia in order to reduce species extinction risk. However, those surprising figures, very different from other countries's profiles, are due to 6 species with a very high STAR R score. We did a senstivity analysis and recalculated STAR scores (total, R and T) for Ethiopia without the 6 species with STAR R scores higher than 3000, and found for Ethiopia the following results, which are more common in terms of national STAR scores:

- STAR T score for Ethiopia = 71% of STAR (T+R) score Ethiopia (instead of 6%)
- STAR R score for Ethiopia = 29% of STAR (T+R) score Ethiopia (instead of 94%)

Threat abatement measures targeting critically endangered (CR) species are crucial because the Threat Abatement STAR score (STAR-T) for critically endangered species is about four times higher than the corresponding STAR-R score (2,740.7 vs 710.6). Furthermore, the threat abatement scores of endemic species was 9893 which represents 84% of the country's STAR-T score. These results do not only illustrate that Ethiopia has a very high responsibility in preserving its endemic biodiversity but also suggest that conservation action plans should include actions that reduce drastically threats coming from activites causing pressures on all the critically endangered species and on all the endemic species (regardless of their IUCN RL status), and restore habitats as much as possible (starting where it will maximise STAR score). Comparison of results of STAR-T threat scores of each of the IUCN level 2 threat categories with threat impact ranking expert-based and non-expert-based assessments showed qualitatively a high convergence (consistence) in the threat rank order. In conclusion, the top four threats identified via the three approaches (STAR, expert-based data and non-expert-based data) were Annual & perennial non-timber crops, Livestock farming & ranching, and Small scale logging & wood harvesting.

Recommendations: The major economic sectors driving the threats are agriculture (subsectors such as cereal crop, coffee and livestock), forestry, biomas energy and urban and housing. For the purpose of the BIODEV2030 project, we recommend the following two broader key economic sectors in Ethiopia: agriculture and Forestry. Overall, we recommend the following measures to reduce the biodiversity threats in Ethiopia:

(1) Enhance KBAs' conservation and species conservation by increasing protection via a better coverage by protected areas, enhanced protected areas connectivity and sharing updated basic data of PAs with relevant stakeholders to be used in decision making processes;

(2) KBA Avoidance by development projects and by livestock grazing;

(3) Avoid the area of habitat (AOH) of threatened species and endemic species;

(4) Mainstream biodiversity conservation both inside protected areas and outside PAs (in agricultural ecosystems) in all decision-making processes of economic actors in productive sectors, by making them contribute to abating threats to biodiversity,

(5) Prioritize restoration actions for the six species with very high (>3000) STAR R scores. Then, prioritize and target the restoration actions on the habitats of critically endangered species. The very STAR R scores for 6 species (see Results section for list of these species) advocates for establishing zoning, increasing the number of PAs and the superficie of areas under (strict) protection. Such areas should i) either be avoided by economic and productive activities such as agriculture and livestock, or ii) become areas where economic activities contribute to habitats restoration and support biodiversity protection with environment-friendly practices;

(6) Threat abatement and restoration actions should focus on agriculture and livestock sectors; and

(7) Reduce the dependence on forest resources for fuelwood and construction, but make sure the alternative do not contribute to an increase of greenhouse gas emissions (and exacerbate climate crisis).

1. Introduction

1.1 Background

The health of the ecosystems on which we depend and on which all other species depend is degrading today at an unprecedented rate. This situation weakens livelihoods, food security, health and quality of life worldwide, and poses economic and financial risks. This is particularly significant for countries and people that are heavily dependent on natural resources and biodiversity for subsistence needs.

The BIODEV2030 initiative aims to accelerate the mainstreaming of biodiversity into economic sectors which are key to biodiversity (BIO-) and development (-DEV), to 'bend the curve' of biodiversity decline and promote more sustainable and resilient economies. BIODEV2030 empowers 16 pilot countries with diverse ecological, economic, political and institutional contexts, to catalyse voluntary national and sectorial commitments for biodiversity to reduce pressures on biodiversity over the next decade. The project is funded by the French Development Agency (AFD), coordinated by Expertise France, and implemented by International Union for Conservation of Nature (IUCN) and World Wildlife Fund (WWF)-France in 8 countries each. Ethiopia is among the 8 countries where BIODEV2030 is implemented by the IUCN. This two-year project shall create the conditions for a national dialogue involving stakeholders around strategic economic sectors, relevant to the national economy and biodiversity. This dialogue will aim to initiate and facilitate tangible voluntary national and sectorial commitments to reduce pressures on biodiversity over the next decade. Such voluntary contributions will be a big step towards building ambitious common goals to halt the decline in biodiversity by 2030 and restore biodiversity by 2050.

As the initial step to BIODEV2030 implementation in Ethiopia, IUCN recruited a consultancy team composed of three experts to conduct Ethiopia's biodiversity threat assessment at national level. This report presents findings of the assessment of the Status and Trends of biodiversity of Ethiopia, direct threats to biodiversity in the country and major economic sectors impacting biodiversity.

1.2 BIODEV2030: Supporting Ethiopia Vision 2030

This assessment is consistent with and contributes to implementation of Ethiopia's National Development Plan (Ethiopia 2030), Climate Resilient Green Economy (CRGE) Strategy, Revised National Biodiversity Strategy and Action Plan (2020 – 2025). Ethiopia's long-term national development is the "Growth and Transformation Plan (GTP), a 30-years (2010-2030) plan launched in 2010. As set forth in the GTP, Ethiopia's vision is "becoming a climate resilient middle-income economy by 2025, with a zero net increase in carbon emissions by 2025." Achieving this vision requires increasing agricultural productivity, strengthening the industrial base, and fostering export growth. Economically, it means growing fast enough to increase the current gross domestic product (GDP), decreasing the share of GDP contributed by agriculture from more than 40% to less than 30%, and migrating from farming and herding to jobs in the services and industry sectors. As such, to ensure a green growth path and fosters development and sustainability, Ethiopia has devised a strategy for Climate Resilient Green Economy (CRGE). Launched in 2011 and fully integrated into the GTP, the CRGE strategy was mainly aimed to address both climate change adaptation and mitigation objectives.

At present, the country has developed and launched in 2021 a 10-year (2021-2030) National Development Plan (NDP), with a theme: "Ethiopia 2030: The Pathway to Prosperity". The plan stresses the importance of inclusive growth to alleviate poverty; reduce inequalities and promote progress in gender equality and youth rights; the importance of promoting private sector investment and trade; and the enhanced provision of social services and public goods to sustain economic growth supported. This NDP is an outcome of a nation-wide consultation process with a whole-of-society approach and is aligned with and outlines strategies to achieve Ethiopia's global commitments, including the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change. The integrated nature of development and the need for multi-sectorial solutions are recognised and addressed, and critical cross-cutting issues such as climate change, green growth, the environment, gender and children equality, disability and governance are mainstreamed in the plan.

Although a landlocked country, Ethiopia also operates as a vital regional hub for travellers and commercial and humanitarian cargo. The country is home to the African Union Commission, the

United Nations Economic Commission for Africa and several other regional and continental partnership platforms. These attributes make Ethiopia a strong partner in global and regional partnerships for both national development action and implementation of the SDGs. The present assessment will contribute to the achievement of the country's development vision, by identifying key biodiversity threats and prioritizing economic sectors driving such threats in order to support effective biodiversity protection and rehabilitation. Specifically, it contributes to the achievement of a revised vision of Ethiopia's NBSAP (2020), which is to conserve, restore and value biodiversity and ecosystems of the country, maintaining rich biodiversity and ecosystems that deliver essential benefits to all the people of Ethiopia.

1.3 Purpose of The Assessment in Ethiopia

The overall goal of this study is to provide a scientific overview and assessment of the threats to biodiversity posed by different economic sectors in Ethiopia based on existing literature and reports, scientific data and interviews with experts and key stakeholders. More specifically, the consultancy task was aimed to:

1. Assess the state of biodiversity in Ethiopia,
2. Identify, classify and rank the threats to Ethiopia's biodiversity from anthropogenic activities, and
3. Identify economic sectors associated with the main threats to Ethiopia's biodiversity for engagement with the BIODEV2030 program in Ethiopia.

2. Methodology

2.1. Conceptual Framework and Definitions

2.1.1. Conceptual Framework

The project framework and associated methodologies, results and outputs used for the purpose of this study are summarised in Figure 1 and Table 1. The simplified conceptual model (Figure 1) is adapted from the DPSIR (Drivers, Pressures, State, Impact, and Response) model. This study focuses specifically on the state of biodiversity and on the threats affecting this state. The threats to biodiversity have natural (volcanic eruptions, earthquakes, etc.) and anthropogenic (human) sources (Residential & Commercial Development, Agriculture & Aquaculture, Biological Resource Use, etc.). For the purpose of this study, we are focusing only on human sources of threats affecting biodiversity status.

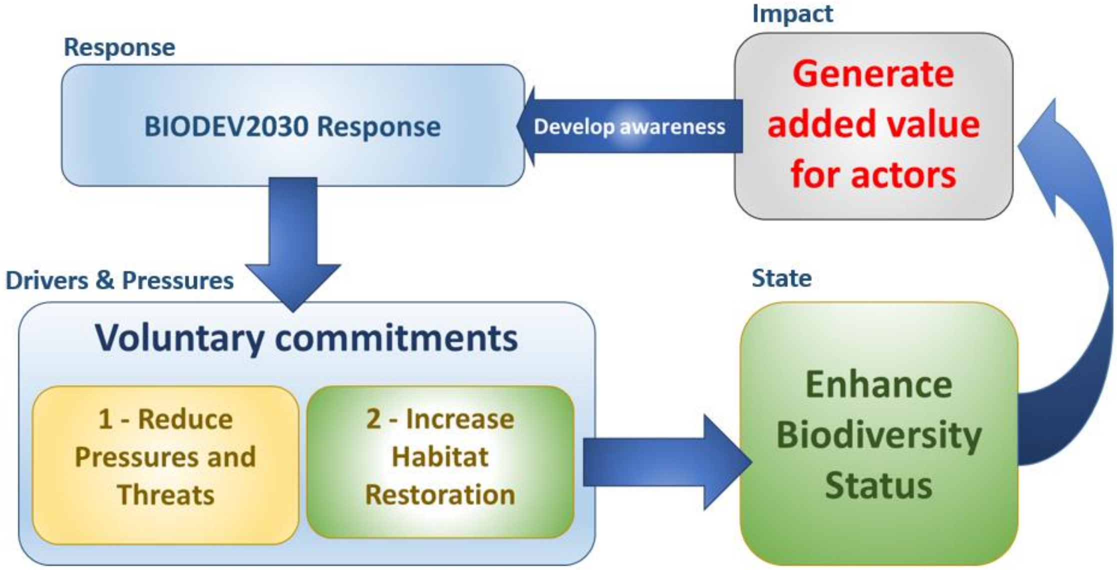

Figure 1. BIODEV2030 simplified conceptual framework derived from DPSIR model.

Target biodiversity components (taxonomic groups) for the assessment of status & trends and threats and approaches followed are presented on Table 1. First, an online search was conducted for peer-reviewed literature, policy documents, IUCN Red List data, other scientific data and sectorial reports relating to biodiversity and threatening processes in Ethiopia (see section 2.2.2 for details). This information was used to assess biodiversity status & trends and threats for the Target taxonomic groups and ecosystems. Second, we evaluated/reviewed the initially proposed STAR analysis conducted by IUCN and revised/reanalysed it. Third, we collected primary data on biodiversity threats using both Expert- and non-expert-based Threat assessment Tools. Fourth, we assessed consistency of severity of biodiversity threat categories identified through literature review, STAR analysis and expert- and non-expert-based assessment. Finally, we used results of the threat analysis to identify sectors contributing most to biodiversity decline in Ethiopia and that need urgent measures in terms of threats abatement and habitats restoration actions.

Table 1. Summary of major approaches used for assessment of biodiversity status & trends and threats in Ethiopia and respective targeted taxonomic groups and ecosystems.

Approach	Purpose	Target Taxon Group	Target Ecosystem
Literature review	Biodiversity Status & Trend	1. Mammals	1. Natural terrestrial
		2. Birds	2. Agroecosystems
		3. Reptiles	3. Freshwater
		4. Amphibians	
		5. Freshwater fish	
		6. Plants	
	Threat Assessment	All the above taxon group	Natural ecosystems
STAR metric analysis	Threat Assessment	1. Mammals	
		2. Birds	
		3. Amphibians	
Expert-based threat assessment	Threat Assessment	All the above six taxon group	
Non-expert-based threat assessment	Threat Assessment	All biodiversity components	All ecosystems

2.1.2. Definitions of Key terms

Biodiversity: The Convention on Biological Diversity (CBD) defines 'biological diversity' as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems" (CBD, 1992).

Drivers: Drivers are external factors that affect nature, and, as a consequence, also affect the supply of Nature Contributions to People (NCP). Drivers of change include indirect drivers (all anthropogenic: here Drivers) and direct drivers (both natural and anthropogenic: here Pressures) (IPBES, 2019).

Threats: Following Salafsky et al. (2008), threats were defined as "the proximate human activities or processes that have caused, are causing, or may cause the destruction, and/or impairment of biodiversity targets (e.g. unsustainable fishing or logging)." Direct threats are the proximate human activities or processes that have impacted, are impacting, or may impact the status of a taxon. Direct threats are synonymous with sources of stress and proximate pressures (IUCN RLTS – TCS; Salafsky et al., 2008), for example unsustainable fishing or logging. Note that the IUCN Red List also contains data on the stresses by which these threats impact species, such as via direct mortality or ecosystem degradation.

Due to the way that The IUCN Red List is compiled (the threats listed by IUCN are those known to impact the species or taxonomic groups at the global level) and managed, all threats listed in the IUCN threat category may not impact species listed within a particular country (or some threats may be absent in a particular country). More information about the nature of the impacts of threats and the threat classification scheme can be found here[1].

To standardise the threat assessment, a universal language applicable lexicon, the IUCN–CMP Classification of Direct Threats Version 3.2 (Salafsky et al., 2008), was adopted here (see also Gudka, 2020). This ensured a consistency and comparability with the IUCN Red List of Threatened Species 2020 (IUCN, 2020), Key Biodiversity Areas (KBA), and BirdLife's Important Bird Areas (IBA), which all use the same classification system. The classification system is hierarchical and structured with three different levels from coarse to fine scale. The first level lists 12 general threat categories (e.g., threat "2. Agriculture and Aquaculture"), subdivided into 45 second-level threat types (e.g., threat "2.1 Annual & Perennial Non-Timber Crops" & "2.2 Wood & Pulp Plantations"). These are further subdivided into third-level threat types (e.g., "2.1.1 Shifting Agriculture"). The classifications are designed to be comprehensive, consistent, and exclusive for the first and second levels. However, the third level is at a much finer scale containing mainly illustrative examples rather than comprehensive listings of threats.

2.2. Data Collection and Analyses

2.2.1. Biodiversity Status & Trends

The documents and data used for the review component of the national biodiversity assessment were collected through online searches of scientific databases, government agency websites, online data repositories, NGO and regional organisation websites, and from local and internationally based Ethiopian biodiversity experts. The documentary and data sources were loosely divided into

[1] http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme

government documents/policies, peer-reviewed literature, reports, and scientific data held by experts of the consultancy team and other experts.

We analyzed biodiversity status and trends in two approaches, ecosystem approach and species approach. For the ecosystem approach of biodiversity assessment for Ethiopia, we followed the standardized typological classification system of the IUCN Global Ecosystem Typology v2, recently developed recently by Keith et al. (2020). The IUCN Global Ecosystem Typology is a hierarchical classification system that, in its upper levels (levels 1–3), defines ecosystems by their convergent ecological functions and, in its lower levels (levels 4–6), distinguishes ecosystems with contrasting assemblages of species engaged in those functions (Keith et al., 2020). The top level of the Global Ecosystem Typology divides the biosphere into five global realms: i) terrestrial; ii) subterranean; iii) freshwater (including saline water bodies on land); iv) marine; and v) the atmosphere. The interfaces between these core realms are recognised as transitional realms, accommodating ecosystems, such as mangroves and riverine, that depend on unique conditions and fluxes between contrasting environments. At Level 2, the typology defines 25 biomes – components of a core or transitional realm united by one or a few common major ecological drivers that regulate major ecological functions. Level 3 of the typology includes 108 Ecosystem Functional Groups that encompass related ecosystems within a biome that share common ecological drivers and dependencies, and thus exhibit convergent biotic traits (for detail see Keith et al., 2020). Level 4 defines biogeographic ecotype – which is an ecoregional expression of an ecosystem functional group derived from the top-down by subdivision of Ecosystem Functional Groups (Level 3). They are proxies for compositionally distinctive geographic variants that occupy different areas within the distribution of a functional group. At level 5, the typology defines Global ecosystem types – a complex of organisms and their associated physical environment within an area occupied by an Ecosystem Functional Group. Global ecosystem types grouped into the same Ecosystem Functional Group share similar ecological processes but exhibit substantial difference in biotic composition. They are derived from the bottom-up, either directly from ground observations or by aggregation of sub-global ecosystem types (Level 6). Finally, level 6 ecosystem typology defines sub-global ecosystem types – a subunit or nested group of subunits within a global ecosystem type, which therefore exhibit a greater degree of compositional homogeneity and resemblance to one another than global ecosystem types (Level 5). These represent units of established classifications, in some cases arranged in a sub-hierarchy of multiple levels, derived directly from ground observations.

In the case of species approach, we compiled the total number of species, genera and families, number of endemic species, number of globally threatened species, and population trends (Decreasing, Increasing, Stable, and Unknown) for mammals, birds, reptiles, amphibians, fish and plants.

2.2.2. Biodiversity Threat Assessment – National Level

2.2.2.1. Literature Review

Literatures used for the review biodiversity threat assessment were collected through online searches of scientific databases, government agency websites, online data repositories, NGO and regional organisation websites, and scientific data held by experts of the consultancy team and other experts.

2.2.2.2. STAR: the Species Threat Abatement and Restoration metric

The "Species Threat Abatement and Restoration" (STAR) metric evaluates and quantifies the potential benefit for threatened species and nearly threatened species of actions to reduce threats and restore habitat. Like the Red List Index, STAR is derived from existing data in the IUCN Red List. As such, STAR contributes to explain which potential actions (threat reduction and/or habitat restoration) could affect the Red List Index (see Mair et al. 2021 for more details on the general STAR methods).

STAR is spatially explicit, enabling identification of threat abatement and habitat restoration opportunities in particular places, which if implemented, could reduce species extinction risk. STAR assumes that for the great majority of species complete alleviation of threats would reduce extinction risk through halting decline and/or permitting sufficient recovery in population and distribution, such that the species could be down listed to the IUCN Red List category of Least Concern.

For each species, a global STAR threat-abatement (STAR-T) score is defined. To calculate the STAR_T score, one uses weighting ratios, varying from zero for Least Concern species to 100 for Near Threatened, 200 for Vulnerable, 300 for Endangered and 400 for Critically Endangered. The sum of STAR-T values across all species represents the global threat-abatement effort needed for all species to become Least Concern.

STAR-T scores can be disaggregated spatially, based on the area of habitat currently available for each species in a particular location. This shows the potential contribution of conservation actions in that location to reducing the extinction risk for all species globally. The local STAR-T score can be further disaggregated by threat, based on the known contribution of each threat to the species' risk of extinction. This quantifies how actions that abate a specific threat at a particular location (or country) contribute to the global abatement of extinction risk for all species occurring in that location. The formula to calculate the STAR score for threat t occurring at site i is the following:

$$T_{t,i} = \sum_{s}^{N_s} P_{s,i} W_s C_{s,t}$$

Where:

Ps,i is the current Area of Habitat (AOH) of each species (s) within location (i), expressed as a percentage of the global species' current AOH;

Ws is the IUCN Red List category weight of species s (NT= 100, VU = 200, EN = 300 and CR= 400);

Cs,t is the relative contribution of threat t to the extinction risk of species s calculated as the percentage global population decline from that threat;

Ns is the total number of species at location (i).

The STAR metric also includes a habitat restoration component to reflect the potential benefits to species of restoring lost habitat. The STAR restoration component is calculated for each species and is based on the area of habitat (AOH) that has been lost and is potentially restorable. The STAR restoration score (STAR-R) quantifies the potential contribution that habitat restoration activities could make to reducing species' extinction risk. For a particular species at a particular location (or country), the STAR restoration (STAR-R) score reflects the proportion that restorable habitats at the location represents of the global area of remaining habitat for that species. Importantly, a multiplier is applied to STAR-R scores to reflect the slower and lower success rate in delivering benefits to species from restored habitats compared with conserved existing habitats. The STAR-R score for threat t occurring at a site t is calculated as follow:

$$R_{t,i} = \sum_{s}^{N_s} H_{s,i} W_s C_{s,t} M_{s,i}$$

Where:

Hs,i is the extent of restorable AOH for species s at location i, expressed as a percentage of the global species' current AOH,

Mi is a multiplier appropriate to the habitat at location i to discount restoration scores. We use a global multiplier of 0.29 based on the median rate of recovery from a global meta-analysis assuming that restoration has been underway for ten years (the period of the post-2020 outcome goals).

The extent of current and restorable Area of Habitat (AOH) for species was determined using 5 km resolution species' AOH rasters. The European Space Agency "Climate Change Initiative" (ESA CCI) land use and cover maps from 2015, with 300 x 300 m pixel size was used to calculate species current AOH. The ESA CCI original 37 land cover classes were reclassified into ten major classes (forests, wetlands, arid ecosystems, natural grasslands, shrublands, croplands, cultivated grasslands, rock and ice, and urban areas), and then matched to the habitat classes from IUCN Red List assessments. Species' range maps were then overlaid with land cover and digital elevation maps to map the area of habitat within each species' range, constrained by the species' elevation range (from the IUCN Red List). Species' range maps are coded for presence and origin; grid cells where the species was recorded as Extinct were excluded from current AOH parts of species' ranges, and only parts of each species' range where the species was recorded as Native, Reintroduced or Assisted Colonisation were included.

Original area of habitat represented the extent of original ecosystem types before human impact (i.e. the land cover before conversion to croplands, pasturelands or urban areas). ESA CCI land use and cover maps from 1992 were used to inform back-casting of the extent of original ecosystem types. Species range maps were then overlaid with this back-cast land cover and with digital elevation maps to map the original area of habitat within each species range. For the purposes of this analysis, the extent of species original AOH was constrained to within individual species' range maps according to the IUCN Red List; these range maps largely reflect current range limits due to a lack of consistent information across all species on their historical, recently extirpated range. As with current AOH, only parts of each species' range where the species was recorded as Native, Reintroduced or Assisted Colonisation were included in original AOH according to the origin coding of the IUCN Red List assessments. However, for original AOH, parts of species' ranges where the species was recorded as Extinct were additionally included, for all species for which this information was available (Brooks et al., 2019). Species restorable AOH was then calculated as the difference between original and current AOH (Mair et al., 2021). The STAR scores have been calculated and mapped at global scale using species' extinction risk categories and threat classification data downloaded for amphibians, birds and mammals from the IUCN Red List website on 16 September 2021. So far, a total of 5,364 species (2,054 amphibians, 1,962 birds and 1,348 mammals) were included in the global analysis based on the availability of the necessary data (IUCN, 2020).

In Ethiopia, a total of 113 species (12 amphibians, 51 birds and 50 mammals), including 31 endemic species, were included in the initial STAR analysis based on the availability of the necessary data. However, the final analysis was made on 115 species, 33 (29%) of which were endemics (Table 19; for detail on the species incuded see Appendix 1). We reviewed this initial list of amphibian, bird and mammal species proposed by IUCN to be used in the STAR analysis. We found that all the proposed species to be relevant but thought that two endemic mammal species should be included. One of these species is the Amphibious Rat (*Nilopegamys plumbeus*) which is currently listed as Critically Endangered in the IUCN Red List, but its distribution range map is not available on the IUCN Red List (Peterhans & Lavrenchenko, 2008). The other species is the Sheko Forest Brush-furred Rat (*Lophuromys pseudosikapusi*), a species known to occur only in Sheko forest in the south-western Ethiopia, listed as Endangered in the IUCN Red List (Dano et al., 2018). Based on literature review, experts' opinion and our experiences on the suitable habitat, distribution range and threats of each species, we calculated STAR scores for these species (see BOXES 1 & 2 for details of how the STAR scores were computed for each of these species and threats to them). Although adding these two species to the initially proposed STAR species list did not change the overall results found from analysis of the initial list, we found it including them in the analysis to be helpful for future site level STAR analysis, when deemed necessary.

BOX 1: Derivation of STAR scores for *Nilopegamys plumbeus*

The Amphibious Rat (*N. plumbeus*) is Ethiopia's endemic rodent species currently listed as Critically Endangered in the IUCN Red List. This semiaquatic-life species (inhabiting permanent, inland wetlands /Rivers/ Streams) is known from a single specimen collected at a locality known as "Little Abbai River" in the 1920s from highland, riparian habitat (Peterhans & Lavrenchenko, 2008). This confinement of the entire known population of *N. plumbeus* to this site has triggered designation of the "Little Abbai River" AZE site. This site has an area 904.7 km^2. Two recent attempts to recollect this species were ended up without any success (Peterhans & Lavrenchenko, 2008), suggesting that it may now be extinct. The habitat where the type locality specimen was collected is now already severely degraded and today is pure pastureland (Peterhans & Lavrenchenko, 2008). Information both on its historical and current AOH is unavailable for *N. plumbeus*. Based on this background knowledge, the STAR-T score for the species is 400.

To derive the STAR-R for the species, based on literature and experts' opinion, we assumed that the area (904.7 km^2) of the "Little Abbai River" AZE site represents historical AOH of the species and that about 75% (678.5 km^2) of this historical/ original AOH has been lost, showing that current available AOH is 226.2 km^2. The extent of restorable AOH for species, expressed as a percentage of the global species' current AOH, is 300. From this, the STAR-R score for the species is estimated as 348 (300*4*0.29].

For the species, The IUCN Red List records only one level 1 threat, 2. Agriculture & Aquaculture, 2. Agriculture & aquaculture -> 2.3. Livestock farming & ranching -> 2.3.2. Small-holder grazing, ranching or farming, which is on-going with Low Impact (score = 3) (Peterhans and Lavrenchenko, 2008). Thus, for both global and national levels, STAR-T score for this threat based on this species, both at global and national levels (since it is an endemic species), is 400 (100*4*1).

The total STAR score for the species is therefore 748 (348+400).

BOX 2: Derivation of STAR components scores for *Lophuromys pseudosikapusi*

The Sheko Forest Brush-furred Rat (*L. pseudosikapusi*), another Ethiopian endemic only known to occur only in Sheko forest of south-western Ethiopia, is listed as Endangered in the IUCN Red List (Dando et al., 2018). Thus, its weighting ratio (in the STAR T and STAR R scores formula) is 300.

The species' historical AOH is unknown, but its estimated current estimated area of occurrence (EOO) is 2,185 km^2. Here, assuming that the area of Sheka KBA (3,723.3 km^2; see Dando et al., 2018; IBTA, 2021) represents the species' historical AOH and the EOO as its current AOH, we estimated extent of lost (potentially restorable) habitat of the species 1,538.3 km^2 [((3723.3-2185)/2185))*100], which accounts for about 70% of its current AOH. Based on this, the STAR-R score for the species is 61.25 (0.704*300*0.29).

For *L. pseudosikapusi*, two IUCN CMP level 3 threats are listed, one for 2. Agriculture & aquaculture -> 2.1. Annual & perennial non-timber crops -> 2.1.2. Small-holder farming, and one for 5. Biological resource use -> 5.3. Logging & wood harvesting -> 5.3.3. Unintentional effects: (subsistence/small scale) [harvest]. These threats are on-going, but the Scope, Severity and Impact Score of both threats are Unknown. Based on literature review (e.g., Dando et al., 2018) and experts consultations, for 2. Agriculture & aquaculture threat, we assigned Scope to be Majority (threat affecting majority of the population), Severity (Slow) and Impact Level (in terms of contribution to population declne) of Medium (Score = 7). Similarly, for 5. Biological resource use, we assigned Impact Score of 5 (Low Impact), following the guideline provided in "Threat Impact Scoring System (based on additive scores and defined thresholds) Version 1.0 [revised version based on implementation in SIS]". Based on this, the STAR-T score for 2. Agriculture & aquaculture was estimated 175 (7/12*300) and for 5. Biological resource use threat 125 (5/12*300).

The total STAR score is thus 186.25 (61.25+125).

2.2.2.3. Expert-based Threat Assessment

The STAR metric, although developed as a possible global science-based target for biodiversity, is currently calculated only for 3 taxonomic groups (mammals, birds and amphibians) that have been the best evaluated globally. In addition, the IUCN threat data may not be comprehensive (some missing) or are irrelevant to the Ethiopian context. Thus, the IUCN threat list may not be considered as exhaustive and STAR results should be corroborated or validated by the national analysis of the most representative national taxonomic groups and ecosystems. Therefore, in addition to the documentary analysis, we undertook interviews with biodiversity experts (referred to as “Expert-based Threat Assessment) to assess the impact of direct human threats on biological targets, following Gudka (2020).

As there are few experts specialized in specific taxonomic group or ecosystem type, we decided to ask each expert to assess threat impacts on each of the target biological taxonomic groups. Prior to conducting formal expert-based interview, we first sent, via email, the questionnaire to 40 experts, where the assessors were asked to assess the relevance of the 12 level 2 and level 3 IUCN global threat (sub) categories to Ethiopian context and to rank the impacts of each threat to each of six major ecosystem types (i.e., wetland, forest, woodlands, grasslands, savannah and shrublands); and six taxonomic groups (plants, mammals, birds, reptiles, amphibians and fish). In the meantime, we shared the questionnaire to IUCN national and regional staffs and presented our assessment methodology to Ethiopia BIODEV2030 project technical committee meeting held at EFCC on 13 August 2021. Based on literature review and useful feedback obtained from these consultations, we refined the questionnaire prepared for the expert-based threat assessment, as well as for non-expert-based threat assessment (see section 2.2.2.4). First, experts found it difficult to understand the boundary of level-three threat subcategories. Second, it is time consuming to assess the impacts of all three-level threats of five ecosystem components and five taxonomic groups, which was found to deter experts from assessing or affect reliability of their assessment data. Third, preliminary analysis of literature review on biodiversity threats in Ethiopia, we found that agricultural activities (cultivation and livestock grazing) and logging to be the most severe and widespread threats (IBC, 2009; EBI, 2014a; Asefa et al., 2015). Accordingly, we revised and sent to expert assessors two separate questionnaires. The first assessment questionnaire is the revised version the initial questionnaire, which was prepared by reducing threat level from level-three to level 2 (which is lower in number, coarser scale, less complicated, easier to understand compared with level 3), and by omitting ecosystem level assessment, as we thought (and also suggested by experts) that few experts are available to do so (see Appendix 2). The second questionnaire was intended to obtain detailed information on the types of agricultural activities (cultivation and livestock grazing) and logging impacting biodiversity in Ethiopia (Appendix 3).

Both the expert-based questionnaires were accompanied by guidance instructions and shared via e-mail with 40 biodiversity expert assessors. In this assessment, for each target taxon, assessors are asked to 1) assess the relevance of the 12 level 2 IUCN global threats to the local Ethiopian context and to rank each threat to each biodiversity taxonomic groups, 2) record existing local threats if missing from the IUCN global threat list, and 3) remove irrelevant global-level threats by assigning a 'not applicable to Ethiopia' label. Relevant threats were ranked on a scale of Low, Medium, High, and Very High, based on 'contribution' and 'irreversibility'. Here 'contribution' is the contribution from a particular threat to population declines and/or habitat degradation of a target taxon, while 'irreversibility' was the difficulty of reversing those declines or degradation.

National biodiversity experts considered for the interviews were those with good experiences in practical biodiversity conservation and/or research from academic institutions (e.g., Addis Ababa University and Wondo Genet College of Forestry & Natural Resources) and non-academic organizations working in the biodiversity, agriculture, investment, fisheries sectors. List of experts and non-experts participated in the questionnaires surveys and their institutional affiliations are provided in Appendix 4.

2.2.2.4 Analysis of Expert-based Threat Assessment Data

Each assessor ranked each source of threat (level 2 IUCN threat categories) for each of the six target taxonomic groups as Very High, High, Medium or Low, based on a combination of the Contribution ranking for the threat and the Irreversibility ranking for the threat. Thus, we combined and summarized expert-based data to assess the impact of each threat to each taxon group.

We followed a three-step procedure to combine the data and assess the severiety of impact of each threat to each taxon group. Firast, we recoded each assessor's rank score given for each threat to each taxon by assigning numerical score values as: Low = 1, Medium = 2, High = 3, Very High = 4. Second, we calculated the weighted average impact rank score of each threat to each target taxon (see Box 3 on how to calculate this). Finally, we recoded back the average values to ordinal values as follow: 0–1.5 = Low; 1.6–2.5 = Medium; 2.6–3.5 = High; and >3.5 = Very High (see Box 3) and these ordinal average rank scores assigned to each cell of taxon group by threat matrix

In addition, we also examined how closer (consistent) were the expert-based rank scores of each threat (summed across the six taxa group) and the STAR T scores calculated for each threat.

Specifically, for each of the 25 level 2 threat categories used in the STAR analysis, we calculated sums of rank scores (that obtained for each taxon in step 2 above) across the six taxonomic groups (see Box 3). Then, we run a rank-based correlation analysis on the summed (across the six taxonomic group) average rank score values of the expert-based data estimated for each threat and the STAR T score values of each threat across the 3 STAR taxa. Similarly, we also computed the analysis between STAR T and STAR R components to see whether the threats with high STAR T are also characterized by having high or low STAR R scores.

BOX 3. An example of how to combine assessors' data for a single threat to a single taxon

Average score for each threat to each taxon was calculated using weighted severity score algorithm. For example, out of the total number of 14 assessors who perceived that Housing and Urban areas impacts amphibians, 4 assessors ranked Low, 3 Medium, 5 High and 2 Very High. The weighted average score for the impact of Housing and Urban areas impacts amphibians was then equals to 1.64 [(4*1+3*2+5*3+2*4)/14]. Assuming that average values falling between 1.5 and 2.5 to be medium, this average rank score (= 1.64) suggests that the impact of Housing and Urban areas on amphibians to be Medium.

2.2.2.5. Non-expert-based Threat Assessment

To complement the expert-based survey, we developed a Simplified Threat Assessment Tool (STAT) for Non-expert-based Threat Assessment. This approach does not require in-depth knowledge of taxonomic groups thus making it more accessible to non-expert stakeholders from government, private sector, and NGO (Gudka, 2020). This enabled a more inclusive threat assessment process allowing a wider range of stakeholders to be involved. The STAT was shared by email with 20 assessors from key government, private sector, and NGO stakeholders (which included some IUCN members), out of which nine completed the assessment (see Appendices 4 & 5 for detail on the assessors consulted and tool, respectively).

In the Simplified Threat Assessment Tool, assessors were requested to list out threats (each expert thinking on her/his own, without supporting material) they perceived as having impacts on biodiversity (species and ecosystems) in Ethiopia and to indicate their top three (of their selection of threats). Data from assessment were summarized and presented in graphs based on the percentage frequency of each level 2 threats. The frequency was calculated as the number of times assessors cited a specific threat.

Finally, to further validate findings of the assessment a questionnaire, containing four key questions, was administered to participants of the 'Validation Workshop" held in Addis Ababa on 28 January 2022 (Appendix 6). Participants of the workshop, most of whom were also involved in the previous data generation, were representatives of biodiversity experts and non-experts (government officials, NGOs representatives and experts of other fields like agriculture, economic, etc) (Appendix 7). This assessment was done following presentation of and discussion on the key findings of the assessment, whereby responses of particpants were immediately summarized and disclosed to the workshop participants (respondents), in light of their convergence with findings of the assessment presented by the consultants. Particpants remarks made during the workshop are compiled, and along with participants' selection of key economic sub-sectors are presnetd in Appendix 8.

Given the COVID-19 outbreak that hit Ethiopia during the study, we were unable to include other stakeholders, especially local communities, during this process as these groups would require a face-to-face approach to engagement and do not have access to online communication platforms due to limited computing and internet capacity.

3. Ethiopia's Biodiversity Status and Trends

3.1. Scope of The Assessment

Ethiopia is a landlocked country situated in the Eastern Africa, between the 3° N and 15° N Latitude or 33° E and 48° E Longitude. The country is bordered to the north by Eritrea, to the east by Djibouti and Somalia, to the south by Kenya and to the west by South Sudan and Sudan. Ethiopia occupies a total area of about 1,127,127 km^2, of which 1,119,683 and 7,444 km^2 are dry land and water body areas, respectively (EBI, 2014a). Following the adoption of the currently in use constitution in 1993, the country follows a federalism governance system, with 11 administrative regional states and 2 city administrations delineated across the country (Figure 2). Ethiopia has the second-largest human population in sub-Saharan Africa after Nigeria (EBI, 2014a), where more than 85% of the total estimated population of 120 million people lives in rural areas and depends on natural resources for their livelihoods, economic development, and food security (EBI, 2014a, b).

The geography of Ethiopia consists of high plateaus with the central mountain range divided by Great Rift Valley. Ethiopia's landscape includes a large highland area of mountains and dissected plateaus, divided by the Rift Valley, which runs northeast to southwest and is surrounded by lowlands, steppes, or semi-desert. This large diversity of terrain has led to wide variations in climate, soils and natural vegetation and thus to unique biodiversity and high endemism. The main rainy season is from June to September and a smaller rainy season between February and April. The global biodiversity significance of Ethiopia has been recognized through Conservation International’s Biodiversity Hotspots. The country spans two Hotspots: the Horn of Africa and the Ethiopian Highlands (which is included in the Eastern Afromontane Hotspot). The areas included in the Hotspots covers the majority of the country, including the entire eastern area of Ethiopia below 1,100m above sea level (asl) and all highland areas above 1,100m asl (Williams et al., 2004).

The highlands of Ethiopia are the source of major perennial rivers. Ethiopia has several large lakes such as Lake Tana – the source of the Blue Nile. There are hardly any perennial surface water flows in areas below 1,500 m. Groundwater provides more than 90% of the water used for domestic and industrial supply in Ethiopia, but a very small proportion of groundwater is used for irrigation. Surface water resources supply most of the country’s electricity through hydropower. However, the country has also suffered recurring devastating droughts. Forests play vital roles in ensuring food security and sustainable livelihoods for millions of households throughout Ethiopia. Forest biodiversity provides ecosystem services estimated at 4% to the GDP through the production of honey, forest coffee, natural gums and timber. Forests also contribute to the economy even if it is with non-marketed products for example through i) soil erosion control which reinforces water infiltration in soils (that is crucial to reload groundwater reservoirs), ii) wood (energy) for households iii) mitigating climate change through C sequestration, iv) recreational (cultural) services for the people, etc.

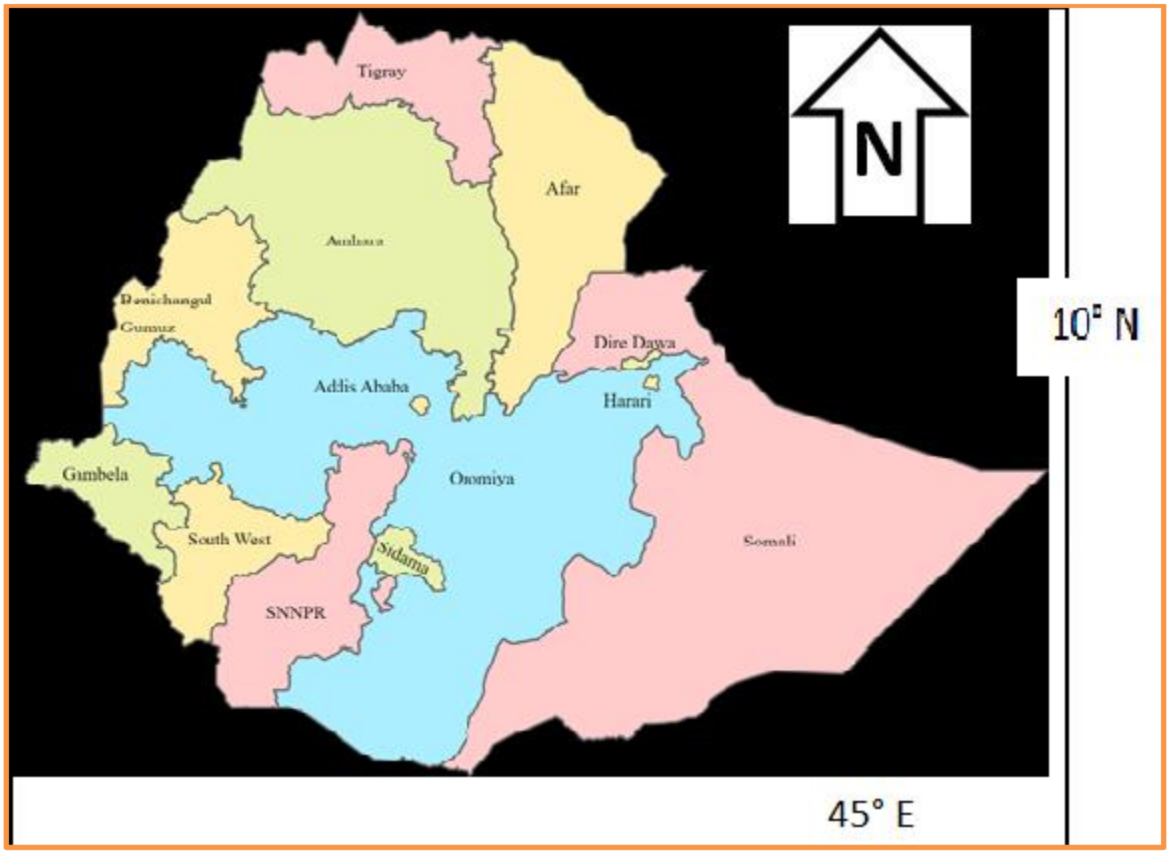

Figure 2. Regional States of the Federal Democratic Republic of Ethiopia (Source: EBI, 2014a).

3.2. Biodiversity Status and Trends – Ecosystem Approach

3.2.1. Realms, Ecoregions and Ecosystem Functional Groups

According to the IUCN Global Ecosystem Typology v2 of Keith et al. (2020), the following ecosystem types can be distinguished in Ethiopia in the three upper level ecosystem typologies: (i) all realms, except marine realm, (i) four of the five Ecosystem Realms (Terrestrial, Subterranean, Freshwater and atmosphere realms) – and three Transitional Realms (Terrestrial-Subterranean, Terrestrial-Freshwater, and Subterranean-Freshwater Realms) –; (ii) 13 of the 25 biomes; and (iii) 49 of 108 EFGs (Table 2; see also Keith et al., 2020).

Table 2. Types of upper three IUCN Global ecosystem typologies (realms, biomes and Ecosystem Functional Groups (EFGs)) identified in Ethiopia, following Keith et al. (2020).

REALM	Biome	EFGs
TERRESTRIAL	T1. Tropical-subtropical forests	T1.1 Tropical-subtropical lowland rainforests T1.2. Tropical-subtropical dry forests and thickets T1.3. Tropical-subtropical montane rainforests T1.4. Tropical heath forests
	T3. Shrublands & shrubby woodlands	T3.4 Rocky pavements, screes and lava flows
	T4. Savannas and grasslands	T4.1 Trophic savannas T4.2 Pyric tussock savannas T4.3 Hummock savannas
	T5. Deserts and semi-deserts	T5.1 Semi-desert steppes T5.2 Thorny deserts and semi-deserts T5.3 Sclerophyll hot deserts and semi-deserts T5.4 Cool deserts and semi-deserts T5.5 Hyper-arid deserts
	T6. Polar-alpine	T6.5 Tropical alpine grasslands and shrublands
	T7. Intensive land-use systems	T7.1 Annual croplands T7.3 Plantations T7.4 Urban and industrial ecosystems T7.5 Derived semi-natural pastures and oldfields
SUBTERRANEAN	S1 Subterranean lithic systems	S1.1 Aerobic caves S1.2 Endolithic systems S2.1 Anthropogenic subterranean voids
SUBTERRANEAN-FRESHWATER	SF1 Subterranean freshwaters	SF1.1 Underground streams and pools SF1.2 Groundwater ecosystems
	SF2 Anthropogenic subterranean freshwaters	SF2.1 Water pipes and subterranean canals SF2.2 Flooded mines and other voids
TERRESTRIAL-FRESHWATER-	TF1 Palustrine wetlands	TF1.1 Tropical flooded forests and peat forests TF1.3 Permanent marshes TF1.4 Seasonal floodplain marshes TF1.5 Episodic arid floodplains TF1.6 Boreal, temperate and montane peat bogs
FRESHWATER	F1 Rivers and streams	F1.1 Permanent upland streams F1.2 Permanent lowland rivers F1.4 Seasonal upland streams F1.5 Seasonal lowland rivers F1.6 Episodic arid rivers
	F2 Lakes	F2.1 Large permanent freshwater lakes F2.2 Small permanent freshwater lakes F2.3 Seasonal freshwater lakes F2.4 Freeze-thaw freshwater lakes F2.5 Ephemeral freshwater lakes F2.6 Permanent salt and soda lakes F2.7 Ephemeral salt lakes F2.8 Artesian springs and oases

		F2.9 Geothermal pools and wetlands F2.10 Subglacial lakes
	F3 Artificial fresh waters	F3.1 Large reservoirs F3.2 Constructed lacustrine wetlands F3.3 Rice paddies F3.5 Canals, ditches and drains
TOTAL	**13**	**49**

3.2.2. Sub-global Ecosystem Types in Ethiopia

Ethiopia spans two of the 34 global Hotspot biodiversity areas (i.e., high biodiversity and high biodiversity threat levels): the Horn of Africa and the Ethiopian Highlands (part of the Eastern Afromontane Hotspot) (Williams et al., 2004; Figure 3).

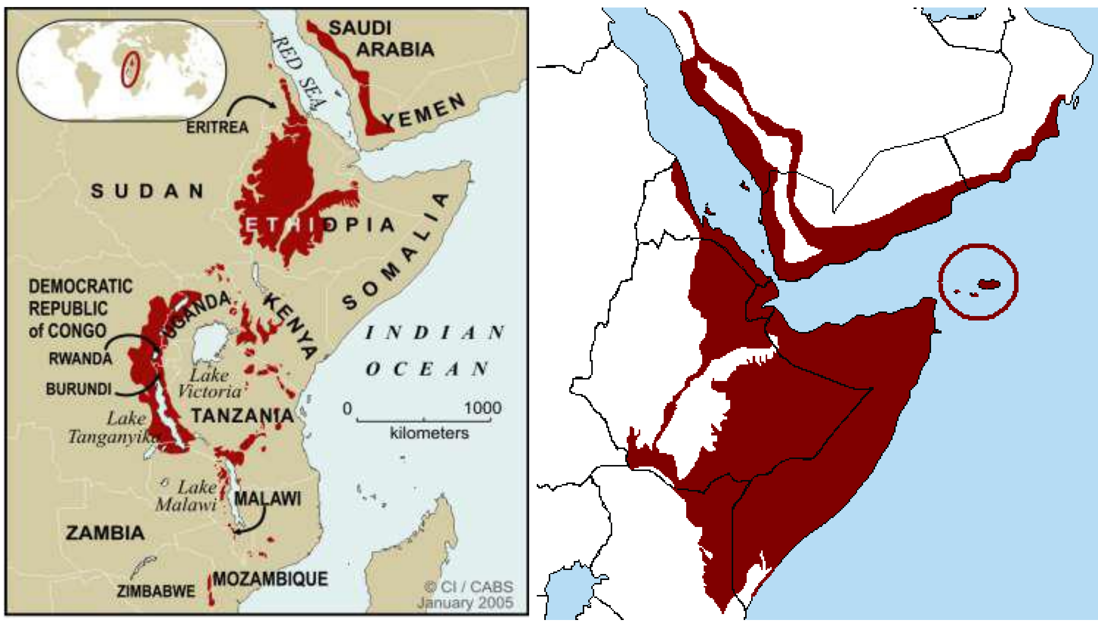

Figure 3. Eastern Afromontane (Ethiopian highlands) (left) and Horn of Africa (right) hotspot biodiversity areas (Source: Williams et al., 2004).

Delineations and descriptions of ecosystem types in Ethiopia have been inconsistent; different ecosystem organizational levels being used either interchangeably or mixed, two or more ecosystem types are lumped or certain ecosystem types often missing (IBC, 2009, 2014). However, vegetation types have been considered as ecosystem types in the country (see Figure 4), corresponding to the lowest level (i.e., level 6) of the IUCN Global ecosystem typologies defined by Keith et al., 2020). This ecosystem classification approach, which is based on resemblances in biodiversity composition (e.g., plant species) and underlying environmental conditions and ecological processes that shaped the ecosystem (vegetation) types (Friis and Demissiew, 2001; IBC, 2009; Friis et al., 2010), has been adopted both in the National Biodiversity Strategy and Action Plan (IBC, 2005; EBI, 2014a) and the Fifth National Biodiversity Report (EBI, 2014b).

In this section, with a slight modification of this nationally adopted ecosystem type classification system, we describe 17 major ecosystem types present in Ethiopia: 14 terrestrial, 2 Terrestrial-Freshwater and 1 Freshwater ecosystem types. Modifications to the traditional ecosystem typologies in this report include splitting the "Afroalpine and Subalpine ecosystems" into "Afroalpine belt" and "Ericaceous Forest" ecosystem types, following Friis et al. (2010). Our justification for this is that these ecosystem types clearly support dissimilar fauna and flora assemblages, and recent ecological studies of global and regional alpine ecosystem (e.g., Junior & Clark, 2019) have treated "Alpine ecosystem" as only areas above the ericaceous belt. Further, despite the ever-increasing trend of land use changes to agricultural lands and urbanization and their impacts on biodiversity, there is growing evidence of the importance of biodiversity conservation of these ecosystems globally (see Asefa et al., 2017a). Thus, we also introduce human-modified ecosystems, "Agricultural ecosystems" and "Urban ecosystems"; both have been missing from ecosystem descriptions in Ethiopia until very recently where they are covered in the revised NBSAP 2015–2025 (see EBI, 2014b). Ethiopia's long agrarian history has caused alterations of natural habitats into human-dominated ecosystems, but also made the country recognised as a centre of agro-biodiversity, designated as one of eight Vavilov Centres around the world (IBC, 2009).

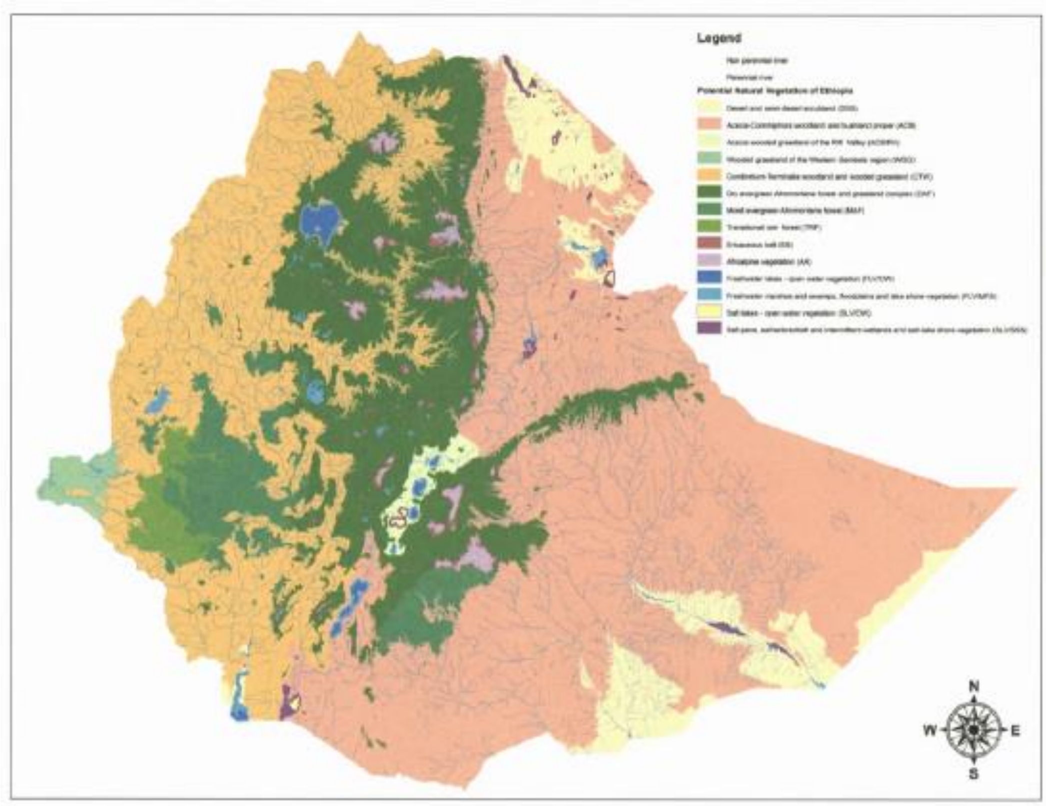

Figure 4. A map showing the distribution/locations of vegetation types of Ethiopia (Source: Friis et al., 2010, Figure 13).

3.2.2.1 Terrestrial Realm

A. Natural Ecosystems

1. Afroalpine Moorlands Ecosystem

This ecosystem is found on the north-western and south-eastern mountain ranges usually at elevation >3,200m asl. The Ethiopian highlands support the greatest proportion of Afroalpine habitat (4,585km^2; 64%) in the continent Africa (Yalden, 1983). While the greatest proportion of Afroalpine belt in Ethiopia is found in the Bale Mountain ranges (in the south-eastern highlands), considerable areas are also found in the Simien mountains (north-western highlands) and Arsi (south-eastern highlands) (Williams et al., 2004). This ecosystem is characterized by vegetation with five distinctive lifeforms (Friis et al., 2010): giant rosette plants, tussock grasses (and sedges), acquiescent rosette plants, cushion plants, and sclerophyllous shrubs (and dwarf-shrubs). As such, vegetation of the Afroalpine belt is best described by a combination of the endemic Giant Lobelia (*Lobelia rhynchopetalum*), cushion-forming species of *Helichrysum spp*. (e.g., *Helichrysum splendidum, H. cymosum, H. gofense, etc),* herbaceous species of *Alchemilla (Alchemilla* *abyssinican, A. haumanni, A. fisherii, etc*), and grass families of Poaeae, including the endemic species of genera *Festuca* and *Agrostis* (IBC, 2009; Figure 5). According to Friis et al. (2010), 22 species of woody species have been recorded to occur in Afroalpine belt.

Afroalpine ecosystems in Ethiopia represent unique ecological islands and are important habitats for several unique, endemic and/or threatened vertebrate species. For example, largest or entire populations of many of the Ethiopian endemic wild mammals are found in this ecosystem, such as Walia Ibex, Mountain Nyala, Starck's Hare, Ethiopian Wolf, Gelada Baboon, and the Giant Mole Rat and several rodent species (see section 3.3 for detail on the importance of Afroalpine ecosystem for vertebrate conservation in Ethiopia). Similarly, 58 bird species are known to breed in the Afroalpine ecosystem, including six Afroalpine specialist and 15 of the total 17 endemic species, such as the Ankober serin (*Crithagra ankoberensis*) which occurs only in the northern ranges of Ethiopia, Spot-breasted Lapwing, Blue-winged Goose and Black-headed Siskin (A. Asefa, unpubl. data). Other important birds include Red-billed Chough, Wattled Crane, Bearded Vulture and Golden Eagle. Ethiopia's Afroalpine regions are also critical stopover and foraging habitats for a significant proportion of sub-Saharan migrants from Eurasia, adding to their cross-continental importance to global avifauna (Clouet et al., 2000; IBC, 2005; BMNP, 2017).

This ecosystem, along with the adjacent ericaceous belt, is the most critically important ecosystem for millions of Ethiopians; it is the source of major rivers of Ethiopia on which people depend for domestic use (drinking, cocking, and sanitation), irrigation and hydropower. In addition, many of Ethiopia's endemic and threatened fauna and flora species are restricted to this ecosystem (SMNP-GMP, 2008; EBI, 2014a; BMNP-GMP, 2017). Consequently, this ecosystem is relatively well-represented in the Ethiopian protected area system, including, among others, the Simien, Bale and Arsi Mountains National Parks, and Guassa and Abune Yosef community conservation areas (EBI, 2014a). However, this ecosystem is found under increasing pressure arising from human settlement and subsequent expansion of crop cultivation and livestock grazing (EBI, 2020; Table 3).

2. Ericaceous Belt Ecosystem

This ecosystem is found below the alpine belt on the north-western and south-eastern mountain ranges between 3,000 and 3,200m asl. The characteristic woody species are *Erica arboria* and *E. trimera* (Friis et al., 2010). They share most of the faunal species occurring in the Afroalpine ecosystem, including the endemic Walia Ibex, Mountain Nyala, Starck's Hare, Ethiopian Wolf and Gelada Baboon, and birds such as the Black-headed Siskin and Ankober Serin. Similar to the Afroalpine ecosystem, this ecosystem has been threatened from settlement, expansion of crop cultivation, livestock grazing and fire burning (EBI, 2020; Table 3).

3. Montane Grassland Ecosystem

This ecosystem occurs in the areas where human activity has been largest and most intense for several thousand years, at altitudes between 1,500 and 3,200m asl. Characteristic species of the montane grassland ecosystems include species, including endemics, of the grasses *Pennisetum, Hyparrhenia, Cynodon, Eragrostis, Panicum, Cymbopogon, Chloris* and *Andropogon.* Legumes species, particularly Trifolium, sedges and rushes are also abundant plants in this ecosystem (IBC, 2009). Ground orchids make up an important component of the montane grassland biodiversity: 10 of the 45 species of Habenaria are endemic. Where soil conditions allow, woodland with an open single-layered canopy or with isolated trees also occur in this ecosystem. Such woody plants include *Acacia abyssinica, Juniperus procera, Olea europaea subsp. cuspidata, Celtis africana* and *Maesa lanceolata* (IBC, 2005).

These ecosystems are those used for the traditional mixed farming of Ethiopia and are densely inhabited by people. They are, therefore, highly disturbed. As a result, the mammalian wildlife resource is extremely poor across most areas; but, at some areas it serves as a critical habitat for a number of conservation significant species. For example, the montane grasslands (Gaysay Valley) in the northern section of the Bale Mountains National Park supports over half of the entire global population of the endangered endemic Mountain Nyala (BMNP-GMP, 2017). The ecosystem hosts high diversity of grassland specialist bird species, including half of the 18 endemic species and 56 Afrotropical Highlands Biome species (IBC, 2005; Asefa et al., 2016). Despite its immense biodiversity importance, this ecosystem has been experiencing considerable habitat degradation and alterations due to agricultural expansion, overgrazing and over harvesting of selected species (EBI, 2020).

Figure 5. Typical Afromalpine and ericaceous ecosystems ecosystems in Ethiopia.

4. Dry Evergreen Montane Forest and Evergreen Scrub Ecosystems

Dry evergreen montane forest ecosystem in Ethiopia is found throughout highlands and mountains occurring at altitudinal ranges of 1,500 to 3,200m asl. This vegetation is characterized by *Olea europea subsp. cuspidata, Juniperus procera, Prunus africana, Celtis kraussiana, Euphorbia ampliphylla, Dracaena spp. Carissa edulis, Euclea divinorum, Rosa abyssinca, Mimusops kummel, Ekebergia capensis*, etc. In moister areas, this vegetation type includes Podocarpus falcatus and is associated with stands of highland Bamboo (*Arundinaria alpina*). The patches of grassland are rich in species including many legumes. The most important grass genera are *Hyparrhenia, Eragrostis, Panicum, Sporobolus* and *Pennisetum* while the most important herbaceous legumes are species of *Trifolium, Eriosema, Indigofera, Tephrosia* and *Crotalaria*. Climbers include *Smilax aspera, Rubia cordifolia, Urera hypselodendron, Embelia schimperi, Jasminum abyssinicum,* various species in the Cucurbitaceae and other families that often are associated with this element of the vegetation (EBI, 2009; Friis et al., 2010; EBI, 2014a,b).

Overall, a total of 460 woody plant species have been recorded from vegetation type, with 128 (27.8%) species not shared with other vegetation types, 102 (22.2%) shared with Riverine Forest ecosystem and 89 (19.4%) with the montane moist forest ecosystems (Friis et al., 2010). This ecosystem is a key habitat for a number of wildlife species, such as Mountain Nayala, Menelik's Bushbuck and Leopard and endemic bird species, such as the Yellow-fronted Parrot, Prince Ruspoli's Turaco, Abyssinian Catbird, White-backed Black Tit and Abyssinian Woodpecker (EWNHS, 2001).

The dry evergreen montane forests are under severe pressure and threat of destruction caused by deforestation for wood products (especially fuel wood extraction), fire, encroaching agriculture and overgrazing. In most areas, these threats have resulted to reduce coverage and being replaced by bushland and scrub (IBC, 2005; Table 3).

5. Moist Montane Forest Ecosystems

The montane moist forest ecosystems comprise the highland forests of the country. They are found on the south-western highlands – within an altitudinal range between 800 to 2,500m asl – and in the south-eastern highlands, including the Harenna forest in the southern slope of the Bale Mountains – within an altitudinal range of between 1,450 to 2,700m asl (Friis et al., 2010). This ecosystem is richer in woody species diversity; about 160 and 200 vascular plant species have been recorded from the south-western forests and the south-eastern plateau forests, respectively (Friis et al., 2010). Characteristic tree species in the upper canopy at relatively lower elevations include *Pouteria adolfi-friedericii, Podocarpus falcatus* (in the Bale Mountains), *Olea capensis, Prunus africana, Albizia schimperiana, Milletia ferruginea and Celtis africana,* and at higher elevations include *Polyscias fulva, Schefflera volkensii, S. abyssinica, Allophyllus abyssinicus* and *Dombeya torrida*. Sub-canopy species include, among others, *Croton macrostachyus, Cordia africana, Dracena steudneri, Syzygium guineense subsp. afromontanum, Sapium ellipticum, Ilex mitisRothmannia urcelliformis* and the tree fern, *Cyathea manniana*. The shrub layer consists of species such as *Coffea arabica, Galiniera saxifraga, Teclea nobilis, Ocotea kenyensis, Clausena anisata, Maesa lanceolata* and *Maytenus spp*. Epiphytes include many species of orchids, the endemic *Scadoxus nutans, Peperomia* spp., ferns and fern allies such as *Lycopodium*. The ground vegetation is mainly made up of herbaceous plants including species of *Acanthus*, *Justicia*, *Impatiens* and some grass and sedge species (IBC, 2005,, 2009).

This ecosystem supports diverse and many endemic and/or threatened species of larger mammals including, among others, unique forest populations of savannah species such as Lion and Wild Dog (in the Bale Mountains), Bale Monkey, Leopard, Common Jackal, Bush Pig and Giant Forest Hog (Williams et al., 2004; BMNP-GMP, 2017). Two regions encompassed within this ecosystem (Bale Mountains and SW highland forests) are recognized as centres of diversity and endemism and speciation of smaller mammals (rodents and shrews) (Lavrenchenko and Bekele, 2017; Lavrenchenko et al., 2017) and amphibians (Largan & Spawls, 2011; Mengistu et al., 2011, 2013). This ecosystem also supports most of forest-specialist and conservation concern (highland biome, endemic, range-restricted, globally threatened) species of birds occurring in the country (EWNHS, 2001).

Although they are included under some types of protected area categories (Natural Forest Priority Areas, Biosphere Reserve, National Parks, etc), such initiatives have been less effective in protecting the ecosystem. Timber extraction, coffee and tea plantations, agricultural expansion, human settlement and fire hazards are the most direct human activities threatening the forests (EBI, 2014; Table 3).

6. Transitional Rainforest

These forest ecosystems are known from the western escarpment of the Ethiopian highlands at altitudes between 450 and 1500m, where the rainfall (between 2000 to 2700 mm per year) and hence humidity from the rainbearing south-westerly winds is highest (Friis et al., 2010). The transitional rain forests are most similar in physiognomy and composition to the Moist Afromontane forests. A total of 101 species of woody plants have been recorded to occur in the Transitional rain forest, of which 47 (47% of the total) only recorded from this vegetation type. Characteristic species in the canopy layer includes *Manilkara butugi, Aningeria altissima, Pouteria alnifolia, Anthocleista schweinfurthii, Antiaristoxicaria, Ficusmucuso, F. exasperata, Milicia excelsa, Morns mesozygia, Trilepisium madagascariense, Croton sylvaticus, Celtis toka, C. zenkeri, C. gomphophylla, Diospyros abyssinica, Zanthoxylum leprieurii, Albizia schimperiana, and A. grandibracteata*. From the lower strata of small trees or large shrubs include *Celtis philippensis, Dracaena fragrans, Eugenia bukobensis, Metarungia pubinervia,* and *Rinorea friisii.*

Liana such as *Urera trinervis* and *Ventilago diffusa* and drought-resistant epiphyte ferns, such as *Phymatosoruss colopendria*, *Microsorum punctatum* and *Platycerium elephantotis* are also characteristic of this forest type (see Friis et al., 2010).

The forests are highly threatened because of the high value of the timber from these tree species. In addition, the areas covered by these forests are highly suitable for development as coffee- and tea-plantations. Also, the increasing population of the area, resulting in more shifting cultivation and burning of the big trees, presents major problems for the preservation of this vegetation type in south-western Ethiopia (Table 3).

7. Acacia-Commiphora Woodland Ecosystem

This ecosystem occurs between 900 and 1,900m asl in the south-eastern dry lowland and in the Rift Valley regions of the country. It is characterized by drought resistant tree and shrub species with small leaves and which are usually deciduous. A total of 565 species have been recorded to occur in this vegetation type (ecosystem), with over half of the total only been being recorded from this vegetation type (Friis et al., 2010; EBI, 2014). This ecosystem is characterized by woody species of *Acacia senegal, A. seyal, A. tortilis, Balanites aegyptiaca, Commiphora africana, C. boranensis, C. cilliata, C. monoica* and *C. serrulata*. The ground layer is rich in *Acalypha, Barleria, Aerva, Aloe* and grass species. The characteristic mammals include the critically endangered African Wild Ass and the endangered Grevy’s Zebra (IUCN, 2020). Key bird species inhabiting this ecosystem include White-tailed Swallow, Stresemann’s Bush Crow, Salvadori's Seedeater and Yellow-throated Seedeater, all of which are globally threatened (EWNHS, 2001; EBI, 2014a; IUCN, 2020; BirdLife International, 2021).

Most of the National parks of the country are found in this ecosystem. However, extraction of firewood and charcoal, expansion of agriculture, wide spreading invasion of exotic species such as *Prosopis juliflora* and bush encroachment of indigenous species and fire are the major threats to these ecosystems.

8. Combretum-Terminalia Woodland Ecosystem

This ecosystem occurs between 500 and 1,900m asl along the western escarpment of the Ethiopian highlands. It is characterized by small to moderate-sized tree species with broad leaves, often deciduous, such as *Boswellia papyrifera, Anogeissus leiocarpa, Stereospermum kunthianum* and *species of Terminalia*, *Combretum* and *Lannea*. There are extensive stands of the lowland bamboo, *Oxytenanthera abyssinica*, in the valleys. The vegetation in this ecosystem has developed under the influence of fire and many of the trees have thick corky bark while the herbs are generally geophytes. The most notable endemic mammal found in the ecosystem is Swaynes' Hartebeest. The characteristic birds include Red-Red-billed Pytilia, Green-backed Eremomela, Bush Petronia and Black-rumped Waxbill.

Overall, a total of 199 woody plant species are known from this ecosystem, of which 81 (40.7% of the total) have only been recorded from this vegetation type (Friis et al., 2010). Indiscriminate fire, settlement/resettlement of refugees and people from the highlands, overgrazing by domestic livestock and inappropriate agricultural investment practices are the major threats to this ecosystem.

9. Woodland of the Western Gambella region

The Wooded Grassland of the Western Gambella Region (WGG) has been defined by the Global Lakes and Wetlands Database (GLWD) as "Freshwater Marsh and Floodplains". This, a lowland semi-evergreen forest ecosystem, is restricted to the lowlands of the eastern Gambella Region in Abobo and Gog (Gok) districts. The area where the ecosystem occurs is characterized by well-drained sandy soils with an altitudinal range of 450 to 800m asl. The area has a mean annual temperature of 35 to 38°C and an annual rainfall range of 1,300 to 1,800 mm (Friis, 1992; Friis et al., 2010). The characteristic species of this forest are *Baphia abyssinica* and *Tapura fischeri* (Friis, 1992). The common species in the upper canopy layer include *Celtis gomphophylla, Celtis toka, Lecaniodiscus fraxinifolius, Zanha golungensis, Trichilia prieureana, Alistonia boonei, Antiaris toxicaria, Malacantha alnifolia, Zanthoxylum lepreurii, Diospyros abyssinica, Milicia excelsa, Baphia abyssinica, Vepris dainellii* and *Celtis zenkeri.* The middle canopy layer is dominated by *Acalyphla neptunica, Erythroxylum fischeri, Tapura fischeri, Ziziphus pubescens* and *Xylopia parviflora* (Friis, 1992). Species such as *Whitfieldia elongata, Argomuellera macrophylla,* *Alchornea laxiflora, Mimulopsis solmsii, Oncoba spinosa, Oxyanthus speciosus* and *Rinorea ilicifolia* are characteristics of the shrub layer (Friis, 1992; IBC, 2009; Friis et al., 2010).

Shifting cultivation through land clearing commonly performed through slash and burn has contributed a lot to the depletion of this forest. Recent development has brought in dam and road construction, various settlements and state farms along with extractions of fuel wood, all of which have contributed a lot towards the shrinkage of this unique forest ecosystem (IBC, 2005, 2009; EBI, 2014a, b).

10. Desert and Semi-desert Scrubland Ecosystems

This vegetation type occurs below 400m asl in the north-eastern (including the Danakil depression), the Ogaden (south-eastern), around Lake Chew Bahir and the delta of the Omo river in in the southern parts of Ethiopia. It is characterized by scarce plant cover and by the presence of small trees, shrubs and herbs, which may be succulent, geophytic or annual. At least, 131 woody species have been recorded from this ecosystem type, including 10 (7.6% of the total) species unique to this vegetation type (Friis et al., 2010). The characteristic species of trees and shrubs include *Acacia ehrenbergiana, Boswellia ogadensis, Commiphora erosa, C. longipedicellata, Gyrocarpus hababensis, Cadaba barbigera, C. divaricata,* and *Ziziphus hamur.* Characteristic succulents include *Euphorbia doloensis (endemic), E. ogadenensis, E. quadrispina* and *Aloe citrina.* Drought-tolerant annual grass species of family Poaceae include *Dactyloctenium aegyptium,* and perennials, such as *Panicum turgidum* (Friis et al., 2010). This ecosystem is a core habitat for critically endangered Wild Ass in Ethiopia (IUCN, 2020).

Due to external influences, such as human and animal trampling around watering points, the land can locally be completely devoid of vegetation and at times also the ground may naturally be bare, because the species are annual or geophytic. The soils are often alluvial, associated with the basins of rivers such as Awash and Wabi Shebele, but may also be derived from basaltic rocks, lava flows and limestone slopes, for example in the north-eastern parts of the Afar region.

Table 3. A summary of threats to each natural ecosystem type.

Ecosystem type	Major threats
Afroalpine Moorlands Ecosystem	Grazing, settlement, agriculture
Ericaceous Belt Ecosystem	Grazing, settlement, agriculture, fire
Montane Grassland Ecosystem	Grazing, settlement, agriculture
Dry Evergreen Montane Forest and Evergreen Scrub Ecosystems	Deforestation for wood products (especially fuel wood extraction), fire, encroaching agriculture and overgrazing
Moist Montane Forest Ecosystems	Timber extraction, coffee and tea plantations, agricultural expansion, human settlement and fire hazards
Transitional Rainforest	Logging, coffee- and tea-plantations, shifting cultivation and burning of the big trees
Acacia-Commiphora Woodland Ecosystem	Extraction of firewood and charcoal, expansion of agriculture, wide spreading invasion of exotic species such as *Prosopis juliflora* and bush encroachment of indigenous species and fire
Combretum-Terminalia Woodland Ecosystem	Fire, settlement/resettlement of refugees, overgrazing by domestic livestock and inappropriate agricultural investment practices
Wooded Grassland of the Western Gambella region	Shifting cultivation, dam and road construction, settlements and state farms, extractions of fuel wood
Desert and Semi-desert Scrubland Ecosystems	Livestock grazing/browsing
Riparian Vegetation Ecosystem	Cultivation, logging and livestock grazing/browsing
Wetland Ecosystem	Cultivation, logging and livestock grazing/browsing, pollution, overharvesting resources
Aquatic Ecosystem	Cultivation, logging and livestock grazing/browsing, urbanization, overharvesting, invasive species, pollution

B. Human-shaped Ecosystems

Human-shaped ecosystems include agricultural and urban ecosystems. Agriculture (crop cultivation and livestock husbandry) is the dominant land use type and the major economic activity contributing to GDP of Ethiopia. In 2019, agricultural land in Ethiopia was estimated at 381,391 km^2 (33.6% of land area of the country), which is a 10.8% increase from that in 2006 or an average annual increase of over 0.8% (Table 4). In Ethiopia, agricultural lands comprise of croplands (arable land – land under seasonal crops – and land under permanent crops), permanent meadows and pasture lands and non-crop plantations (FAO, 2021; Table 4). These are briefly described as follow.

11. Annual & Perennial Non-timber Crops

Crop cultivation is the dominant land use type and the major economic activity contributing to GDP of Ethiopia. In 2019, agricultural land in Ethiopia was estimated at 381,391 km^2 (33.6% of land area of the country), which was a 10.8% increase from that in 2006 or an average annual increase of over 0.8% (Table 4). These data also indicate that net forest change between the two periods was a net reduction of 9,537.6 km^2, with natural forest showing a decline of 15,336.9 km^2 (8.5%) and plantation forest almost doubled (an increase of 5,799.3 km^2) (Table 4). Assuming that the major cause of reduction in the extent of natural forest were agricultural land and plantation, then out of the 37,128.6 km^2 increase in agricultural land between the two periods, 9.537.6 km^2 was likely due to conversion of natural forest to crop land. The remaining 27,591 km^2 agricultural land might be conversion of other not arable lands (e.g., hilly slopes, wetlands, etc).

Table 4. Extent of areas (in km^2) of major agricultural related land use/cover in Ethiopia in year 2006 and 2019 and change in extent of coverage between the two periods (calculated as: area in year 2019 - area in year 2006) and percentage change [computed as: ((area in year 2019 – area in year 2006)/area in 2006)*100], divided by area in 2006). Total land area of Ethiopia 1,135,429 km^2. Values in bracket are percentages.

Land use/cover	Year: 2006	Year: 2019	Extent of Change	% change
Forest area (% of land area)	182,009.3 (16.0)	172,471.7 (15.2)	-9538	-5.2
Planted Forest (% forest land)	5,842.5 (3.2)	11,641.8 (6.4)	5799	99.3
Other naturally regenerated forest (% forest land)	176,166.8 (96.8)	160,829.9 (93.3)	-15337	-8.7
Agricultural land (% of land area)	344,262.1 (30.3)	381,390.7 (33.6)	37129	10.8

Cropland (% of Agricultural land)	143,064.1 (41.6)	180,079.1 (47.2)	37015	25.9
Arable land (% of cropland)	134,778.6 (94.2)	162,892 (90.5)	28113	20.9
Land under permanent crops (% of cropland)	8,296.7 (6.2)	17,277.0 (10.6)	8980	108.2
Land under permanent meadows and pastures (% of Agricultural land)	201,198.1 (58.4)	201,198.1 (52.8)	0	0.0

Source: FAOSTAT. 2021. http://www.fao.org/faostat/en/#data/EL [accessed 27 august 2021].

The Ethiopian government's plan to transform Ethiopia from an agriculture-based economy into a manufacturing hub is assumed to hinge on greater agricultural-sector productivity and improved transport and energy infrastructure[2]. As such, the broad-based average annual growth economic 9.9% a year from 2007 to 2018 Ethiopia experienced has been largely driven by high levels (over 50%) of general government's expenditure allocated and public and private-sector investment in the agricultural sector such as coffee, oilseeds, pulses, fruits and vegetables, honey, cut flowers, tea, spices, fruits, sugarcane and cotton production Boere et al., 2016; Zewdie et al., 2021).

The major field crops grown in Ethiopia are classified in four groups: cereals, pulses, oil seeds, stimulant and industrial crops. The widely cultivated cereal species are teff (*Eragrostis tef*), barley (*Hordeum vulgare*), Emmer and other wheat species (*Triticum spp*), sorghum (*Sorghum biocolor*), finger millet (*Eleusine coracana*), maize (*Zea mays*), rice (*Oryza sativa*), oat (*Avena sativa*), and pearl millet (*Pennisetum glaucum*). Pulse species include Faba bean (*Vicia faba*), Field pea (*Pisum sativum*), chickpea (*Cicer arientinum*), lentil (*Lens culinaris*), haricot bean (*Phaseolus vulgaris*) and grasspea (*Lathyrus sativus*). The major oil seed species in terms of production are *Brassica spp*., niger seed (*Guizotia abyssinica*), linseed (*Linum ustitatissimum*), sesame (*Sesamum indicum*), safflower (Carthamus tinctorius), sunflower (*Helianthus annuus*), crambe (*Crambe abyssinica*) and groundnut (*Arachis hypogea*)[3]. Coffee, tea and khat are the major stimulant cash crops both for domestic and international trades.

Coffee and oily seeds are the main export crops in Ethiopia. For example, in 2018, Ethiopia has exported 836 Mt Coffee, making it the 11th largest exporter of Coffee in the world (USDA, 2020a). In the same year, Ethiopia also exported 363Mt of other Oily Seeds, making it the 3rd largest

[2] FAOSTAT. 2021. http://www.fao.org/faostat/en/#data/EL [accessed 27 august 2021].
[3] FAOSTAT. 2021.

exporter of Other Oily Seeds in the world. The three major oilseed crops (sesame, soybean, and Niger seed) together contribute to nearly 15% of Ethiopia's total agricultural export earnings, second only to coffee (USDA, 2020b).

12. Permanent Meadows and Pasture Lands

Permanent meadows and pasture lands are one of the two major types of agricultural land uses in Ethiopia, representing over half (201,198 km^2) of the total area of land under agricultural uses (FAO, 2021; Table 4). In Ethiopia, livestock grazing takes place virtually across all ecosystems, but meadow and pasture lands provide permanent grazing areas for domestic animals. This ecosystem is characterized by natural grasslands under permanent grazing by domestic animals and/or used for harvesting the grass; arable land abandoned for more than 3 years, being in the process of succession by herbaceous vegetation; drained wetlands/peatlands converted to pasture; pastures with scattered trees and shrubs, with woody vegetation covering <30% of the ground. Although the conservation values of this ecosystem is not fully understood in Ethiopia, some studies show that meadows and pasturelands support many conservation dependent (globally threatened and/or endemic), grassland-specialist bird species, such as the near threatened, endemic Abyssinian Long-claw and Rouget's Rail, and the critically endangered White-winged fluftail and Liban Lark (EWNHS, 2001).

13. Plantation Forests

Plantation forestry practices in the county comprise of three major forms: industrial plantation (19.6% of the total plantation forest area), peri-urban energy forestry (77.7%) and small-scale plantations (2.7%) (Limenih and Kassa, 2011). Current estimated total area of plantation forests in Ethiopia is about 11,642 km^2, representing about 5% of the total forest land of the country (FAO, 2021; Table 4). As shown on Table 4, area covered by plantation forests in Ethiopia has been increasing at an average annual rate of 6% since 2006. A limited number of species from four genera (*Eucalyptus, Cuppressus, Pinus* and *Acacia*) account for the majority of plantation forests in Ethiopia. Eucalyptus, with *E. globulus* and *E. camaldulensis* being the most widespread species of the genus, covers more than 90% of the total planted forest area in Ethiopia (Limenih and Kassa, 2011).

Plantation forests are dominant in four regional states of Ethiopia: Amhara, Southern Nations, Nationalities and Peoples, Tigray and Oromia regions (Lemenih and Kassa, 2014). Plantation forestry practices in the county comprise of three forms: industrial plantation (19.6% of the total plantation forest area), peri-urban energy forestry (77.7%) and small-scale plantations (2.7%) (Limenih and Kassa, 2011). The former two are mainly government-driven, while the third is undertaken principally by farming households. In some cases, industrial plantations are established on degraded forest lands bordering remnant natural forests such as Munessa Shashamane and Belete Gera forests (Lemenih and Kassa, 2014). These plantations have dual objectives of providing round industrial wood and reducing pressure on natural forests.

14. Urban Ecosystem

Urbanization is becoming the fastest growing rate of land use amongst many other land use types in developing countries, like Ethiopia, due to high influx of rural communities to local towns and cities coupled to industrialization and technology advancement (Woldesemayat and Genovese, 2021). Expansion of urban areas in Ethiopia often takes place in the expense of natural ecosystems (Coppel and Wüstemann, 2017; Pramanik and Punia, 2019), but there are some government-led initiatives (e.g., urban greenery projects, such as creation of public parks, home garden tree planting and riverside development projects) that may serve to off-set potential impacts on biodiversity of urban expansion. Here, we propose that urban environments to be considered as one ecosystem type of human-shaped ecosystems and be treated in any relevant national and local biodiversity conservation programmes.

Although our current knowledge and understanding about land use patterns and their values for biodiversity conservation in urban environments of Ethiopia is limited, the major components of urban ecosystems in Ethiopia that are relevant to biodiversity conservation are public parks, riverside (semi)-natural vegetation, street side tree/shrub plantations, home gardens and office gardens (e.g., embassies). For example, Urban Green Space in the city of Addis Ababa covers 97 km^2 (19% of the total 520 km^2 are of the city) (Woldesemayat and Genovese, 2021). These green spaces include vegetation in the residence landscape structure, commercial landscape, municipal services (e.g., abattoirs, fire and emergency services, green centres, cultural and civic centres, centres, and festival sites and plaza functions), social services (e.g., built-up areas commonly used for healthcare, stadiums, social care centres, district sports fields, research centres, education, and civic services), transport areas (bus freight terminals, bus depots, surface parking, parking buildings and linear features such as roads), and administration premises (federal institutions, city institutions, sub-city and district administration, as well as international organizations such as embassy compounds) (Woldesenber and Genovese, 2021). The conservation values of urban ecosystems in Ethiopia should be studied and integrated in all urban development plans.

3.2.2.2 Terrestrial-Freshwater Realm

15. Riparian Vegetation Ecosystem

Riverine ecosystem has been defined as vegetation found along perennial and non-perennial rivers. As such, they are neither terrestrial nor freshwater realms in the strict sense; rather represent an interface between these realms. Width of areas along the rivers covered by Riparian Vegetation varies considerably depending on topography and edaphic conditions, but typically is narrow stripes of 20-50m wide (IBC, 2005; Friis et al., 2010). They occur across elevation ranges as a matrix within other ecosystem types, wherever water is available, and the soil and other environmental variables conditions allow their growth. However, the vegetation along rivers at altitudes above 1800m is mostly similar to that of the forests of similar altitudes (Moist or Dry Afromontane Forests). Thus, characteristic Riparian ecosystems are found below 1800m altitude, especially conspicuous even at non-vegetated areas (Friis et al., 2010).

The fact that it occurs embedded within other ecosystem types mean that Riparian Vegetation ecosystem is not only highly variable in vegetation structure, density and floristic composition, but also contains high species diversity but low unique species (Friis et al., 2010). About 242 species of woody plants are known to occur in this Riverine vegetation; of these only 64 (26.5% of the total) have only been recorded from this vegetation type. This vegetation type consists of taller tree forests and woodlands, with typical woody species including *Diospyros mespiliformis, Syzygium guineense, Tamarindus indica, Hyphaene thebaica* and *Phoenix reclinata* (Friis et al., 2010).

16. Wetland Ecosystem

Marshes and swamps are wetlands with temporary or permanent body of water. Commonly marshes are restricted to those wetlands that are dominated by grasses, rushes, reeds, Typha spp., sedges and other herbaceous plants, while swamps often also contain low woody vegetation (shrubs and trees) in addition to the wetland vegetation. Swamps and marshes are two dominant types of wetlands in Ethiopia, both together covering an estimated area of 1,803 km^2 (0.16% landmass of the country) (Mckee, 2007). Floodplains are flat or nearly flat landscapes adjacent to rivers that experience occasional or periodic flooding (Friis et al., 2010). There are many areas with swamp vegetation in the central and western parts of Ethiopia, while there are fewer to the east. The Fogera and Dembia swamps (both around Lake Tana in the GD floristic region), the Chomen swamps and the Dabus swamps (western Ethiopia) region, and large areas of the lower part of the Omo valley. While most wetlands in Ethiopia, including all those described above) are freshwater, there are also some saline wetlands (salt pans, brackish saline) in the Danakil depression in the Afar region and in the southern part of the Rift Valley lakes.

The characteristic species in Freshwater marsh/swamp, floodplain and lake shore vegetation along the shores of fresh water lakes include the sedges such as *Cyperns digitatus, C. denudatus, C. dichroostachys, C. elegantulus, C. latifolius* and *Ascolepis capensis*, as well as other herbs, including *Juncus dregeanus, Floscopa glomerata, Syngonanthus wahlbergii, Xyris capensis, Persicaria decipiens, Ranunculus multibus, Plectranthus punctatus, and Nymphaea lotus.* Among the woody species characteristic of these habitats are *Phoenix reclinata, Lannea edulis, Aeschynomenecristata var. pubescens, Aeschynomene elaphroxylum, Aeschynomene pfundii* and *Aeschynomene schimperi* (Mckee, 2007; Friis et al., 2010; EBI, 2014a, b). The vegetation in saline wetlands is characterized by *Suaeda monoica*, and herbaceous species of *Atriplex spp.* and *Salicomia spp*. (Friis et al., 2010; Figure 6).

Wetland ecosystem plays vital roles in socioeconomic development (crucial water source to the people and their livestock, especially during dry season) and biodiversity conservation (Mckee, 2007; IBC, 2005, 2009). For example, many of Ethiopia’s endemic and/or globally threatened bird species are wetland dependent. This includes Spot-breasted Plover, Blue-winged Goose, Rouget’s Rail, White-winged Flufftail, Wattled Crane, Corn Crake, Shoebill, Black-winged Pratincole and

Great Snipe. As such, many of the wetlands have been identified as Important Bird Areas (IBAs) of the country (EWNHS, 2001).

3.2.2.3 Freshwater Realm

17. Aquatic Ecosystem

Aquatic ecosystems are areas covered by open-water bodies. In Ethiopia, it includes rivers, lakes and reservoirs, which all together are estimated to cover a surface area of 11,896 km^2 (1.1% of total landmass of the country) (for detail on the river basins and major contributing rivers and on the lakes, see Abebe and Gebeh, 2003; FAO, 2021).

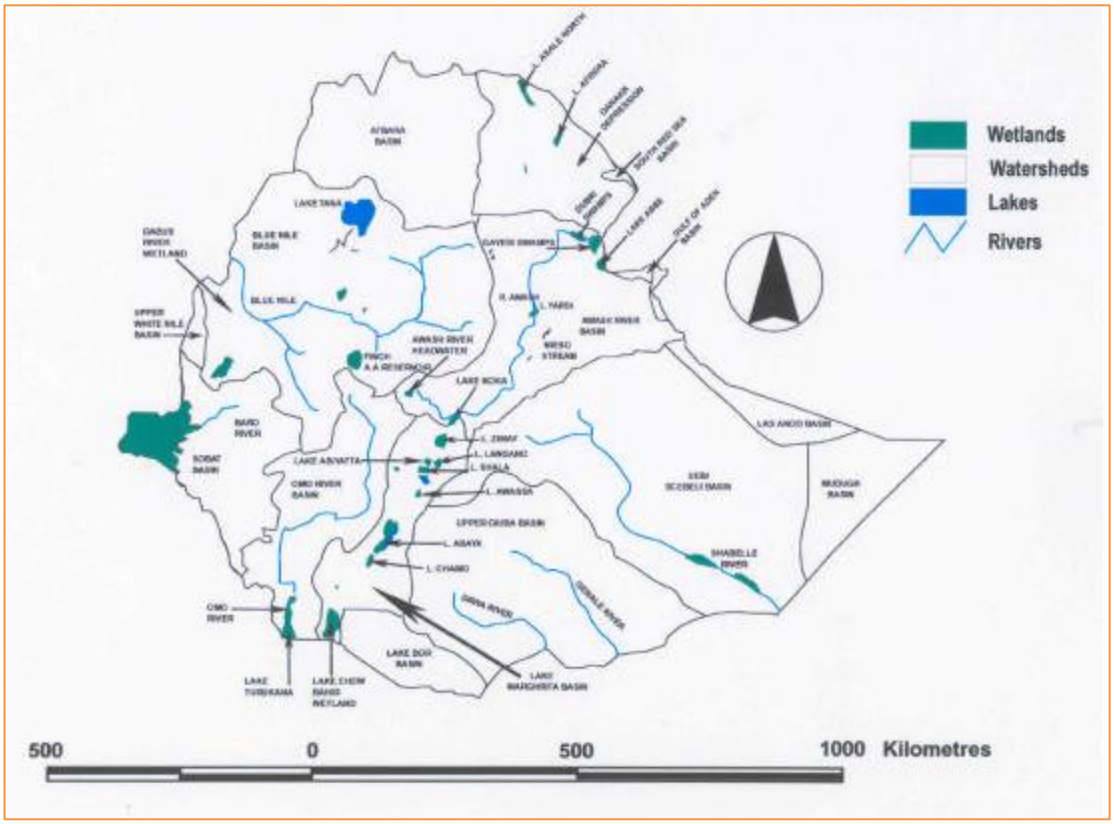

Figure 6. A map showing major freshwater ecosystems in Ethiopia, including lakes, rivers and other types of wetlands, such as marshes and swamps (source: Abebe and Gebeh, 2003).

Ethiopia also has 12 major river basins with total annual surface runoff of 110 billion m3. These drainage basins cover almost the whole country, with the main drainage basins flowing away from the rift system either towards the Nile System in the West or to the Indian Ocean in the Southeast. For instance, Tekeze and Angereb rivers, the headwaters of Atbara, drain the plateaus north of

Lake Tana; the Central plateau is drained by Blue Nile rising from the same Lake Tana (Diddessa and Dabbus, rising in the high rainfall western regions being its main tributaries). West of the Rift valley, the Omo River (part of the Omo-Gibe Drainage System) flows south to Lake Turkana. The Wabi-Shebele and Genale Dawa river watersheds drain the plateaus of the southeast to Indian Ocean. However, the rivers that flow in the rift system form closed basins, the Awash River basin, moves northward into the closed Lake Abbe in the Afar Depression (Figure 6; for detail on the basins and major contributing rives, see Abebe and Gebeh, 2003).

Ethiopia has about 61 major natural lakes (9 of which are saline and 4 Crater lakes), and 29 man-made reservoirs (13 hydroelectric, 11 irrigation and 5 drinking water reservoirs/dams) (Abebe and Gebeh, 2003; IBC, 2005). These lakes are distributed across the country between altitudes of 150m below sea level to 4,000m asl. The surface areas of the lakes varies considerably from less than 1 km^2 to over 3,600 km^2 (Lake Tana, the largest lake) and mean depths range from few meters to over 266m (Lake Shalla, the deepest lake in the country). This ecosystem type can be classified into two subtypes of natural lakes: freshwater water bodies (lakes with salt content of <3000 parts per million) and saline water bodies (lakes with salt content >3000 parts per million) (Friis et al., 2010). The major freshwater lakes in Ethiopia include Lake Tana (in the north-eastern Ethiopia), Lake Ashange (in the Tigray region), Lakes Hayk and Ardibo (northern Ethiopia), Lake Langeno, Lake Ziway and Lake Awasa (central rift valley), Lakes Abaya, Chamo and Turkana (southern rift valley). The Koka reservoir, and the Fincha and Chomen reservoirs. The salts in the salty lakes are found in the central rift valley, including Lakes Abijata, Shala and Chitu and Afar lakes in the north-eastern Ethiopia.

The characteristic plant species in the freshwater lakes include floating aquatics such as native *Lemna aequinoctalis, L. gibba, L. minor, Wolfia marrhiza, Pistia stratiotes, Eichhomia crassipes* and *E. natans*. In addition, there are several phytoplankton species, such as *Aphanothece microspora, Chroococus disperses, Closterium spp., Meliorosa granulata, Microcystis aeruginosa*, etc (Friis et al., 2010). Characteristic species of saline lakes is species of the family Chenopodiaceae tends to dominate, and phytoplankton, mainly consisting of cyanobacteria, such as *Anabaenopsis spp., Anomoeoneis sphaerocarpa, Oscillatoria spp.* and *Spirulina platensisis*.

Aquatic ecosystems harbor over 200 species of phytoplankton, including many important blue-green algae such as *Arthrospira spp*. (Friis et al., 2010; EBI, 2020). They are also feeding and/or breeding habitats of many conservation significant resident and migratory bird species. The large-sized reptile, the Nile crocodile, mammal, Hippopotamus, species are found in these ecosystems.

3.3. Biodiversity Status & Trends - Species Approach: Flora and Fauna

The IUCN Red List Index (RLI) measures overall trends in extinction risk for sets of species, based on genuine changes in their status over time. The Red List Index is calculated based on genuine changes in the number of species in each category of extinction risk on The IUCN Red List of Threatened Species. Thus, the RLI is calculated based on a number of species groups for which all species included in the calculation have been assessed multiple times (birds, mammals, amphibians, corals and cycads). This allows the Red List Index to function as an indicator measuring the aggregate change in survival probability across the entire species group. Red List Indices for each country are weighted by the fraction of each species' distribution occurring within the country; they therefore show how adequately species are conserved or not in the country relative to its potential contribution to global species conservation. The index varies from 1 if the country has contributed the maximum it can to the global RLI (i.e., if all species in the country are classified as Least Concern) to 0 if the country has contributed the minimum it can to the global RLI (i.e., if all species in the country are classified as Extinct or Possibly Extinct). A downwards trend indicates declining aggregate survival probability of the country's species.

The RLI for Ethiopia is for three taxonomic groups (mammals, birds and amphibians). It is depicted on Figure 7 and shows a constant trend over time, indicating that the overall extinction risk for species in Ethiopia is unchanged over the period of the last 25 years (1995–2020). However, the RLI of species survival in Ethiopia is low (0.85) which indicates that the status of biodiversity is degraded and should be enhanced.

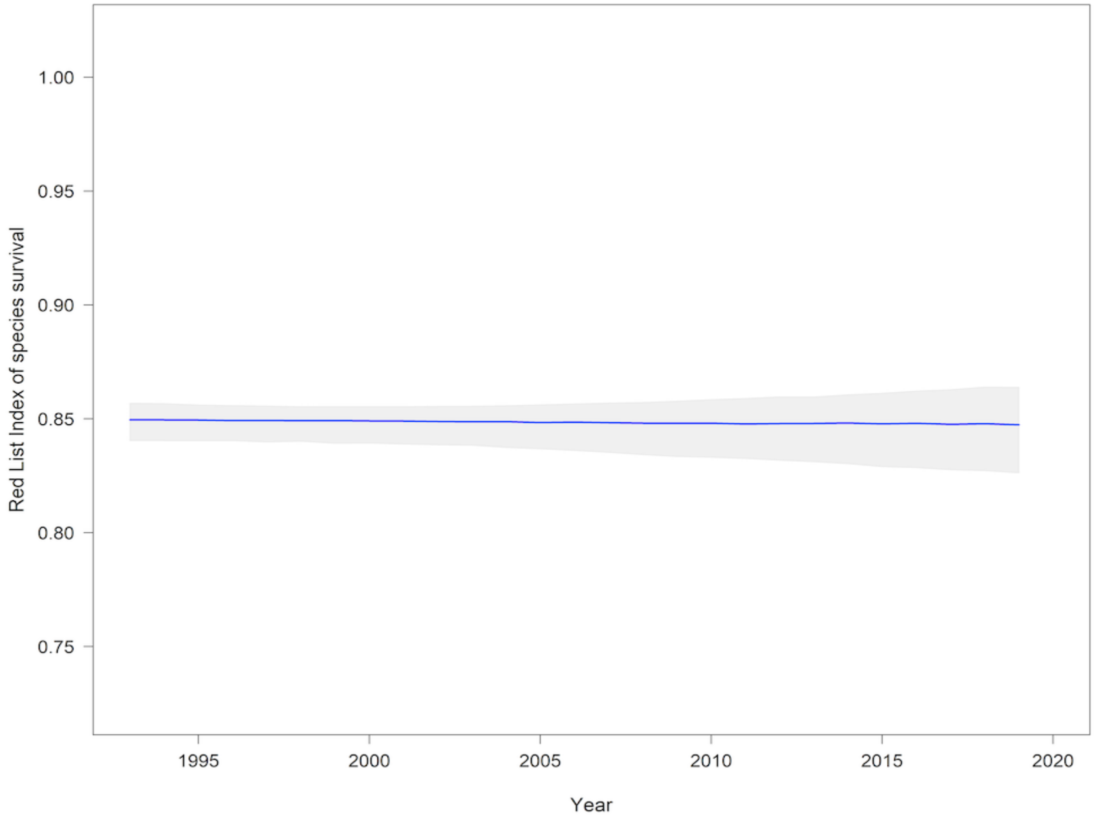

Figure 7. The Red List Index[4] of species survival for Ethiopia, weighted by the fraction of each species' distribution occurring within the country. Grey shading shows 95% confidence intervals, where relevant. The index varies from 1 to 0 (Source: IBAT country profile - Ethiopia).

3.3.1. Mammals

The first comprehensive summary checklist of Ethiopia's mammal species was published in the mid-1990s by Yalden et al. (1996), who described 277 species. Extensive research works conducted on the taxonomy, ecology and evolutionary history of mammals in Ethiopia in the last two decades, for example by the Ethio-Russian, and the Ethio-Czech Joint Biological Expeditions (Lavrenchenko et al., 2017), have provided improved knowledge on the diversity, endemism and ecology of mammals of Ethiopia (Lavrenchenko et al., 2016; Lavrenchenko and Bekele 2017; Bryja et al., 2019, 2022). For example, the detection for the first time within the boundaries of Ethiopia of one order (Pholidota), one family (Manidae), four new genera and 1 species, and

[4] For further information on RLI visit http://www.iucnredlist.org/about/publication/red-list-index.

description of 16 new endemic species have been reported during this period (Bryja et al., 2022; Krasova et al., 2022).

Updated checklist shows that Ethiopia has 322 mammal species, distributed across 144 genera, 43 families and 14 orders (Lavrenchenko and Bekele, 2017; Konečný et al., 2020; Mizerovská et al., 2020; American Society of Mammalogists, 2021; Bryja et al., 2022; Krasova et al., 2022; Table 5). Out of these, 63 (19.6% of the total species) species are endemic to Ethiopia, comprising of 42 rodents, 13 shrews, 3 bats, 2 primates, 2 artiodactyls, 1 carnivore and 1 hare (Lavrenchenko and Bekele 2017; Konečný et al., 2020; Bryja et al., 2022; Krasova et al., 2022; Table 5; Figure 8). The three most species rich taxonomic Orders, that altogether comprised of 70% of the total species, are Rodentia (93 species, 30% of the total), Artiodactyla (84, 27%) and Chiroptera (40, 13%) (Table 5).

Table 5. Orders and number of families and species of mammals in Ethiopia.

Order	No. family	No. genera	No. species
Artiodactyla	5	25	40
Carnivora	6	24	33
Chiroptera	11	37	84
Eulipotyphla	2	4	35
Hyracoidea	1	2	2
Lagomorpha	1	1	5
Macroscelidea	1	1	1
Perissodactyla	1	1	3
Pholidota	1	1	1
Primates	2	9	15
Proboscidea	1	1	1
Rodentia	10	39	101
Tubulidentata	1	1	1
Total:	**43**	**146**	**322**

Despite the occurrence of high diversity, endemism and globally threatened species, the current status and/or trends of populations are unknown for nearly half (156 species: 48.5%) of the total mammal species of Ethiopia and for 42 (66.7% of the total 63) of the endemic species. Furthermore, IUCN Threat status has not been established for 50 species, including about a third (24 species) of the endemic species (Tables 6 & 7), due to data deficiency or not evaluated yet (IUCN, 2020 Table 6). Thus, information provided herein on these parameters should be interpreted cautiously and while taking into account of these caveats. Overall, considering the subset of 163 (52% of the total species) species for which population trend has been known, 89 species are showing either increasing (4 species) or stable (84 species) populations trend and 74 species showing declining trend (IUCN, 2020). There are 39 (12.4%) globally threatened mammal species in Ethiopia: (i) 3 critically endangered species—Harenna Shrew (*Crocidura harenna*), African Wildlife (*Equus africanus*) and Water Mouse (*Nilopegamys plumbeus*), (ii) 16 endangered species, (iii) 20 vulnerable (IUCN, 2020; Table 7). Furthermore, 13 species are currently considered as near threatened (IUCN, 2020). Sixteen (28%) of the total threatened species in Ethiopia are endemics, with populations of 14 species being either declining or unknown (Table 6 & 7). Among threatened endemic species, only *Ibex walie* (Vulnerable) is exhibiting increasing population trend and *Crocidura lucina* (Endangered) showing Stable trend (IUCN, 202o; Table 6). However, two critically endangered endemic species (*Nilopegamys plumbeus* and *Crocidura harenna*) deserve special attention for research and conservation actions. For example, repeated field expeditions have failed to relocate, even from their type localities, these species, suggesting that these species might have possibly extinct (Lavrenchenko and Bekele, 2017; Lavrenchenko et al., 2017; IUCN, 2020). Finally, looking at the geographic and habitat distributions of Ethiopia's endemic mammals show that 28 (48.3%) and 25 (43.1%) are highland (alpine moorlands) and forest species, respectively. Further analysis of these species reveals that 38 (65.5%) are restricted either to the south-eastern or the western (north-western and south-western highlands in the west of the rift valley) highlands (Table 7). These results demonstrate the importance of Ethiopian highlands for mammal species evolution and speciation and of the rift valley acting as a geographical barrier between these highlands, but also the need to prioritize key areas within these regions for effective conservation.

Table 6. Number of species of mammals with different population trend and IUCN Red List threat category in Ethiopia (Abbreviations for threat categories: CR = critically endangered; EN = endangered; VU = vulnerable; NT = near-threatened; LC = least concern; DD = data deficient; NE = not evaluated).

	IUCN Red List threat category							
Population trend	CR	EN	VU	NT	LC	DD	NE	Total
(a) All species								
Decreasing	2	12	13	12	34	2		75
Increasing			1		3			4
Stable		1	2		79	1		83
Unknown	1	3	4	3	99	21	24	153

Total	3	16	20	14	215	24	22	314
(b) Endemic species								
Decreasing	1	4	2	2	6			15
Increasing			1					1
Stable			1		3			4
Unknown	1	3	3	2	9	7	18	43
Total	2	7	7	4	18	7	12	63

Table 7. Updated list of the endemic mammals of Ethiopia. Habitat: Highland = Erica bush and Afroalpine moorland. Distribution is given for forest, highland and intrazonal species: W = western plateau, E = eastern plateau, NE/RV = North-east/Rift Valley. Conservation status is assessed by the World Conservation Union (IUCN). The IUCN threat categories (based on version 3.1): CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NE = Not Evaluated.

No.	**Species**	**Habitat**	**Distribution**	**IUCN Threat status**	**Population trend**
1	*Crocidura harenna*	Forest	E	CR	Decreasing
2	*Nilopegamys plumbeus*	Intrazonal	W	CR	Unknown
3	*Crocidura afeworkbekelei*	Highland	E	DD	Unknown
4	*Canis simensis*	Highland	W + E	EN	Decreasing
5	*Crocidura bottegoides*	Forest	E	EN	Decreasing
6	*Crocidura phaeura*	Forest	W + E	EN	Unknown
7	*Lophuromys chercherensis*	Forest	E	EN	Unknown
8	*Lophuromys pseudosikapusi*	Forest	W	EN	Unknown
9	*Tachyoryctes macrocephalus*	Highland	E	EN	Decreasing
10	*Tragelaphus buxtoni*	Highland	E	EN	Decreasing
11	*Capra walie*	Highland	W	VU	Increasing
12	*Cercopithecus djamdjamensis*	Forest	E	VU	Decreasing
13	*Crocidura lucina*	Highland	E	VU	Stable
14	*Desmomys yaldeni*	Forest	W	VU	Unknown
15	*Grammomys minnae*	Forest	W + E	VU	Decreasing
16	*Lophuromys melanonyx*	Highland	W + E	VU	Unknown
17	*Myotis scotti*	Forest	W + E	VU	Unknown
18	*Arvicanthis blicki*	Highland	E	NT	Unknown
19	*Crocidura glassi*	Highland	E	NT	Decreasing
20	*Crocidura macmillan*	Forest	W	NT	Unknown
21	*Lophuromys brevicaudus*	Highland	W	NT	Decreasing

22	*Arvicanthis abyssinicus*	Highland	W + E	LC	Stable
23	*Crocidura baileyi*	Highland	w	LC	Decreasing
24	*Crocidura thalia*	Forest	W + E	LC	Unknown
25	*Dendromus lovati*	Highland	W + E	LC	Decreasing
26	*Desmomys harringtoni*	Forest	W + E	LC	Unknown
27	*Lepus starcki*	Highland	W + E	LC	Unknown
28	*Lophuromys chrysopus*	Forest	W + E	LC	Unknown
29	*Lophuromys flavopunctatus*	Forest	W	LC	Unknown
30	*Lophuromys simensis*	Forest	W	LC	Unknown
31	*Mastomys awashensis*	Savanna	RV	LC	Unknown
32	*Mus imberbis*	Highland	W + E	LC	Decreasing
33	*Mus mahomet*	Forest	W + E	LC	Stable
34	*Mus proconodon*	Savanna	RV	LC	Stable
35	*Mus triton*	Forest	E	LC	Stable
36	*Otomys typus*	Highland	W	LC	Decreasing
37	*Stenocephalemys albipes*	Forest	W + E	LC	Unknown
38	*Stenocephalemys albocaudata*	Highland	W + E	LC	Unknown
39	*Stenocephalemys griseicauda*	Highland	W + E	LC	Decreasing
40	*Theropithecus gelada*	Highland	W + E	LC	Decreasing
41	*Crocidura yalden*	Forest	W	DD	Unknown
42	*Dendromus nikolausi*	Highland	E	DD	Unknown
43	*Lophuromys menageshae*	Forest	W	DD	Unknown
44	*Mylomys rex*	Forest	W	DD	Unknown
45	*Plecotus balensis*	Forest	W + E	DD	Unknown
46	*Stenocephalemys ruppi*	Highland	W	DD	Unknown
47	*Crocidura makeda*	Highland	NW	NE	Unknown
48	*Crocidura similiturba*	Highlands	SW	NE	Unknown
49	*Dasymys griseifrons*	Intrazonal	W	NE	Unknown
50	*Lophuromys brunneus*	Forest	W	NE	Unknown
51	*Otomys cheesmani*	Intrazonal	W	NE	Unknown
52	*Otomys fortior*	Forest	W	NE	Unknown
53	*Otomys helleri*	Highland	E	NE	Unknown
54	*Otomys simiensis*	Highland	W	NE	Unknown
55	*Otomys yaldeni*	Highland	E	NE	Unknown
56	*Scotophilus ejetai*	Forest	W	NE	Unknown
57	*Stenocephalemys sokolovi*	Highland	W	NE	Unknown

58	*Stenocephalemys zimai*	Highland	W	NE	Unknown
59	*Acomys mullah*	Savanna	NE RV	NE	Unknown
60	*Acomys louisae*	Savanna	NE RV	NE	Unknown
61	*Mus harennensis*	Forest	E + W	NE	Unknown
62	*Acomys mullah*	Savanna	NE RV	NE	Unknown
63	*Arvicanthus mearnsi*	Savanna	NE RV	NE	Unknown

Figure 8. Some globally threatened mammal species of Ethiopia (from top left to botton right: Ethiopian wolf, Walia Ibex, Harenna Shrew and Mountain Nyala).

3.3.2. Birds

The number of bird species in Ethiopia ranges from 821 to 875 (BirdLife International, 2021; Lapage, 2021), depending on the source of data. Lapage (2021) data include migrant and vagrant species and recent new records, most of which not documented by BirdLife International. Futhermore, official checklist of the Ethiopian Biodiversity Institute comprises of 926 species of birds, including 19 enedemic (EBI, unpublished data). Thus, to avoid confusion and be consistent with IUCN Red List data (IUCN, 2020), in this particular study, analysis and descriptions are made based on the BirdLife International's checklist and associated data. Accordingly, Ethiopia has a total of 821 bird species belonging to 342 genera, 89 families and 26 orders (BirdLife International, 2021; IUCN, 2020). Ethiopia's avifauna consists of: i) 665 (81% of the total) of landbird species and 156 (19%) waterbird species; and ii) 546 (67%) resident species, including 17 (2% of the country total) breeding endemic species (Table 8; Figure 9), and 275 (33%) migratory species. Nearly half of the bird species occurring in Ethiopia belong to the taxonomic order Passeriformes (BirldLife International, 2020; see Appendix 9). Following Ash and Atkins (2009), bird species of Ethiopia comprises of 187 (27.8% of the total) biome-restricted species: 56 species of Afrotropical biome, 97 species of Somali-Masai, 19 species of Sudan-Guinea biome, 9 species of Saharo-Sindian biome and 6 species of Sahelian biome. Furthermore, Ethiopia has 13 bird species of restricted range (distribution confined to an area of <50,000 km^2; EWNHS, 2001; Table 8).

Data on global level population trends for over 90% of the total species are accessible on the IUCN Red List of Threatened Species website (IUCN, 2020). Here, in the absence of a national Red List for birds of Ethiopia, we used these data as the most robust available data. For endemic species these data can reliably be used to reflect local trends. Overall, two-thirds of the bird species occurring in Ethiopia are characterized by Stable (471 species, or 57%) or Increasing (79 species, 10%) population trends. Whereas a quarter (214 species) of the species are experiencing Decreasing population trends (BirdLife International, 2021). There are 36 globally threatened bird species in Ethiopia, all with declining populations: seven critically endangered, 12 endangered and 17 vulnerable (BirdLife International, 2021; IUCN, 2020; Table 8–10). Critically endangered species include White-winged Flufftail (*Sarothrura ayresi*), Sociable Lapwing (*Vanellus gregarious*), Liben Lark (*Heteromirafra archeri*) and four vulture species (Table 9). Eight (47% of the total) of the 17 endemic species are currently known to be facing extinction risks (or with IUCN red list status of CR, EN or VU). This includes two endangered species, Ethiopian Bushcrow (*Zavattariornis stresemanni*) and Yellow-throated Seedeater (*Crithagra flavigula*), and six vulnerable species, such as the White-tailed Swallow (*Hirundo megaensis*), Salvadori's Seedeater (*Crithagra xantholaema*) and Ankober Serin (*Crithagra ankoberensis*) (Table 10).

Table 8. Restricted-range bird species within the Endemic Bird Areas in Ethiopia (number in front of each EBA name refers to their Codes).

113 – Jubba and Shabeelle valleys Endemic Bird Area (Occur in four IBAs)	**114 – South Ethiopian highlands Endemic Bird Area (Occur in seven IBAs)**
Streptopelia reichenowi	*Tauraco ruspolii* (endemic, EN)
Mirafra degodiensis (endemic, EN)	*Caprimulgus solala* (endemic, EN)
Ploceus dichrocephalus	*Heteromirafra sidamoensis* (endemic, EN)
	Hirundo megaensis (endemic, VU)
	Zavattariornis stresemanni (endemic, EN)
115 – Central Ethiopian highlands Endemic Bird Area (Occur at seven IBAs)	**063 – Northern Ethiopia Secondary Area (occur at 1 IBA)**
Francolinus harwoodi (endemic, EN)	*Cercomela dubia* (endemic, EN)
Myrmecocichla melaena (endemic, EN)	
Serinus flavigula (endemic, EN)	
Serinus ankoberensis (endemic, VU)	

Table 9. Number of bird species with different population trend and IUCN Red List threat category in Ethiopia (Abbreviations for threat categories: CR = critically endangered; EN = endangered; VU = vulnerable; NT = near-threatened; LC = least concern; DD = data deficient; NE = not evaluated).

	IUCN threat status category						
Population trend	CR	EN	VU	NT	LC	DD	Total
(a) All species							
Decreasing	7	10	14	21	162		214
Increasing					79		79
Stable		2	2	3	463	1	471
Unknown			1		54	2	57
Total	7	12	17	24	758	3	821
(b) Endemic species							
Decreasing		2	5	3	2		12
Stable					3		3
Unknown			1		1		2
Grand Total		2	6	3	6		17

Figure 9. Some endemic species pf Ethiopia (from left to right: Prince Ruspoli's Turaco, Stressman's Crow, Harewood's Francolin)

Table 10. IUCN Threat Status and population trends of globally threatened (CR = critically endangered; EN = endangered; VU = vulnerable; NT = near-threatened) bird species of Ethiopia.

No.	Species	IUCN Threat Status	Population trend	Remark	No.	Species	IUCN Threat Status	Population trend	Remark
1	*Gyps africanus*	CR	Decreasing		31	*Falco fasciinucha*	VU	Decreasing	
2	*Gyps rueppelli*	CR	Decreasing		32	*Hirundo megaensis*	VU	Decreasing	Endemic
3	*Heteromirafra archeri*	CR	Decreasing		33	*Oxyura maccoa*	VU	Satble	
4	*Necrosyrtes monachus*	CR	Decreasing		34	*Streptopelia turtur*	VU	Satble	
5	*Sarothrura ayresi*	CR	Decreasing		35	*Struthio molybdophanes*	VU	Decreasing	
6	*Trigonoceps occipitalis*	CR	Decreasing		36	*Tauraco ruspolii*	VU	Decreasing	Endemic
7	*Vanellus gregarius*	CR	Decreasing		37	*Ardeotis arabs*	NT	Decreasing	
8	*Acrocephalus griseldis*	EN	Satble		38	*Ardeotis kori*	NT	Decreasing	
9	*Aquila nipalensis*	EN	Decreasing		39	*Aythya nyroca*	NT	Decreasing	
10	*Crithagra flavigula*	EN	Decreasing	Endemic	40	*Buteo oreophilus*	NT	Decreasing	
11	*Falco cherrug*	EN	Decreasing		41	*Calidris ferruginea*	NT	Decreasing	
12	*Geronticus eremita*	EN	Satble		42	*Circus macrourus*	NT	Decreasing	
13	*Neophron percnopterus*	EN	Decreasing		43	*Falco vespertinus*	NT	Satble	
14	*Polemaetus bellicosus*	EN	Decreasing		44	*Gallinago media*	NT	Decreasing	
15	*Pternistis atrifrons*	EN	Decreasing	Endemic	45	*Glareola nordmanni*	NT	Decreasing	
16	*Sagittarius serpentarius*	EN	Decreasing		46	*Gypaetus barbatus*	NT	Decreasing	
17	*Terathopius ecaudatus*	EN	Decreasing		47	*Haematopus ostralegus*	NT	Satble	
18	*Torgos tracheliotos*	EN	Decreasing		48	*Heterotetrax humilis*	NT	Decreasing	
19	*Zavattariornis stresemanni*	EN	Decreasing	Endemic	49	*Limosa lapponica*	NT	Decreasing	
20	*Aquila heliaca*	VU	Decreasing		50	*Limosa limosa*	NT	Decreasing	
21	*Aquila rapax*	VU	Decreasing		51	*Macronyx flavicollis*	NT	Decreasing	Endemic
22	*Aythya ferina*	VU	Decreasing		52	*Neotis denhami*	NT	Decreasing	
23	*Balearica pavonina*	VU	Decreasing		53	*Numenius arquata*	NT	Decreasing	
24	*Bucorvus abyssinicus*	VU	Decreasing		54	*Phoeniconaias minor*	NT	Decreasing	
25	*Bugeranus carunculatus*	VU	Decreasing		55	*Pternistis harwoodi*	NT	Decreasing	Endemic
26	*Caprimulgus solala*	VU	Unknown	Endemic	56	*Rougetius rougetii*	NT	Decreasing	

27	*Clanga clanga*	VU	Decreasing		57	*Rynchops flavirostris*	NT	Decreasing
28	*Crithagra ankoberensis*	VU	Decreasing	Endemic	58	*Scleroptila psilolaema*	NT	Decreasing
29	*Crithagra xantholaema*	VU	Decreasing	Endemic	59	*Stephanoaetus coronatus*	NT	Decreasing
30	*Cyanochen cyanoptera*	VU	Decreasing	Endemic	60	*Streptopelia reichenowi*	NT	Satble

3.3.3. Reptiles

Ethiopia has 253 species of reptile belonging to 81 genera, 27 families and 2 orders (Uetz et al., 2021). Five families are monotypic, represented by a single species and their corresponding genius. Only two families consist of about a quarter of the total genera and species of reptiles in Ethiopia: Gekkonidae, represented by 7 genera and 38 species, and family Colubridae by 12 genera and 31 species (Table 11). Twenty-six (10%) of reptile species are endemic to the country. Threat status of 94 (37% of the total species) reptile species in Ethiopia has not been assessed and population trends of 211 (83%) species are unknown (IUCN, 20201; Table 12). Currently, only Nubian Flapshell Turtle (*Cyclanorbis elegans*) is critically endangered and African Spurred Tortoise (*Centrochelys sulcata*) to be endangered. Two more species, Senegal Flapshell Turtle (*Cyclanorbis senegalensis*) and African Softshell Turtle (*Trionyx triunguis*) are also considered as vulnerable and Bale Two-horned Chameleon (*Trioceros balebicornutus*) as near-threatened species (IUCN, 2020). All these globally threatened species are experiencing population declines (IUCN, 2020; Table 12).

Table 11. Number of genera and species of reptiles of Ethiopia.

Family	No. genera	No. species	Family	No. genera	No. species
Agamidae	5	21	Leptotyphlopidae	2	9
Amphisbaenidae	1	1	Pelomedusidae	1	2
Atractaspididae	2	8	Phyllodactylidae	2	3
Boidae	1	2	Prosymnidae	1	4
Chamaeleonidae	3	12	Psammophiidae	4	18
Colubridae	12	31	Pseudoxyrhophiidae	1	1
Cordylidae	1	1	Pythonidae	1	1
Crocodylidae	1	1	Scincidae	5	21
Elapidae	2	8	Sphaerodactylidae	1	5
Eublepharidae	2	2	Testudinidae	3	3
Gekkonidae	7	38	Trionychidae	2	3
Gerrhosauridae	2	2	Typhlopidae	3	11
Lacertidae	6	19	Viperidae	4	11
Lamprophiidae	6	15	**Total: Families = 27**	**51**	**253**

Table 12. Number of species of reptiles with different population trend and IUCN Red List threat category in Ethiopia (Abbreviations for threat categories: CR = critically endangered; EN = endangered; VU = vulnerable; NT = near-threatened; LC = least concern; DD = data deficient; NE = not evaluated).

Population trend	IUCN Threat status category							
	CR	EN	VU	NT	LC	DD	NE	Total
(a) All species								
Decreasing	1	1	2	1	4			9
Stable					33			33
Unknown					88	29	94	211
Total	1	1	2	1	125	29	94	253
(b) Endemic species								
Decreasing				1				1
Stable					1			1
Unknown					9	7	8	24
Total				1	10	7	8	26

3.3.4. Amphibians

The first two most comprehensive reference materials on Ethiopian amphibians have been M.J. Largen's works who published annotated checklist of amphibians of Ethiopia in 1997 (Largen, 1997), followed by his publication of catalogue (Largen, 2001). These pioneer works have highlighted the exceptionally high level of endemism and the urgent need for further extensive research works (Largen, 2001). Studies conducted in the last decade, based on field surveys and application of modern DNA and molecular analysis technologies, have resulted to the discovery of many new taxa (i.e., genus and species) and several taxonomic revisions (e.g., Mengistu, 2012; Mengistu et al. 2013; Goutte et al., 2019; Tiutenko and Zinenko, 2021). The rate at which new species have been discovered clearly shows that our current knowledge on Ethiopia's amphibians is still incomplete (Mengistu et al. 2013; Tiutenko and Zinenko, 2021).

So far, 78 amphibian species, across 24 genera and 16 families, are known to occurring in Ethiopia (Amphibiaweb, 2021). All the species belong to order Anura, except the endemic species *Sylvacaecilia grandisonae* (family Indotyphlidae) that belongs to order Gymnophiona (Caecilians). Only four families contributed 75% (58 species) to the total 78 amphibian species in Ethiopia: Ptychadenidae making up 30% (23 species) to the total species, Bufonidae 18% (14 species), Hyperoliidae 17% (13 species) and Arthroleptidae 10% (8 species) (Amphibianweb, 2021). Ptychadena (within family Ptychadenidae) is the most specious genus (represented by 22 species), followed by Sclerophrys (Bufonidae) and Hyperolius (Hyperoliidae) which are represented by 10 and 5 species, respectively. However, a third of the total 24 genera are monotypic, i.e., in Ethiopia being represented by a single species (Amphibiaweb, 2021). Overall, five (20.8% of the total 24 genera) genera – *Sylvacaecilia*, *Altiphrynoides*, *Ericabatrachus*, *Balebreviceps* and *Paracassina* –, and half of the total species are endemic to Ethiopia (see Largen, 2001; Mengistu et al., 2017; Goutte et al., 2019; Amphibiaweb, 2021; IUCN, 2020; Tiutenko and Zinenko, 2021; Table 13).

Table 13. Number of amphibian species with different population trend and IUCN Red List threat category in Ethiopia (Abbreviations for threat categories: CR = critically endangered; EN = endangered; VU = vulnerable; NT = near-threatened; LC = least concern; DD = data deficient; NE = not evaluated).

	IUCN threat status category							
Population trend	CR	EN	VU	NT	LC	DD	NE	Total
(a) All species								
Decreasing	1	2	0	0	7	0	0	10
Stable	0	1	4	0	34	0	0	39
Unknown	2	3	0	1	6	5	14	31
Total	3	6	4	1	47	5	12	80
(b) Endemic species								
Decreasing	1	2						3
Stable		1	4		2			7
Unknown	2	3		1	6	5	14	31
Total	3	6	4	1	8	5	14	41

Three species appear to be confined to lowland areas of Ethiopia, but most endemics are associated with the Ethiopian highlands in the altitudinal range 1800–4000m asl (Table 14). The Highlands are particularly important habitats as several endemic amphibian genera and species are restricted to these highly fragmented areas. For Ethiopia, five – namely: *Sylvacaecilia, Altiphrynoides*, *Ericabatrachus*, *Balebreviceps* and *Paracassina* – of the 24 genera, and half of the 78 known species are endemic (Largen 2001: Amphibiaweb, 2021; IUCN, 2020; Table 13). As is the case for amphibians worldwide, survival of these species has been facing threats from habitat degradation, climate change, and a pathogenic fungal disease (Gower et al., 2021).

Distribution of 38 species is restricted to highlands, 31 to lowlands and 9 widespread in many habitats (Largen, 2001; Mengistu et al., 2017). Out of this, 18 species are restricted to south-eastern highlands and 10 species to western highlands (Mengistu et al., 2017). All, but four, of the endemic species are highland inhabitants, of which 18 are restricted to eastern highlands and 8 to western highlands (Table 14). There are 18 globally threatened species of amphibians in Ethiopia (3 CR, 9 EN, 5 VU, 1 NT), all of which are endemic to the country (IUCN, 2020 Table 14). However, the number of threatened species is probably underestimated: the threat status of 17 species (all endemic) has not been evaluated (12 species) or has been assessed as data deficient (DD, five species) (IUCN, 2020). Population trend for 61(78% of the total), including 29 endemic species, remains unknown. Nonetheless, the limited available data show that three species – the three critically endangered endemic species: *Altiphrynoides osgoodi*, *Balebreviceps hillmani* and *Ericabatrachus baleensis* – are experiencing severe population declines, while 14 species, including seven endemic, stable population trend (IUCN, 2020; Tables 13 & 14).

Table 14. Updated list of the endemic amphibians of Ethiopia. Habitat: Highland = Erica bush and Afroalpine moorland. Distribution is given for forest, highland and intrazonal species: W = western plateau, E = eastern plateau, LL= ?. Conservation status is assessed by the World Conservation Union (IUCN). The IUCN threat categories (based on version 3.1): CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NE = Not Evaluated.

No.	Scientific Name	Distribution	IUCN Threat Status	Population trend	No.	Scientific Name	Distribution	IUCN Threat Status	Population trend
1	*Balebreviceps hillmani*	E	CR	Decreasing	21	*Sylvacaecilia grandisonae*	W	LC	Unknown
2	*Altiphrynoides osgoodi*	E + W	CR	Unknown	22	*Phrynobatrachus minutus*	W	LC	Unknown
3	*Ericabatrachus baleensis*	E	CR	Unknown	23	*Sclerophrys langanoensis*	LL	DD	Unknown
4	*Ptychadena neumanni*	E + W	EN	Decreasing	24	*Phrynobatrachus inexpectatus*	E	DD	Unknown
5	*Xenopus largeni*	E + W	EN	Unknown	25	*Ptychadena filwoha*	LL	DD	Unknown
6	*Ptychadena nana*	E	EN	Stable	26	*Ptychadena wadei*	W	DD	Unknown
7	*Leptopelis susanae*	E + W	EN	Unknown	27	*Ptychadena harenna*	E	DD	Unknown
8	*Altiphrynoides malcolmi*	E	EN	Decreasing	28	*Phrynobatrachus inexpectatus*	E	DD	Unknown
9	*Afrixalus clarkei*	E	EN	Unknown	29	*Ptychadena robeensis*	E	NE	Unknown
10	*Leptopelis ragazzii*	E	VU	Stable	30	*Ptychadena beka*	E + W	NE	Unknown
11	*Leptopelis yaldeni*	E	VU	Stable	31	*Ptychadena amharensis*	W	NE	Unknown
12	*Afrixalus enseticola*	E	VU	Stable	32	*Ptychadena doro*	W	NE	Unknown
13	*Paracassina kounhiensis*	E + W	VU	Stable	33	*Ptychadena levenorum*	E	NE	Unknown
14	*Ptychadena erlangeri*	E + W	NT	Unknown	34	*Ptychadena nuerensis*	LL	NE	Unknown
15	*Ptychadena cooperi*	E + W	LC	Unknown	35	*Phrynobatrachus bibita*	W	NE	Unknown
16	*Leptopelis vannutellii*	E	LC	Stable	36	*Ptychadena baroensis*	LL	NE	Unknown
17	*Leptopelis gramineus*	E	LC	Stable	37	*Ptychadena goweri*	LL	NE	Unknown
18	*Conraua beccarii*	E + W	LC	Unknown	38	*Ptychadena delphina*	W	NE	Unknown

19	*Hemisus microscaphus*	W	LC	Unknown	39	*Leptopelis difidens*	E	NE	Unknown
20	*Paracassina obscura*	E	LC	Unknown	40	*Leptopelis montanus*	E	NE	Unknown

3.3.5. Fish

Ethiopia has 175 fish species, including two species, *Enteromius trispilopleura* and *Schilbe durinii*, possibly present in the country/island (Fishbase, 2021). Out of these, 123 (70%) are native species, including 41 (23%) endemic species, and 11 (6%) introduced species (Fishbase, 2021). Fish species of Ethiopia belong to 15 taxonomic Orders and 32 families (Table 15). Order Cypriniformes is represented by 68 (39% of the total) species and Siluriformes, which also have the highest number of families, by 36 (21%) fish species. A third of the taxonomic Orders are represented by a single species (Table 15).

Population status of 150 (75%) fish species in Ethiopia is unknown, and for those known 16 species are stable, seven are experiencing Decreasing population trend and only populations of two native species (*Haplochromis macconneli* and *Lates longispinis*) are known to be Increasing (IUCN, 2020; Table 16). Out of 143 species for which threat status has been assessed, 13 species (four Endangered and nine Vulnerable species) are globally threatened. All of the four Endangered species are endemic, *Labeobarbus ethiopicus*, *Aphanius stiassnyae*, *Danakilia franchettii* and *Labeobarbus macrophtalmus* (IUCN, 2020).

Table 15. Taxonomic Orders of fish in Ethiopia and their number of families and species.

Order	No. Family	No. Species
Anabantiformes	2	2
Carangaria/misc	1	2
Ceratodontiformes	1	1
Characiformes	3	18
Cichliformes	1	11
Cypriniformes	4	68
Cyprinodontiformes	4	12
Esociformes	1	1
Gobiiformes	1	1
Gonorynchiformes	1	1
Osteoglossiformes	3	16
Polypteriformes	1	3
Salmoniformes	1	2
Siluriformes	7	36
Tetraodontiformes	1	1
Total:	**32**	**175**

Table 16. Number of species of mammals with different population trend and IUCN Red List threat category in Ethiopia (Abbreviations for threat categories: CR = critically endangered; EN = endangered; VU = vulnerable; NT = near-threatened; LC = least concern; DD = data deficient; NE = not evaluated).

	IUCN threat status category					
(a) All species	EN	NE	LC	DD	VU	Total
Decreasing	1		1		5	7
Increasing			1	1		2
Stable			15		1	16
Unknown	3	32	97	15	3	150
Total	4	32	114	16	9	175
(b) Endemic species						
Decreasing	1				3	4
Stable			8		1	9
Unknown	2	10	9	7		28
Total	3	10	17	7	4	41

3.3.6. Plants

An intensive activity involving floristic and taxonomic studies took place in Ethiopia and Eritrea in the 19th century, particularly before ca. 1850. The Ethiopian Flora Project, which had been active between 1980 and 2009, has resulted in more than 470 species being described as new during the period, and more than 440 species described from elsewhere have been discovered to occur inside the Flora area (Friis, 2009). Currently, about 6,027 vascular plant species (including subspecies) known to occur in Ethiopia and Eritrea have been documented in eight volumes in ten books (Kelbessa and Demissew, 2014). This list includes about 600 (10%) species endemic to Ethiopia and Eritrea and 1,024 (17%) endemic to the Horn of Africa (Friis, 2009; Demissew, 2014). Distribution of endemic species among life-forms show that there are: 137 woody taxa (32 trees and 105 shrubs), that represent 13% of the total endemic woody plants estimation for the country, 376 herbs, 57 succulents, 12 climbers, 8 epiphytes, 3 weeds, 2 geophytes and 1 submerged herb (Vivero et al., 2006). Local level endemism (restricted to a given floristic region) is also high, with 38.6% of the endemic flora having such distribution (Vivero et al., 2006; Friis, 2009; Kelbessa and Demissew, 2014). More specifically, more than 200 taxa are found in a single locality, 72 are known only from type material, and 13 taxa have not been collected since the 19th Century; at least seven are presumed to be extinct (Vivero et al., 2006).

The species richness of vascular plants in Ethiopia shows a general trend that the south-western and south-eastern parts of the country have the highest richness (Friis, 2009). Similar patterns of richness have been found when national-level and local-level endemic species are considered (Friis, 2009). These two parts of Ethiopia share species that are characteristics of the two centres of endemism of Ethiopian flora: the Somalia-Masai (the area which continues towards the south into Kenya and Tanzania, with the region cut by the border between Somalia and Ethiopia being the core area of this region) and the Afromontane archipelago-like regional centre of endemism (referring to the highlands of Ethiopia) (Friis, 2009).

Although plants are the most well-studied biological taxa group in Ethiopia, the studies mainly focus on taxonomy and systematics and little information is available on the conservation status of the species described. As such, IUCN Red List assessments have been conducted for only 800 endemic, or near endemic, species (IUCN, 2020; Table 17). These data show that 68 species are currently globally (and nationally) threatened: 10 critically endangered, 26 species endangered, and 32 vulnerable (Table 17). Populations of about 6% of the total endemic species are showing decreasing trend, 3% increasing, 51% stable and 40% unknown (IUCN, 2020). The species present in the Red List include useful trees (*Erythrina burana, Boswellia pirottae*), spices (*Aframomum corrorima*), medicinal plants (*Pycnostachys abyssinica, Taverniera abyssinica*), weeds (*Pentaschistis trisetoides, Avena vaviloviana*), species not collected for more than 150 years (*Blepharis cuspidata, Phagnalon phagnaloides, Leptagrostis schimperiana, Onobrychis richardii*), species presumably extinct by human action (*Crotalaria boudetii, Crotalaria heterotricha*), two monotypic endemic genera (*Pseudoblepharispermum bremeri* and *Nephrophyllum abyssinicum*), and species restricted to but widely distributed within the FEE area (*Acanthus sennii, Echinops longisetus, Satureja paradoxa*) (Vivero et al., 2006; IUCN, 2020).

Table 17. Number of endemic vascular plant species classified under IUCN Red List Threat Categories.

Taxonomic group	**Total assessed species**	**Total known threatened species (CR, EN & VU)**	**CR**	**EN**	**VU**	**NT**	**LC**	**DD**
Magnoliopsida	441	46	8	15	23	7	355	8
Liliopsida	323	22	2	11	9	5	286	10

Polypodiopsida	29	0	0	0	0	0	29	0
Pinopsida	2	0	0	0	0	0	2	0
Gnetopsida	2	0	0	0	0	0	2	0
Lycopodiopsida	3	0	0	0	0	0	3	0
Total	**800**	**68**	**10**	**26**	**32**	**12**	**677**	**18**

3.4. Areas of Conservation Importance

3.4.1 Key Biodiversity Areas

Key Biodiversity Areas (KBAs) are sites of global importance to the planet's overall health and the persistence of biodiversity. The Key Biodiversity Area Partnership - a partnership of 13 global conservation organizations - is helping prevent the rapid loss of biodiversity by supporting nationally led efforts to identify these places on the planet that are critical for the survival of unique plants and animals, and the ecological communities they comprise. By mapping the KBAs and providing information about the wildlife living there, private industry, governments and other stakeholders can make the best decisions about how to manage that land (or waters), where to avoid development, and how best to conserve and protect the animals and plants for which the sites are so important.

Two subsets of KBAs have been identified so far across virtually all countries worldwide: Important Bird and Biodiversity Areas (IBAs) are sites identified by the BirdLife International Partnership, and Alliance for Zero Extinction Sites (AZEs)[5]. Ideally, protected areas should cover all the surface of KBAs.

There are 93 KBAs in Ethiopia, which cover a surface area of 151,091 km^2 (13% of the country area) and protect 340 birds (76%), 50 mammals (11%), 32 plants (7%), 24 amphibians (5%), and 2 invertebrates (1%). Among the 93 KBAs are 68 IBAs (EWNHS, 2001; Figure 10) and 3 AZEs[1] (Simien Mountains National Park, Little Abbai River and Bale Mountains National Park). Globally available data (IBTA, 2021) show that only 4.4% of the KBAs are completely covered and 27.2% partially covered by protected areas of the country (Figure 10). However, as discussed in detail in the next section, nationally available updated data show that the number of KBAs that are

[5] KBAs in Ethiopia. http://www.keybiodiversityareas.org

completely or partially covered by protected areas of Ethiopia is estimated at 25% and 30%, respectively (Gizaw and Gebretensae, 2019; Gizaw, 2021).

Analysis of threats to KBAs reveals that agriculture (cultivation and grazing) and human disturbance (e.g., refugees and military activities) are the most significant threats to biodiversity across the KBAs (Figure 11). These findings suggest that in Ethiopia, conservation should focus on reducing pressures from agriculture and human disturbance.

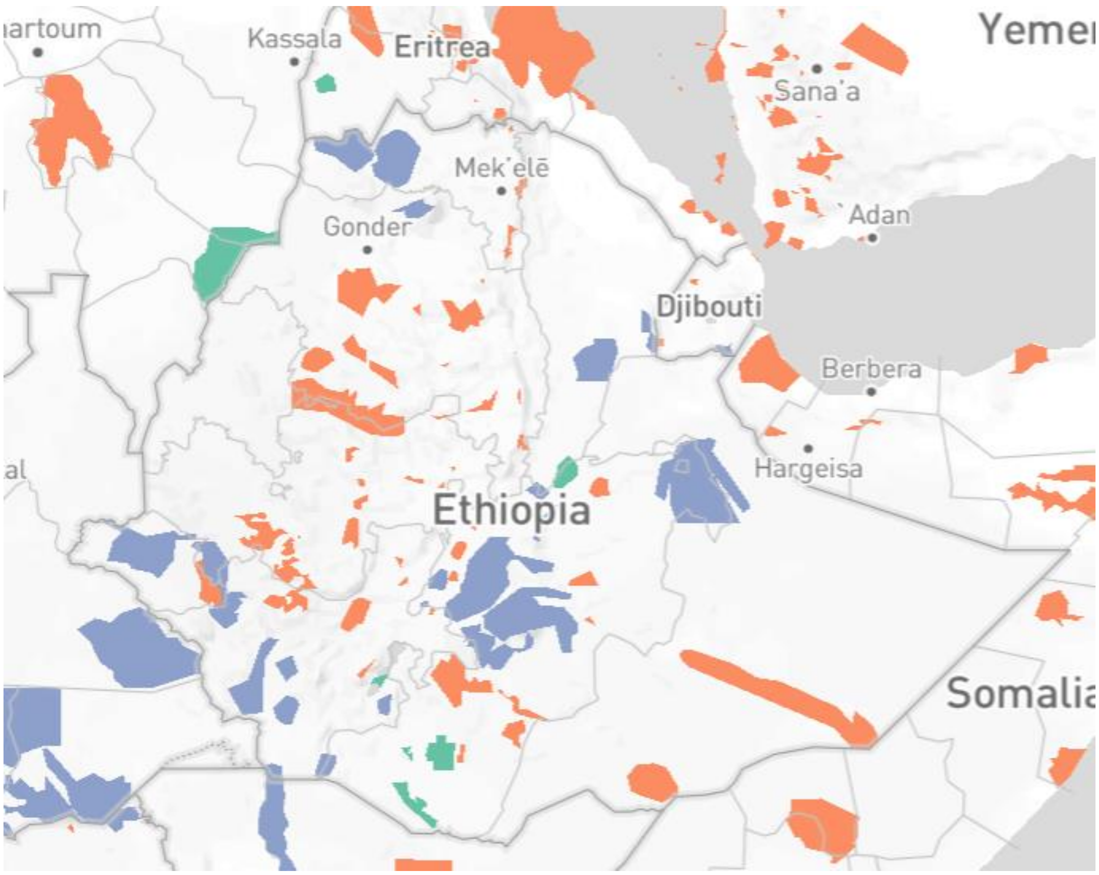

Figure 10. Map of Key Biodiversity Areas fully within (blue), partially within (green) or outside (red) protected areas on land in Ethiopia[6] [Note: - this map should be seen as a provisional since map of Ethiopia's protected areas are currently under revision].

[6] http://www.keybiodiversityareas.org/kba-data

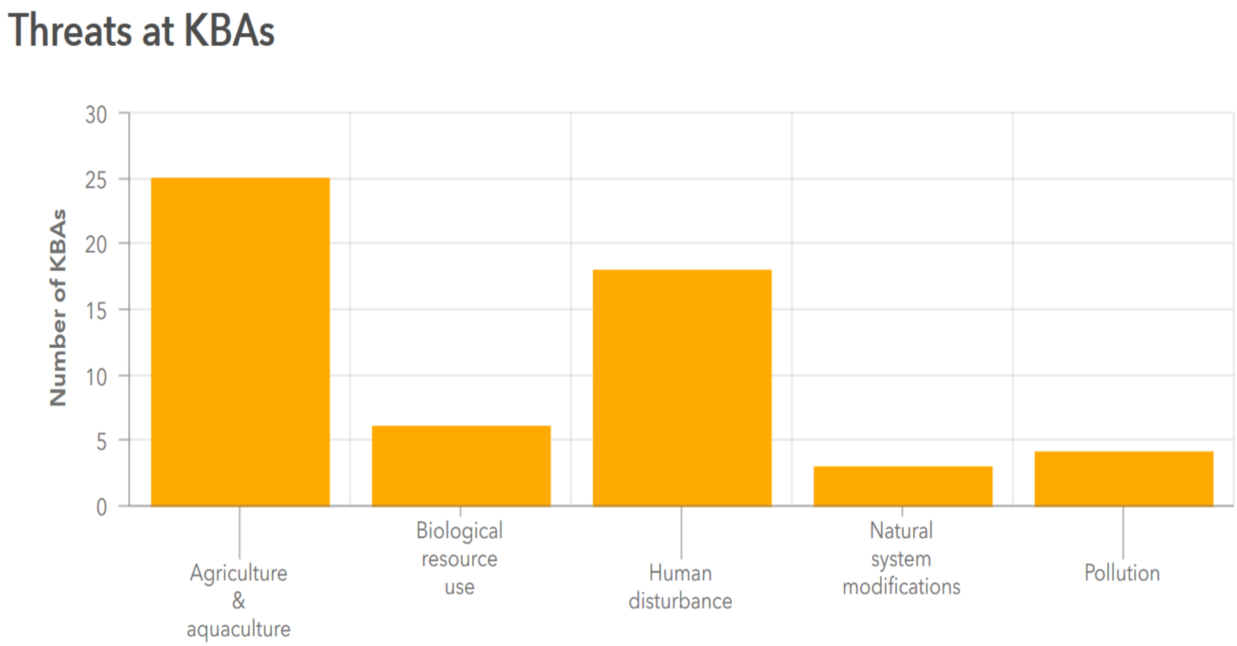

Figure 11. Number of KBAs affected by major five threats in Ethiopia[1].

3.4.2 Protected Areas

Currently available global and national data on PAs of Ethiopia is inconsistent, which partly is due to the establishment of new PAs, and the complete or partial upgrading of existing protected areas management category (e.g., sanctuary or controlled hunting area to national parks). According to our consultation during this study period with Gebremeskel Gizaw, IUCN WDPA (World Database of Protected Areas) focal person at Ethiopian Wildlife Conservation Authority (EWCA), we were informed that initiatives to remap and compile complete data of PAs are going-on. It is, therefore, unlikely to reliably assess the status and trend of PAs of Ethiopia before this initiative is successfully completed and data presented herein should be seen as provisional.

We compared data from IBAT with nationally available data to find out the discrepancy between the two datasets (see UNEP-WCMC, 2021). Accordingly, we found three reasons related to recent changes in the PA system of the country. First, 52 PAs are newly established and have no WDPA ID Number (i.e., not recognized by the WDPA): 19 controlled hunting areas, 6 open hunting areas, 10 Community Conservation Areas, 3 Biosphere Reserves, 2 sanctuaries, 10 National Parks and 2 sanctuaries (Table 18). Second, the following PA management category changes have been made: 1 controlled hunting area changed to 1 wildlife reserve; 5 controlled hunting areas and 1 wildlife reserve to National Park; and 14 NFPAs changed to other types of PA categories. And third, 13 Controlled Hunting Areas and 1 Sanctuary (with a total area of 10,331,300 ha) which have been registered in the WDPA with ID Number are currently not recognized because their designation changed either fully or partially or because they are included within the newly established protected areas. Thus, for the purpose of this report, we based our analysis of number and area of PA category types on the updated nationally available data.

Accordingly, Ethiopia has 127 Terrestrial Protected Areas (PAs), including inland waters, 121 of which are national designation type and 6 international designations type (Table 18). The total area coverage of the PAs is about 130,542 km^2 plus 6,555 km^2 national priority forest area and both together represent 12.14% of the total land mass of the country (Gizaw and Gebretensae, 2019; Table 18). National Forest Priority Area (NFPAs) is the largest number of PA category (44, 35% of the total PAs), followed by National Park (29, 23%). Considering area coverage of each PA designation name, National Park contributes about a third of the total area of PAs, followed by NFPAs (27%) (Table 18). These PAs fall under three IUCN governance/management/ types: Federally appointed ministry, subnational ministry and local communities. As shown on Table 18, PAs managed under the auspices of the federal level agencies include 12 national parks and 2 sanctuaries that are managed by the Ethiopian Wildlife Conservation Authority (EWCA), and 5 UNESCO-MAB biosphere reserves managed under the Ethiopian Biodiversity Institute (Gizaw and Gebretensase, 2019). Community conservation areas (CCAs) are protected and used by communities, with assistances from their respective regional state government authorities. The number of PAs has been increasing, particularly since 2015 (Figures 12 & 13). In addition, there are many informally protected areas whose values have not been evaluated yet, including urban/city parks, church compounds, military training bases, embassies/ministerial offices, large government offices (Mckee, 2007). Together with these Other Effective Conservation Means (OECMs), the total area of Ethiopia's protected area is estimated at 137,091.68 km2 or about 12.14% of Ethiopia's total land mass (EBI, unpubl. data; see also Mckee, 2007).

Table 18. Ethiopian protected areas by category and management authority (adapted from Gebremeskel, 2021). UNESCO BSM and WHS are excluded from number and area calculations. Numbers given in bracket following each relevant National designation type refer to the total number of each type known on IBAT.

Designation name	IUCN Management Category	IUCN Governance /management/Type	Managing Authority	No. of PAs	Total area (km²)
National Park (16)	II	Federal	EWCA	12	26,546
		Subnational Ministry	Regional States	17	17,953
Sanctuary (4)	II	Federal	EWCA	2	7,036
		Subnational Ministry	Regional States	3	660
Wildlife Reserve (6)	IV	Subnational Ministry	Regional States	6	20,596
Community-based Conservation Areas	VI	Local communities	Regional States	10	1,911
Controlled Hunting Area (18)	VI	Subnational Ministry	EWCA, Regional States and concessionaires	21	7,950
Open Hunting Area	VI	Subnational Ministry	EWCA, Regional States and concessionaires	7	666
UNESCO BMS (2)	N/A	Federal	EBI	5	14,348
UNESCO Natural WHS (1)	N/A	Federal	EWCA	1	412
National Forest Priority Areas (57)	N/A	Subnational Ministry	Regional States	44	36,414
Total				**127**	**130,542**

3.4.3. Protected Area Efficiency

We roughly assessed protected area efficiency as (i) trends in number and/or coverage of PAs, (ii) threats in PAs, (iii) their connectivity, and (iv) the degree of representativeness in terms of major ecosystem types and key wildlife species (range-restricted, globally threatened, endemic, etc) covered in the current protected areas systems.

Protected areas in Ethiopia, as a network of sites to conserve nature and wildlife, have been on the increase ever since the first national park was set aside in the early 1960's. While setting aside protected areas is greatly commendable, it does not mean that their integrity is protected nor does it directly relate how efficiently they act to save species and ecosystems from decline. The following graphs (Figure 12 & 13) show that there was a marked increase in numbers of PAs established in the early 1970s (which has been mentioned to be the golden years of wildlife conservation in Ethiopia) to a steady rise to 2018.

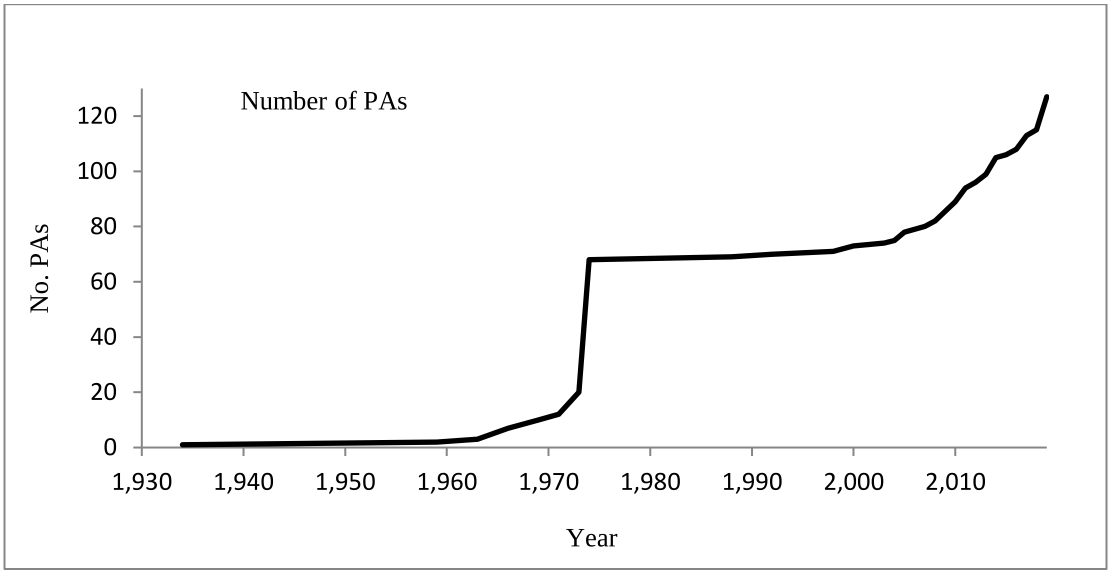

Figure 12. Growth in number of protected areas in Ethiopia (Source: Gizaw & Gebretensae, 2019).

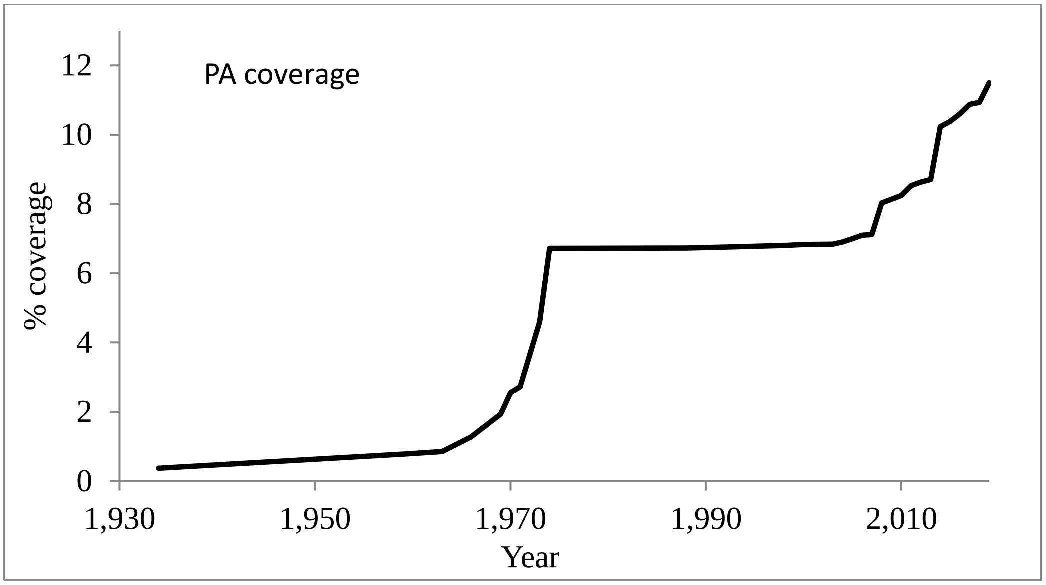

Figure 13. Growth in protected area coverage in Ethiopia (Source: Gizaw & Gebretensae, 2019).

Several studies have been conducted on the effectiveness of protected areas in Ethiopia, but they are only localized (a single site) and parameters used vary. To our best knowledge, only one study has evaluated at national level the effectiveness of Ethiopia's protected areas to conserve biodiversity (Vreugdenhil et al., 2012). Their findings show that, since the 1970s, wildlife populations have been precipitously declining in Ethiopia across nearly all PAs. In addition, the current formal protected area network of Ethiopia represents less than 50% of amphibian, mammal, and bird species richness, with some key ecosystems and several globally threatened species not covered in the existing network of PAs (Vreugdenhil et al., 2012). Almost all protected areas are suffering from human and livestock encroachment, deforestation and logging (Vreugdenhil et al., 2012; EBI, 2014a, b; for detail see also section 4.1).

At the global level, the "Protected Connected" (ProtConn) indicator was recently developed to quantify the degree to which national terrestrial protected area systems are well designed to promote connectivity. Saura et al. (2018) found that on average 7.5% of the terrestrial surface of the planet is covered by protected connected lands, which is about half of the global protected area coverage (~15.0%), and that 30% of the countries currently meet the connectivity element of Aichi Target 11. In Ethiopia, "protected connected land' using the ProtConn indicator, for species with a median dispersal distance of 10 km is between 8% and 12% (Saura et al. 2018). In order to enhance protected area connectivity on land in Ethiopia, the Protected Planet Report (2018) recommends a general increase of protected area coverage.

4. Biodiversity Threat Assessment

4.1. National Level Assessment – Literature Review

The complex inter-related nature of direct human-induced threats to biodiversity makes difficult of the efforts to understanding the nature, extent and mechanisms of the impacts. Furthermore, available scientific studies investigating the impacts of biodiversity threats in Ethiopia have been mainly focusing on protected areas (see Asefa et al., 2015, 2017a). The management plans of eight protected areas we reviewed indicate that the threats vary both across protected areas and among different ecosystems within a particular protected area. Nonetheless, when threats were ranked within each PA, it is evident that cultivation, grazing, logging and settlement expansion are the top four biggest threats to biodiversity across most PAs; while other threats are either low or localized (see Tessema et al., 2019; SMNP GMP, 2008; BMNP GMP, 2017). Although information on biodiversity threats outside PAs in Ethiopia is limited, it is also likely that similar threats impact biodiversity outside protected areas, including in the KBAs that are not covered by PAs and in the agricultural ecosystems (i.e. in the range lands and cultivated lands) (see Asefa et al., 2015, 2017a).

Here below, we present the nature and impacts on biodiversity of major threats to natural ecosystems and faunal species for terrestrial and freshwater realms.

4.1.1. Main Threats to Terrestrial Natural Ecosystems and Species

Residential/Urbanization: Expansion of settlement is common across most PAs and unprotected areas in Ethiopia. It directly affects wildlife through habitat loss, fragmentation, blockade of movement corridors and disturbance (IBC, 2005; Tessema et al., 2019). Furthermore, presence of humans within and around PAs also leads to frequent contact between humans (and their associated livestock) and wildlife, particularly large carnivores, resulting to escalated human-wildlife conflicts arising from livestock depredation (Tessema et al., 2021). This ultimately affects the breeding and survival performances of many species, thereby heightening their vulnerability to extinction.

Crop cultivation: The current rapid economic growth recorded in Ethiopia is largely due to the contribution of the agricultural sector (EBI, 2014a, b). The economic growth in the agricultural sector, on the other hand, is partly attributed to yield increment and partly to expansion of agricultural land (EBI, 2014a). Rate of deforestation in Ethiopia between the years 2006 and 2019 amounts to between 1500 and 2000 km^2 per year (Mckee, 2007; Table 4), a rate which is expected to increase in the future to meet the ever-increasing demand for arable land by small-scale farmers attributed to high population growth rate. Expansion of agricultural land is the major cause of deforestation (Table 4). Key PAs of the country (e.g., Bale Mountains, Awash, Semien Mountains and Abijata Shalla National Parks) and their buffer areas are among the most impacted from small-scale cultivation land expansions (Mckee, 2007; EBI, 2014a, b). Impacts on biodiversity of expansion of state- and private-owned large-scale agricultural investment projects are also increasing. For example, mid-scale to large-scale (thousands of hectares) commercial agricultural investments in the forested areas have resulted in the clearance of prime rainforest to give way to cash crop plantations of tea, spice species such as ginger (*Zingiber officinale*) or turmeric/erd (*Curcuma longa*), coffee, rubber and endod (*Phytolacca dodecandra*) (Mckee, 2007; EBI, 2014a). This increasing encroachment and land-use pressure on the Montane rainforests has resulted in the endangerment of the gene pool of *Coffea arabica*, for example (EBI, 2014a). Other forms of state-owned agro-industries and factories that are posing critical threats to biodiversity in the lowland areas include the Wonji/Metehara Sugar Factory and Amerti agroindustry (adjacent to Awash National Park), Tendaho Sugar Factory (around Yangudi Rasa National Park), and Omo Kuraz Sugar Factory (in the core wildlife habitats in the Omo National Park) (Tessema et al., 2019). Expansion of sugar cane, cotton and other industrial crops has reduced grazing land, thereby heightening degradation of livestock range lands and forcing pastoralist communities to use protected areas (IBC, 2005, 2009; Tessema et al., 2019). Through habitat loss and fragmentation, this activity poses detrimental threat to the survival of many wildlife species. The combined mid- and long-term negative impacts of such land use change include degradation and shrinkage of natural ecosystems, loss of biodiversity and eventual loss of ecosystem services.

Livestock Grazing**:** Livestock grazing occurs almost across all ecosystems of Ethiopia. Ever increasing livestock encroachment into Bale Mountains, Semien Mountains, Awash, and Abijata Shalla National Parks has been severely impacting ecosystems and species of these parks and other unprotected KBAs. The impacts of livestock grazing on ecosystems include deterioration of the grass layer; soil compaction and decrease of below-ground carbon content; bush encroachment; suppression of regeneration of trees in forests; changes in the natural ecological succession, such as replacement of forbs by grasses in forests (Vreugdenhil et al., 2012).

Overstocking rate of livestock, usually interactively with other threat factors, has also led to local disappearance of many wildlife species from several KBAs, including from exceptionally important PAs and their surrounding areas, such as Swayne's Hartebeest from Nech Sar National Park, Oryx and Ostrich from Awash National Park (Vreugdenhil et al., 2012). Further, elephant range in Mago National Park has decreased by more than 52% since the 1980s (Demeke, 2008), with similar devastation occurring in the key habitats of the Babille elephant population. Finally, the critically endangered Harenna Shrew (*Crocidura harenna*; see IUCN, 2020), African Wildlife (*Equus africanus*, Vreugdenhil et al., 2012) and Water Mouse (*Nilopegamys plumbeus*; Lavrenchenko and Bekele, 2017) are due to livestock overgrazing-induced habitat degradation and alteration. In sum, the combined mid- and long-term negative impacts of overgrazing in KBAs include degradation and alteration of natural ecosystems, loss of biodiversity and loss of ecosystem processes, which eventually leads to loss of ecosystem services and poor development of human well-being.

Transportation Corridors: Highways in the country cross many KBAs, including PAs. As a result, road killing, littering (plastic materials by passengers) and taming of wildlife (Baboons) are growing threats to ecosystems and wildlife in Bale, Awash, Mago, Yangudi Rassa, Hallaideghi and Geralle National Parks (Asefa et al., 2017b). Although localized (occurs only at certain PAs), reports indicate that several conservation concern species are impacted from roadkill, such as the endemic endangered Mountain Nyala and Ethiopian Wolf in Bale Mountains National Park (Asefa, 2008) and African Wild Dog in Omo and Geralle National Parks (Asefa et al., 2017b). Highways are also the causes of pollution through plastic littering and habitat fragmentation for certain fossorial species.

Poaching Terrestrial Animals: Historically, the motivations for practicing wildlife poaching were for food (when food is scarce), cultural purposes and in retaliation to property lost (Asefa et al., 2017b; Tessema et al., 2021). Currently, however, poaching is mainly driven by economic needs – an increase in demands for Elephant tusks and skins and claws of carnivores on the global black market (Tessema et al., 2021). Poaching affects the target species by causing decline in population size, altered demographic structure and reduced genetic diversity. For example, elephant poaching in Ethiopia has led to a decline in population by 90% since the 1980s and extirpation from at least 6 of the 16 areas in which elephants were found in the early 1990s (EWCA, 2015). Similarly, poaching, interactively with other threat factors though, have ultimately resulted in the extinction of several mammal species from the five PAs in the African Elephant range studied by Tessema et al. (2019), including Giraffe, Rhino, Oryx, Tiang, Zebra, Gerenuk and Grant's Gazelle in the Mago NP; and Zebra, Oryx and Rhino in the ONP.

Overall, poaching-induced changes in population demography and genetic diversity of the target species increases risk of extinction of the species concerned. Furthermore, most of the wildlife species targeted for poaching in Ethiopia are keystone species (e.g., Elephant, Lion, Leopard, Cheetah, etc) (Asefa et al., 2017b; Tessema et al., 2021). Thus, the declines in their populations and distribution ranges leads to loss of their ecosystem functions, such as seed dispersal and nutrient recycling by Elephant and prevention of prey populations from exploding by predators. In sum, wildlife poaching affects the rest of the food chain that ultimately results to local extinction of many species, the overall diversity and health of the ecosystems (Tessema et al., 2019, 2021).

Logging and Wood Harvesting: The demands of raw material for construction and fuel/domestic energy by rural and local town inhabitants in Ethiopia are solely met from natural forest products. This subsistence/small scale logging and wood harvesting affects harvested species as well as non-target [non-harvest] species. Over harvesting have threatened timber tree species such as *Hagenia abyssinica*. In addition, 75% of Ethiopians use traditional medicinal treatments, where over 95% are extracts of wild flora. Unsustainable harvesting of medicinal plants has threatened several species, such as *Taverniera abyssinica*. Deforestation for charcoal making and fuelwood are also the main threats to forests and woodlands, especially in Rift Valley region (Mckee, 2007; Vreugdenhil et al., 2012).

Fire: Ethiopian fire cycles centre primarily on lowland or midland areas. However, unlike in the past, in the last three decades fires were concentrated in the highlands and high National Priority Forest Areas (NFPAs). Among the places where forest fires broke out are Bale, Borana, Jimma, Ilubabor, East Wellega, East and West Hararghe and Arsi Zones of Oromia Region, Benishangul Gumuz and Gambella Region and SNNPR zones. It is estimated that over 1000 km^2 was affected in Bale and Borana zones alone in the year 2000 (Mckee, 2007). This has caused secondary succession which is primarily composed of species different from the original ones.

Invasive Alien Species: Alien invasive species play bioengineering role where they directly or indirectly affect ecosystem structure, processes and functions by modifying availability or quality of nutrients and physical resources (e.g., living space, water, or light) (Shiferaw et al., 2018). Invasive species cause biodiversity loss by competing with native species for feed and habitat and altering the physical environment in ways that exclude native species. They are also known to causing enormous reduction in forage production, crop yield losses and health hazards (developing skin allergies, itching, fever, and asthma in some of the farmers who involved in such weed control practices) (Fissaie, 2005; IBC, 2009; Enyew et al., 2020).

About 35 invasive plant species have been identified in Ethiopia, with *Prosopis juliflora*, *Parthenium hysterophorus* and *Lantana camara* being the three top invasive alien plant species threatening terrestrial biodiversity in Ethiopia (Fessehaie et al., 2012; Shiferaw et al., 2018). *P. juliflora* and *P. hysterophorus* are aggressively invading pastoral areas in the Middle and Upper Awash Valley and eastern lowland areas in the Oromia, Afar and Somali national regional states (IBC, 2009; Asefa et al., 2017c; Shiferaw et al., 2018). *P. hysterophorus* is also infested Gambella national regional states, western Ethiopia (IBC, 2009). Ecosystem invasion of these species is reported to be fostered by human disturbances such as agricultural lands, settlement, grazing lands and road construction (Asefa et al., 2017c; Shiferaw et al., 2018). Currently, most ecosystems and protected areas (e.g., Awash, Allideghie and Yangudi Rassa National Parks and Babille Elephant Sanctuary) in the Rift Valley and south-eastern lowland regions are severely invaded (Endris et al., 2019).

Climate Change: Reports indicate that precipitation has shown high spatial and temporal variability in Ethiopia over the last 50 years; although it remained fairly stable when averaged over the country. However, temperature in the country has increased at about 0.2°C per decade, with the increase in minimum temperatures more pronounced with roughly 0.4°C per decade (Keller, 2009; EBI, 2014a). Climate change, as manifested through the spatio-temporal variability of precipitation and increased temperature, has caused adverse ecological, economic and social impacts in the country. For example, it has caused reduction in the length of growing seasons that has resulted in the loss of many long duration varieties as well as force large areas of marginal agriculture out of production. Climate change will fundamentally alter the underlying agro-ecosystems through elevated temperatures and CO_2 levels, leading to changes in crops pests and disease activity and population levels. Additionally, climatic variables influence the spread of vector-born diseases through determining the distribution and growth rate of vectors and shortening the life cycle (Holly and David, 2001).

Climate change also causes shortage of livestock feeds, disease outbreak, change in disease distribution and shrinkage of rangelands. Furthermore, it causes desertification, forest fire, high evapo-transpiration, and drought. For example, prolonged drought that occurred for consecutive years in Borena zone of Oromia and Somali national regional states has, reportedly, resulted in loss of animals, especially cattle. During this time, rangelands were degraded and there were shortages of water and feed. In some places, climate change favoured bush encroachment such as *Acacia drepanolobium* to invade the rangelands.

4.1.2. Main Threats to Freshwater Ecosystems and Species

Settlement and Cultivation: Aquatic biodiversity is directly or indirectly affected by several conditions occurring in Ethiopia. Soil erosion has affected and continues to affect all parts of the country. Agricultural work on steep topography and on poor or degraded land reduces soil fertility and associated agricultural productivity (see Figure 14). The accumulation of silt in water leads to degradation of water quality for aquatic organisms and human consumption and loss of storage capacity for livestock, irrigation, and hydroelectric power (McKee, 2007). Deforestation and losses of vegetation within a wetland catchment area is resulting in biodiversity alteration, in decreases in the water holding capacity of the wetland and in the worst case in the collapse of the wetland itself (Fissehaie, 2005; Enyew et al., 2002).

Grazing: Throughout Ethiopia, past and present, wetlands areas have been and still are important sites for livestock grazing. Specifically, wetlands are often a last destination for pastoralists during the dry season in most parts of the country. However, livestock population increases, fodder shortages and the simultaneous expansion of agricultural activities have contributed to exacerbating the grazing pressure on wetlands. The pressure from grazing has resulted in changes of the wetland characteristics. In some cases, wetlands have been transformed into rough grazing land. Over grazing in wetlands can become a threat when for instance year-round grazing excludes ecological recovery period of the wetland. Compaction of the wetland by livestock is also known to have a significant impact on the infiltration capacity of the soil hence affecting the hydrological system and balance of the wetland itself (Fissehaie et al., 2005; Enyew et al., 2020). Loss of biodiversity is another negative impact of overgrazing.

Fishing and Harvesting Aquatic Resources: Wetlands in Ethiopia are important sources of water, food and raw materials (fish, reeds, water, medicinal plants, papyrus, etc) that sustain the livelihoods of significant populations. Over-exploitation or harvest of these resources is now a major threat in several wetland areas of Ethiopia (Mckee, 2007). In this regard, a good example is over-exploitation of the fishery resource from Lake Tana, which has resulted to steady decline in catch size from the lake over years (Fissehaie, 2005; Enyew et al., 2020).

Draining for Agriculture Use: Draining of wetlands for agricultural purpose is a century old practice in some parts of Ethiopia. However, improper draining mechanisms, double cropping, growing of perennial crops such as sugar cane within wetlands ecosystem have become major threats for the survival of wetlands (Mckee, 2007). Excessive abstraction of surface water for agricultural from freshwater ecosystems can also lead in some cases to a direct collapse of the wetland itself. A good example for this scenario is the collapse of Lake Haramaya in Eastern Ethiopia due to an excessive water withdrawal by the neighbouring communities to irrigate a commercial crop-chat (*Catha edulis*) (Bekele & Haile, 2021).

Figure 14. Some key threats to Ethiopia’s biodiversity

Invasive Alien Species: Water hyacinth (*Eichhornia crassipes*) is the most serious weed in freshwater ecosystem in Ethiopia (Fessehaie, 2005). Since it was reported for the first time in

Ethiopia in 1965s from Koka lake and the Awash River, its infestations have spread widely, affecting many water bodies of the country, such in the Gambella area (Sobate, Baro, Gillo and Pibor rivers), the Abay river (south of Lake Tana) and Lake Ellen in the Rift Valley. Currently, Lake Tana is the most threatened freshwater ecosystem by water hyacinth, with the infested area increasing from about 200 km^2 in 2011 to 500 km^2 at present (Enyew et al., 2020; Ethiopian Weed Society, 2021). The main mechanisms through which this weed impacts aquatic ecosystem and species include increased water loss via evapo-transpiration, restricting water flow; blocking sunlight from reaching native water plants and depleting oxygen in the water. Recent studies in Lake Tana show a serious decline in fish stocks due to the spread of Water hyacinth around fish spawning grounds (Ethiopian Weed Society, 2021).

Pollution: Sources of pollutants to freshwater ecosystems (wetlands and aquatic ecosystems) are rural agricultural activities and industrial effluents in urban areas. In rural areas, irrigation, run-off from farming activities containing insecticides, fertilizers and herbicides applied to crops are affecting aquatic and wetland ecosystems and organisms. Excessive draining of nitrogen and phosphorous from agricultural fields to freshwater systems can cause excessive plant and algae growth and growth of invasive alien species such as the Water hyacinth due to eutrophication that leads to depletion of oxygen as well as to other environmental problems, which in turn will cause loss of species in that site (Mckee, 2007; EBI, 2014a). Major large-scale industrial activities producing dangerous pollutants to freshwater ecosystems in Ethiopia include garages, petrol stations, tanneries, slaughterhouses, market centres, breweries; textile, chemical, tobacco, thread and garment, and paint factories; hospitals, oil and flour mills, metal works and car washing. They are causing major damage to the nearby aquatic and wetland ecosystems through deposition of heavy metals as is the case in Akaki River, and Abasamuel and Koka reservoirs (Fissehaie, 2005; EBI, 2014a).

Climate Change: Changes in air temperature and precipitation that accompany climate change have direct effects on the physical, chemical, and biological characteristics of lakes and wetlands (Vincent, 2009). Ethiopia is more vulnerable to the adverse impact of climate change as the large part of the country is dry sub-humid, semi-arid and arid. According to recent metrological reports, a warning trend in annual temperature was recorded over the past half century (Bekele and Haile, 2021). Together with unpredictable rainfall variability, it has been forecasted the worst scenario to happen in the upcoming decades (Bekele and Haile, 2021). In Ethiopia, failed rains and droughts occur variably in time and space and recently this have been worsened by the 2015 El Niño (Bekele and Haile, 2021). If rainfall does not come on time, if droughts are prolonged, if temperature increases highly over time, if water table drops, wetlands will dry out and the stored carbon will release back to the atmosphere by oxidation and other processes. Ponds, wetlands and alpine/highland lakes are especially vulnerable to changes in the precipitation relative to evaporation (P/E ratio) because of their shallow depths and large surface to volume ratio (Vincent, 2009). These physio-chemical changes of wetlands due to climate changes will have a significant effect on species composition and diversity at the primary producer level, which in turn may impact on higher trophic levels, including zooplanktons and other invertebrate and vertebrate species (Vincent, 2009).

4.2 National Level Assessment - STAR Metric Scores

We analysed the STAR metric in Ethiopia based on the updated selection of 115 (including two more species we added to the original proposed list) species: 12 amphibians, 51 birds and 52 mammals. Forty-three (36.5% of the total) of these species are endemic (see Table 19 for summary).

Table 19. Number of all and endemic species of the three taxonomic groups with diffrent IUCN Red List categories included in the STAR calculation for Ethiopia.

	All				Endemic			
	NT	VU	EN	CR	NT	VU	EN	CR
Amphibians	1	3	5	3	1	3	5	3
Birds	21	14	9	7	2	4	3	1
Mammals	14	20	14	4	4	8	6	1
Total	36	37	28	14	7	15	15	4

The total STAR score for Ethiopia is 206,544. Habitat Restoration (STAR R) component of the STAR metric represents 94% of the total score for Ethiopia, which is, by far, higher than the country’s score for Threat Abatement component (STAR T; 6%). However, those surprising figures, very different from other countries’s profiles, are due to 6 species (see below) with a very high STAR R score (higher than 3000). We did a senstivity analysis and recalculated STAR scores (total, R and T) for Ethiopia without the 6 species with STAR R scores higher than 3000 (Table 20), which are:

- *Arvicanthis blicki* (STAR R score = more than 95000)
- *Ptychadena nana* (STAR R score = more than 46000)
- *Crocidura Lucina* (STAR R score = more than 31000)
- *Tachyoryctes macrocephalus* (STAR R score = more than 6000)
- *Leptopelis yaldeni* (STAR R score = more than 5000)
- *Crithagra ankoberensis* (STAR R score = more than 3000)

Without those six species, we have for Ethiopia:

- Total STAR score = 14996 (instead of 205731)
- Total STAR T score= 10599 (instead of 11804)
- Total STAR score R= [7832] 4397 (instead of 193832)

So we found:

- STAR T score for Ethiopia = 71% of STAR (T+R) score Ethiopia (instead of 6%)
- STAR R score for Ethiopia = 29% of STAR (T+R) score Ethiopia (instead of 94%)

Table 20. Original and recalculated without the 6 species with STAR R scores higher than 3000 of STAR scores (total, R and T) for Ethiopia.

		STAR Scores		
		ThreatAabatementScore	RestorationScore	
Ethiopia	Total STAR score (sum of 115 species score) for Ethiopia	11899	193832	
	%	6%	94%	
	Total STAR score (109 species) without 6 species with highest Restoration scores for Ethiopia	10599	4397	
	%	71%	29%	
				Proportion of Ethiopia STAR score compared to Global score

Global	Global STAR score	1226300	615888	11.20%
	Global STAR score without 6 species with highest Restoration scores for Ethiopia	1225000	426453	.35%

Threat abatement measures targeting critically endangered (CR) species are crucial. As shown on Figure 15, the Threat Abatement STAR score for critically endangered species is about four times higher than their STAR R score (2,740.7 vs 710.6). Regarding birds, the same kind of measures should target endangered birds (EN) (see Figure 15).

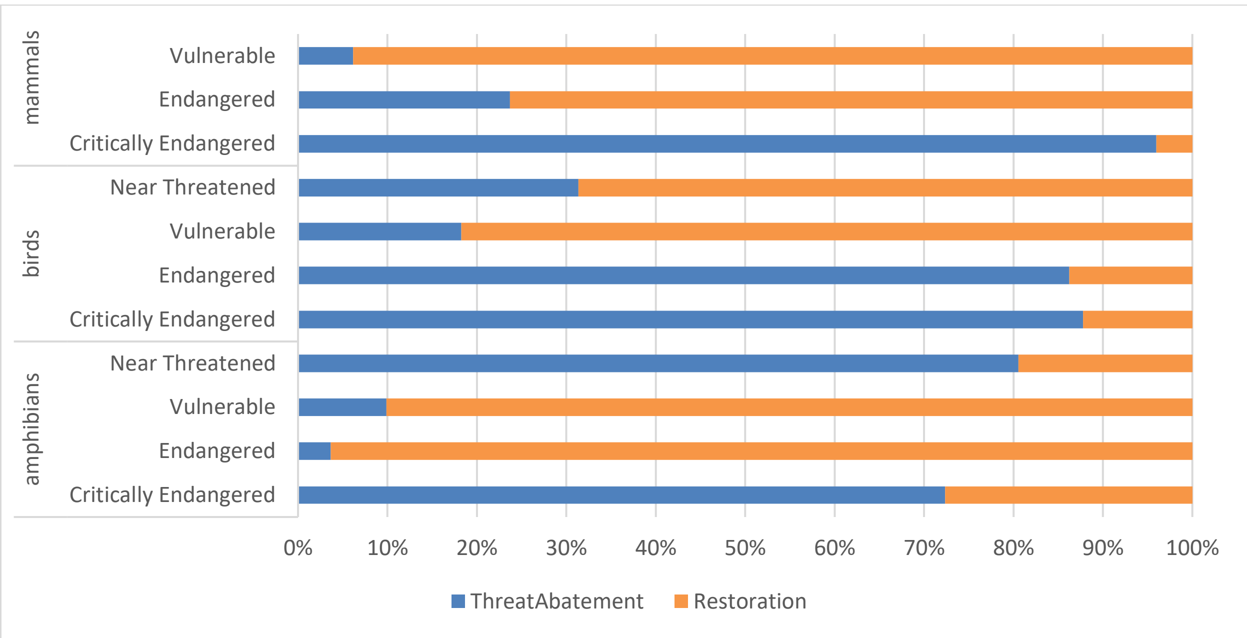

Figure 15. STAR-T Score and STAR-R Score in Ethiopia per taxonomic groups and IUCN red list categories.

When the STAR-R (Restoration) scores for the three taxonomic groups are compared, score for mammals was the highest of all and that for amphibians is higher than that for birds. However, the threat abatement scores (STAR-T) for the taxonomic groups are relatively closer to each other (Figure 16a). After removing the 6 species with very high STAR scores of amphibian, bird and mammal used for this study, the relative contribution (in %) of each taxon group to the tptal STAR R score was significantly changed: for birds it was increased from 3% to 43% and that of mammals decreased from 70% to 29%, and that of amphibians was not affected (Figure 16b). These results may suggest that conservation measures related to habitat restoration should focus on sites where mammal and amphibian species are concentrated, while threat reduction strategies should be implemented across all KBAs and agricultural-scapes.

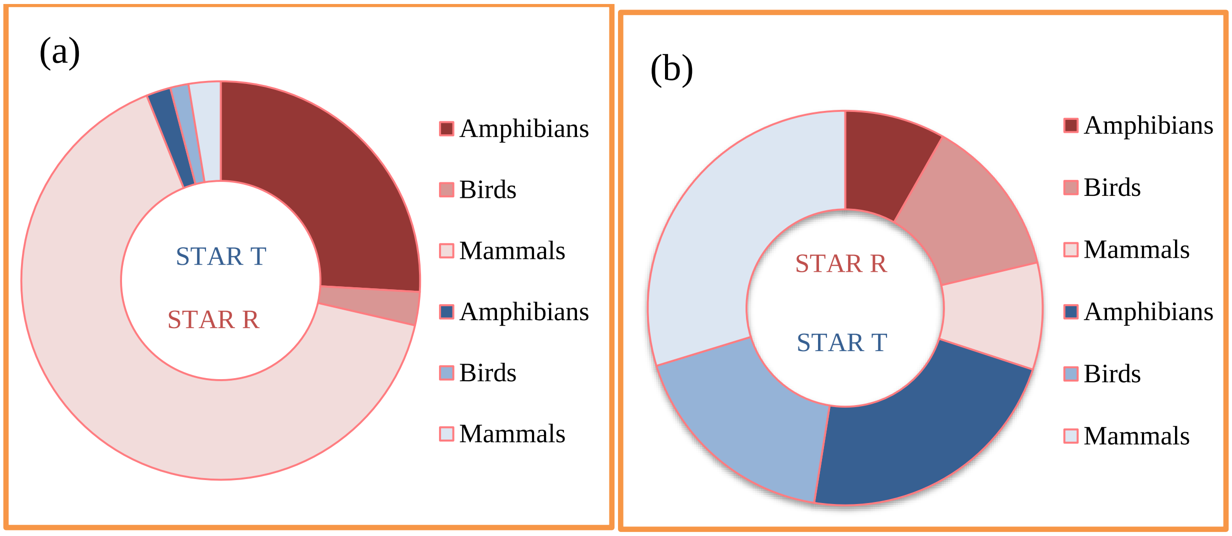

Figure 16. STAR Threat Abatement (STAR T) and STAR Restoration (STAR R) scores summed for the 115 species (a) and 109 species after omitting the 6 species with very high STAR scores (b) of amphibian, bird and mammal used for this study.

The STAR-T score allows the threats to be ranked according to their potential to reduce the risk of species extinction. As in many countries, activities related to agriculture and livestock farming present the highest potential for threat abatement in Ethiopia. As shown on Figures 17 & 18, small-holder farming and grazing are the most impacting agricultural activities.

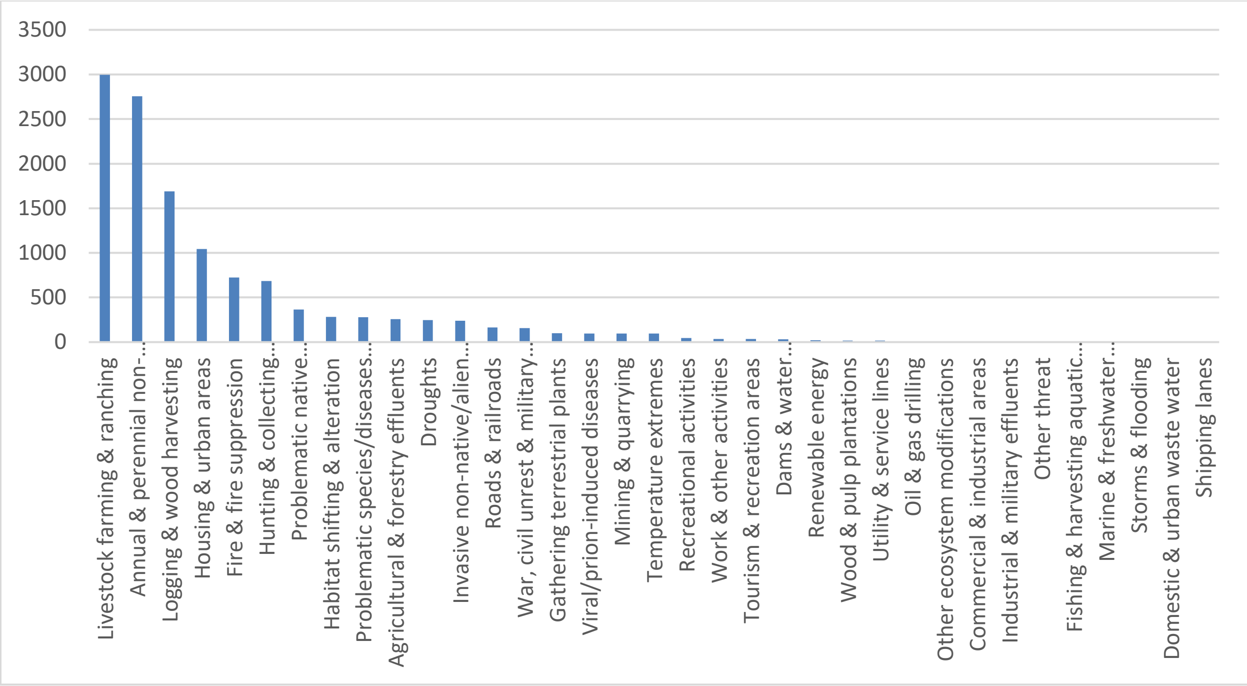

Figure 17. STAR-T Threat Abatement Scores in Ethiopia for threats impacting biodiversity in the country (using level 2 of the Threat Typology coming from CMP (Salafsy et al 2008 "A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions").

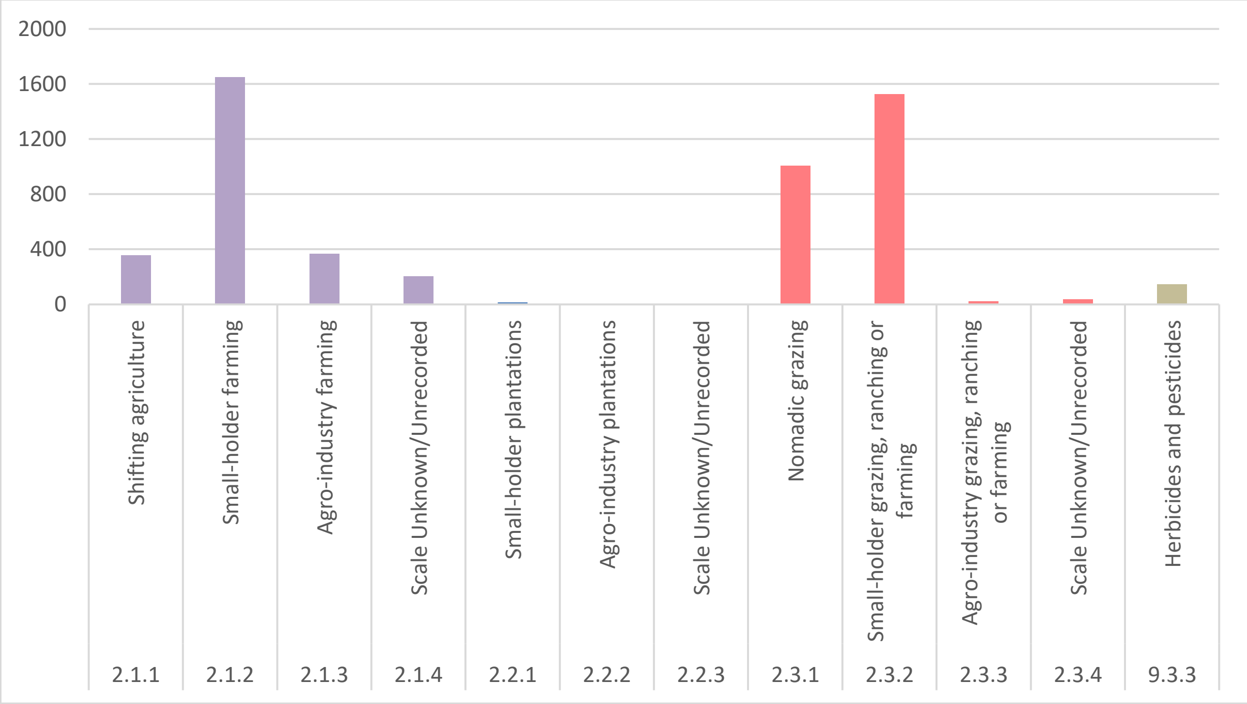

Figure 18. STAR-T Scores in Ethiopia for threats related to agriculture and grazing (using level 3 of the Threat Typology coming from CMP (Salafsy et al 2008 “A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions”).

Finally, examination of the STAR scores maps reveal KBAs with highest threat levels which should be prioritized for abatement and restoration (Figure 19A & B). While both scores indicate that biodiversity of the highland region are more threatened, there are specific KBAs that are exceptionally impacted. These KBAs include the Simien Mountains National Park (NE highlands), the Bale Mountains (both the Bale Mountains National Park and the adjacent Harenna Forest KBAs), and the south-western highland forests. Only two areas can be viewed as threatened in the lowland region, the north-eastern rift valley (Afar Denakil depression) and southern Ethiopia (Yabello, Liban plan, Arero and Mega areas).

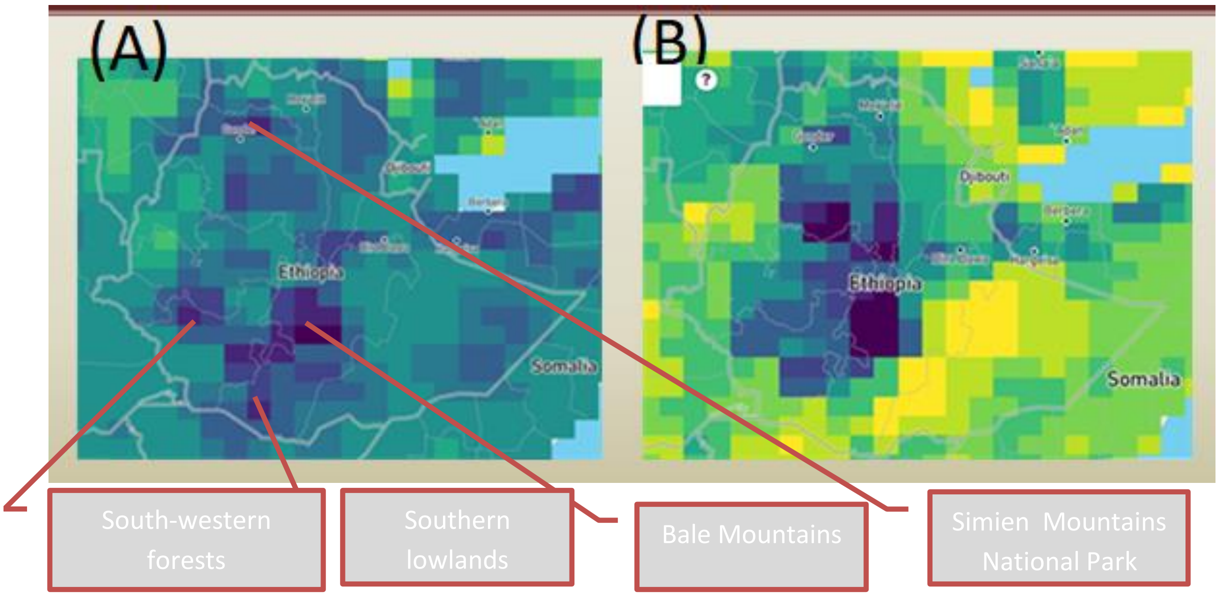

Figure 19. Maps showing the STAR T (A) AND STAR (R) score values for Ethiopia. Grids filled with deep blue are those with the highest STAR scores and includes KBAs such as Simien Mountains National Park, Bale Mountains (Bale Mts National Park and Harenna forest), SW highland forests and southern lowlands (Yabello, Arero, Mega, and Liban plain).

4.3. National Level Assessment – Expert-based Threat Assessment

4.3.1 National Expert-based Threat Assessment: Overall

Of the 33 experts identified who received a questionnaire, 18 individuals responded. Most of them have general expertise in biodiversity and only a few are specialized in the areas of mammals, birds, amphibians, reptiles, fish and plants (see Appendix 4 for list of experts). The results of the expert assessments follow the same format as for the STAR metric scores presented in section 4.2. The taxonomic groups presented below are mammals, birds, reptiles, amphibians, fish and plants for both the natural terrestrial and freshwater ecosystems.

Considering the score rank of each threat to each taxon, none of the level 2 threat categories was ranked 'Very High' for any of the six target taxonomic groups (Table 21). This result is expected given that the rank scores were averages of the scores assigned by the expert assessors who have experience of working in different geographical regions of the country (and thus their knowledge about biodiversity threats is more on the situation of the region). Thus, experts' data seem to be more accurate for local assessments and national level assessments should consider large number of experts to obtain more accurate data that reflect the situation in the country. Specifically, each assessor can reliably assess for the situation in the areas where she/he has been or is more actively working (Asefa et al., 2020). Each major threat are described below.

Table 21. Rank scores of level 2 threats to each of the six target taxon groups, of each threat across taxon (overall, last column), and across threats for each taxon (overall, last row). Ranks were: L = low; M = medium; H = high; VH = very high ranks. For detail on how overall threat scores were derived, see section 2.2.2.4, and also Salzer (2007).

Level 1 Threats	Level 2 CMP Threats Typology	Amphibians	Birds	Fish	Mammals	Plants	Reptiles
1. Residential and commercial development	1.1 Housing & urban areas	M	M	H	M	H	L
	1.2 Commercial & industrial areas	M	M	M	L	M	L
	1.3 Tourism & recreation areas	L	L	L	L	L	L
2. Agriculture & Aquaculture	2.1 Annual & perennial non-timber crops	H	H	H	H	H	H
	2.2 Wood & pulp plantations	L	L	L	M	M	L
	2.3 Livestock farming & ranching	H	H	H	H	H	H
3. Energy production & mining	3.2 Mining & quarrying	M	M	L	L	M	H
	3.3 Renewable energy	L	M	L	L	L	L
	4.1 Roads & railroads	L	L	L	L	L	L

4. Transportation & service corridors	4.2 Utility & service lines	L	L	L	L	L	L
	4.4 Flight paths	L	L	L	L	L	L
5. Biological resource use	5.1 Hunting & collecting terrestrial animals	L	L	L	M	L	L
	5.2 Gathering terrestrial plants	M	H	L	H	M	M
	5.3 Logging & wood harvesting	H	H	M	H	H	H
	5.4 Fishing & harvesting aquatic resources	L	L	H	L	L	L
6. Human intrusions & disturbances	6.1 Recreational activities	L	L	L	L	L	L
	6.2 War, civil unrest & military exercises	L	L	L	L	L	L
	6.3 Work & other activities	L	L	L	L	L	L
7. Natural system modifications	7.1 Fire & fire suppression	H	H	M	H	H	M
	7.2 Dams & water management/use	M	M	H	M	M	M
	7.3 Other ecosystem modifications	L	L	L	L	L	L
8. Invasive species and other problems, genes and diseases	8.1 Invasive non-native/alien species/diseases	M	H	H	H	H	M
	8.2 Problematic native species/diseases	L	L	L	M	M	L
	8.3 Introduced genetic material	L	L	L	L	L	L
	8.4 Problematic species/diseases of unknown origin	L	L	L	L	L	L
	8.5 Viral/prion-induced diseases	L	L	L	L	L	L
	8.6 Diseases of unknown cause	L	L	L	L	L	L
	8.7. Other threats	L	L	L	L	L	L
9. Pollution	9.1 Domestic & urban wastewater	M	M	H	M	M	M
	9.2 Industrial & military effluents	L	L	H	L	L	L
	9.3 Agricultural & forestry effluents	M	M	H	M	M	M
	9.4 Garbage & solid waste	L	L	L	M	M	M
	9.5 Air-borne pollutants	L	L	L	L	L	L
	9.6 Excess energy	L	L	L	L	L	L
	9.7. other related threats	L	L	L	L	L	L
11. Climate change and extreme weather conditions	11.1 Habitat shifting & alteration	H	H	H	H	H	H
	11.2 Droughts	H	H	H	H	H	H
	11.3 Temperature extremes	H	H	M	H	M	H
	11.4 Storms & flooding	M	M	H	M	M	M
	11.5 Other threats	L	L	L	L	L	L

The question addressed to the expert assessors was to identify three top ranked threats to biodiversity of Ethiopia. Based on 51 statements (17 assessors listing 3 top threats), Annual & perennial non-timber crops, Livestock farming & ranching, Logging & wood harvesting, and Housing & urban areas were the most frequently cited top ranked threats to biodiversity of Ethiopia (Figure 20).

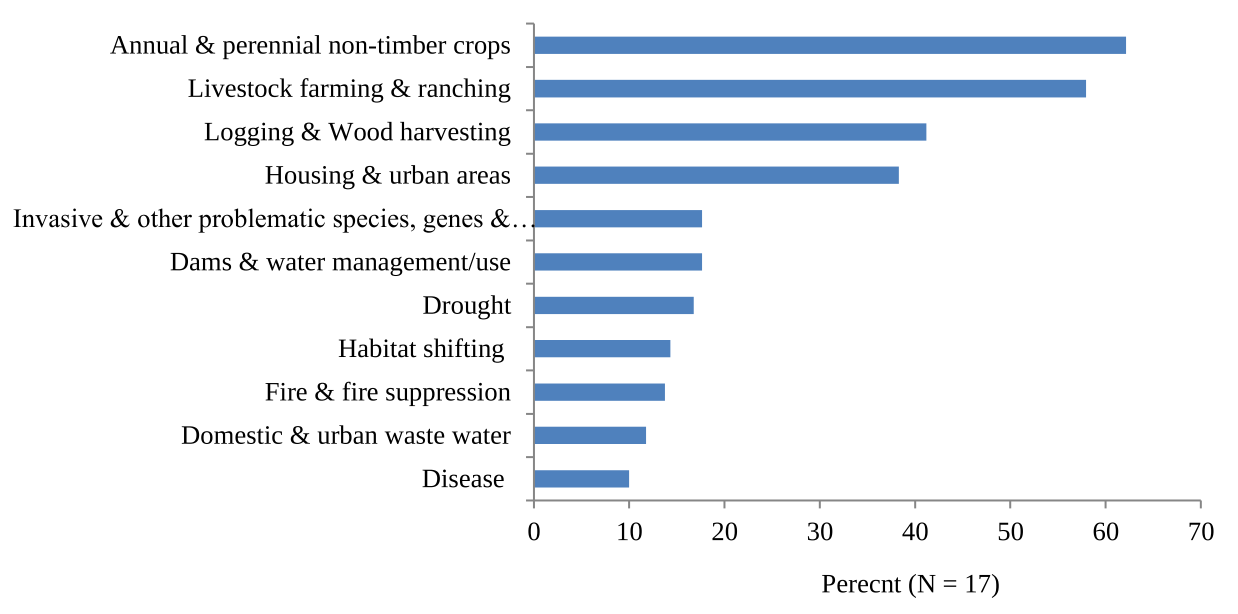

Figure 20. Frequency (%) of top ranked biodiversity threats in Ethiopia as identified by expert-based assessment across the six taxa.

A - Residential and Commercial Development

All the target taxonomic groups were reported to be impacted, with varying levels of severity, from all the three level 2 threat categories of the main threat Residential & Commercial development. While Housing & urban areas was perceived by the expert assessors to have medium impacts on amphibians, birds and mammals, it was reported to have high impact for fish and plants and low for reptiles. The severity of impacts of Commercial & industrial areas was reported to be medium for all taxonomic groups, except for mammals and reptiles which was ranked low. Assessors ranked Tourism & recreation areas as having low threat to all the target taxonomic groups. Overall, when the threat ranks were aggregated across the target taxonomic groups, Housing & urban areas was high, Commercial & industrial areas medium and Tourism & recreation areas low (Table 21).

The assessors' comment on the validity (justifications) for ranking Commercial & Industrial Areas and Tourism & recreation areas as medium or low impacts indicate that these activities are generally less developed in the country and are localized (mostly concentrated in the central rift valley). Instead, the experts stated that Housing & Urban Areas is the fastest growing and wide spreading of all the three threat categories, virtually occurring across all ecosystems and also moderately or highly impacting most biodiversity components. Specifically, the assessors pointed out that their main concern was impacts to fish and plants from unplanned and unregulated Housing & Urban Areas developments near streams, rivers, or wetlands.

Results of experts' threat ranking and justifications for the rank given are in line with findings of previous studies in the country. For example, IBC (2005), EBI (2014a) and Tessema et al., 2019) have reported the increasing expansion of urban and rural settlements areas into natural, causing habitat loss, fragmentation, blockade of wildlife movement corridors, and disturbance. This human activity also indirectly affects wildlife by causing recurrent human-wildlife conflicts arising from livestock depredation, cultivation, pollution, poaching, logging and other forms of unsustainable natural resources use (Tessema et al., 2019, 2021). However, in contrast to some empirical reports that urbanization and settlement are more concentrated in wetlands area and thus amphibians and wetland birds are among the most impacted taxonomic groups (Mengistu et al., 2011; Brown et al., 2012; Gower et al., 2013), the expert assessors failed to affirm this. Overall, lack of land use policy and poor implementation of urban management policies and plans are the major underlying causes of unregulated urban and settlement expansion in Ethiopia. However, assessors reported a need for further studies to fully understand the impacts in Ethiopia.

B - Agriculture and Aquaculture

Both Annual & perennial non-timber crops and Livestock farming & ranching were the top ranked threats to each taxonomic group, with overall ranking of very high impact to biodiversity in Ethiopia (Tables 21 & 22). Conversion of natural forests, grazing lands, woodlands and wetlands into agriculture land is the main threat to biodiversity of Ethiopia. Land use change results in the loss of nearly all species of fauna and flora on-site, especially those species with certain ecological requirements (narrow niche breadth) (Mengistu et al., 2011; Gower et al., 2013). While the predominant type of cultivation in Ethiopia is small scale farming, large scale agroindustrial investments are currently growing rapidly (EBI, 2014a, b). As such, the economic growth achieved in the agricultural sector in the country over the recent years is due to agricultural land expansion (EBI, 2014b, 2020). As a result of this, significant portions of highland forests, woodlands, rangelands and wetlands have been converted into commercial agricultural crop lands such as tea, rice, sugarcane, biofuel, feedstock, coffee and rubber tree (MoFED, 2011; EBI, 2014a). Small scale farming activities are common throughout the country, but agroindustry farming is largely concentrated in the south-western highlands and almost across all lowlands, except in the eastern lowlands (EBI, 2014b). Assessors reported that extensive conversion of natural habitat (e.g., native forests, wetlands or grasslands) into subsistence crops and commercial monocultures (e.g., tea, spices, coffee, wheat, maize, and sugarcane) was one of the biggest contributors to habitat loss and fragmentation for all the target taxonomic groups.

In Ethiopia, unregulated grazing and poor rangeland management have led to ecosystem degradation and alterations, which mostly is accompanied by other threats such as expansion of invasive alien plant species (Mckee, 2007; Vreugdenhil et al., 2012), resulting in the decline in populations of many wildlife species. Currently, overgrazing is one of the major threats to most of the critically endangered vertebrate species in Ethiopia [e.g., Harenna Shrew (*Crocidura harenna*), African Wildlife (*Equus africanus,*) and Water Mouse (*Nilopegamys plumbeus*)] (Vreugdenhil et al., 2012; Lavrenchenko and Bekele, 2017; IUCN, 2020).

Assessors reported impacts of Wood & Pulp Plantations to the target taxonomic groups to be low, except medium impact to mammals and plants. However, this result should be seen while keeping in mind that eucalyptusis the most widespread and abundant plantation – an exotic species known to outcompete and suppress the germination and growth of other native species and to degrade wetland. As such, its impacts on amphibians should be high (see Gower et al., 2013). However, the low coverage area of plantations in Ethiopia probably explains how the assessors ranked their impact on biodiversity..

C - Energy Production & Mining

The impact of Mining & quarrying and Renewable energy production was reported to have a greater impact on plants, followed by amphibians and birds. This is especially true of quarrying for road and building constructions since they are practiced wherever raw materials are available, regardless of considering what actual and potential impacts they may have and mitigation measures needed to minize the impacts. Solar energy production is reported by assessors to have impact on birds, particularly migratory raptors. However, the overall impact on birds of this threat is relatively low at present. Nonetheless, given Ethiopia's planned expansion of renewable energy sources, energy production is likely to have a greater impact on birds in the future, particularly around important flyways and nesting sites of resident threatened species.

D - Transportation & Service Corridors

Roads & railroads, Utility & service lines and Flight paths were all reported to have low level impacts on all the target taxonomic groups (Table 21). The assessors commented that these facilities are currently underdeveloped, and their impacts are thus very low, except for roads that cross protected areas and other unprotected KBAs where wildlife are occasionally killed due to traffic accidents.

E - Biological Resource Use

The impacts of Hunting & collecting terrestrial animals and Fishing & harvesting aquatic resources were ranked low by assessors, but they ranked high for Logging & wood harvesting and gathering terrestrial plants (Table 21). Nonetheless, assessors ranked the impact on mammals of Hunting & collecting terrestrial animals as relatively greater compared to the impact levels on the other target taxonomic groups. They claimed that commercial poaching was among the major causes for the declining populations of iconic species, such as the African Elephant, Lion, Leopard and Cheetah.

Logging & wood harvesting for timber, construction, charcoal production and firewood was perceived to have the greatest impact on the target taxonomic groups, except fish (Table 21). Assessors stated that large scale clear cutting of trees usually leads to habitat loss and fragmentation. Recognizing the future expected increase in the demands of raw materials for construction and fuel/domestic energy by rural and local town inhabitants in Ethiopia, the assessors suggested that effective measures should be in place to mitigate the level of current logging and its impacts on biodiversity.

F - Human Intrusions & Disturbance

According to the assessors' report, Recreational activities, War, civil unrest & military exercises and Work & other activities all had low levels of impacts on biodiversity.

G -Natural System Modification

Fire is reported by assessors to have high impact on all target taxonomic groups, except medium impact on fish and reptiles (Table 21). As commented by the assessors, both the frequency and intensity of unregulated fire burning are currently increasing, impacting almost all ecosystems and associated flora and fauna. The highest impact of Dams & water management/use was reported for fish.

H - Invasive & Other Problematic Species, Genes & Diseases

Invasive non-native/alien species was ranked as having high impact on four of the target taxonomic groups and medium for amphibians and reptiles (Table 21). The most aggressive invasive alien plant species in Ethiopia reported were *Prosopis juliflora*, *Parthenium hysterophorus* and *Eichhornia crassipes*. Assessors mentioned that the former two species are causing sever terrestrial and freshwater (mainly rivers) biodiversity loss by outcompeting and displacing native vegetation species. Eichhornia crassipes, on the other hand, was reported to threaten freshwater birds' habitat and food sources. Transmission of diseases from domestic animals to wildlife (e.g., Canine Distemper and Rabies) was also reported to cause significant declines in population of the endemic, endangered Ethiopian Wolf.

I – Pollution

All forms of pollution were considered to have high impact on fish but either medium (Domestic & urban wastewater and Agricultural & forestry effluents) or low (Industrial & military effluents) level impact on the other target taxonomic groups (Table 21). The assessors suggested that water pollution from urban and agricultural run-off can lead to an overabundance of nutrients (e.g. nitrogen and phosphorus) in wetlands, lakes, and streams, resulting in eutrophication. This, in turn, leads to eutrophication which reduces the amount of dissolved oxygen in the water, degrading habitat and making it difficult for fish to survive.

J - Climate Change & Severe Weather

Habitat shifting & alteration and Droughts brought about by to climate change were among the highest ranked threats to all target taxonomic groups (Table 21). Climate change is believed to alter the ecosystems through elevated temperatures, erratic rainfall and flooding, among others. It also causes shifts in distribution, upslope movement, of flora and fauna, thereby reducing their area of occupancy and exposing montane specialist species to extinction risk. Climate change, as manifested through the spatio-temporal variability of precipitation and increased temperature, causes adverse ecological, economic and social impacts in the country (EBI, 2014a, 2020). Additionally, climatic variables influence the spread of vector-borne diseases through determining the distribution and growth rate of vectors and shortening the life cycle (Holly and David, 2001).

4.3.2 National Expert-based Threat Assessment: Focusing on Cultivation, Grazing and Logging

Non-Timber Crops Production

Almost all (92%, 11 of the 12 respondents) of the expert assessors indicated that Non-Timber Crops production is one of the major agricultural activities affecting biodiversity in Ethiopia. As shown on Figure 21, most crop types are produced both under small-scale and large-scale (agro-industrial) production systems, except some crop types, such as tea, cut flower and Jatropha that are produced only for agro-industry. However, small-scale farming is the major production system for most of subsistence crop types, such as Teff and Sorghum/Maize, oily seed (Niger), and the cash crop Khat (*Khata edulis*), whereas crops such as wheat/barley, coffee, fruit, oily seeds (sesame and soybean) and sugarcane are largely cultivated on large-scale for agro-industry purposes (Figure 21). These results are consistent with reports of empirical studies. For example, Taffesse et al. (2012) indicated that Ethiopia's crop agriculture is dominated by smallholders, which accounts for about 96% of the total area cultivated and 95% of the total production of main crops (cereals, pulses, oil seeds, vegetables, root crops, fruits, and cash crops). Although low both in their overall share of the total area cultivated and the total production of main crops, large farms (in 2007/2008) accounted for a considerable share of production of coffee (19%), sesame (43%) and sugarcane (78%). Regarding coffee production systems, all the known three major production systems (see Denu et al., 2016) are indicated to have significant impacts on biodiversity, but the assessors (92% of the total 12 assessors) consider that the completely managed coffee cultivation/harvesting system has the highest impact on forest biodiversity, followed by Semi-natural (semi-managed) coffee growing (ranked second), and Wild (naturally grown) coffee harvesting.

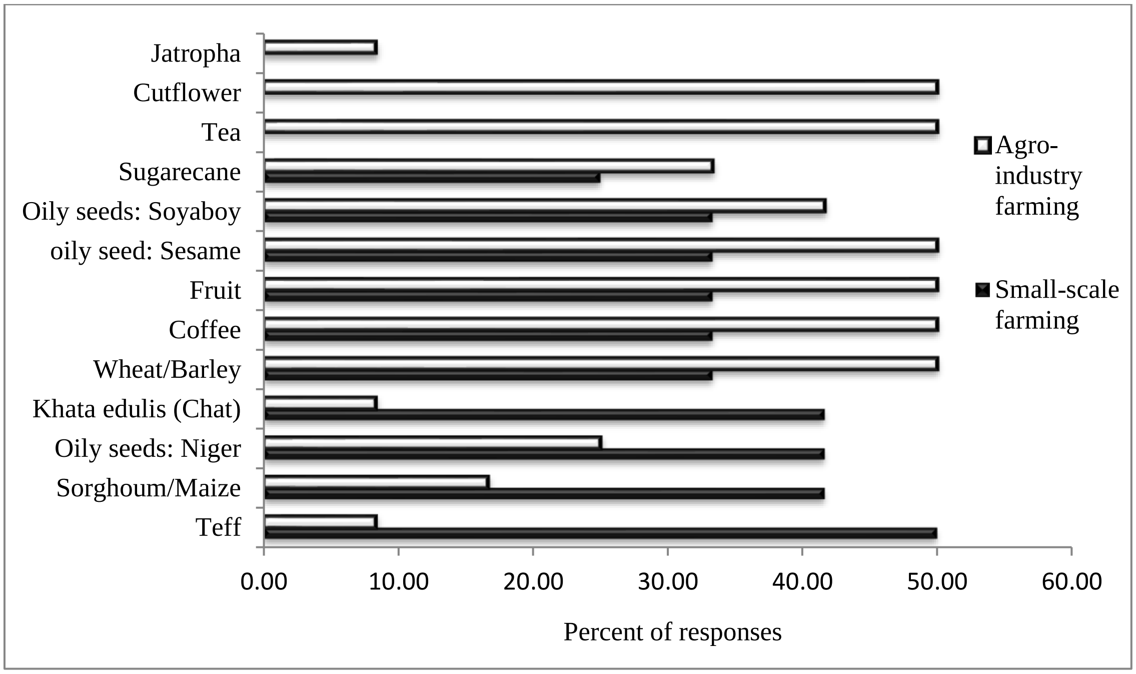

Figure 21. Percent of experts (N = 12) stating Annual & Perennial Non-Timber Crops cultivated under small- and large-scale agricultural systems in Ethiopia.

Livestock Farming & Ranching

As reported by the national expert assessors, Livestock Farming & Ranching scales that affect biodiversity in Ethiopia are small-scale nomadic farming of camels, cattle and shoats (sheep and goats), and small-scale non-nomadic (permanent) farming of equines (donkeys, horses and mules). Agro-industrial farming and ranching of cattle and shoats are also perceived to impact biodiversity to some extent (Figure 22). These findings of experts' opinions mimic results of a recent study reported by Tegegne and Feye (2020).

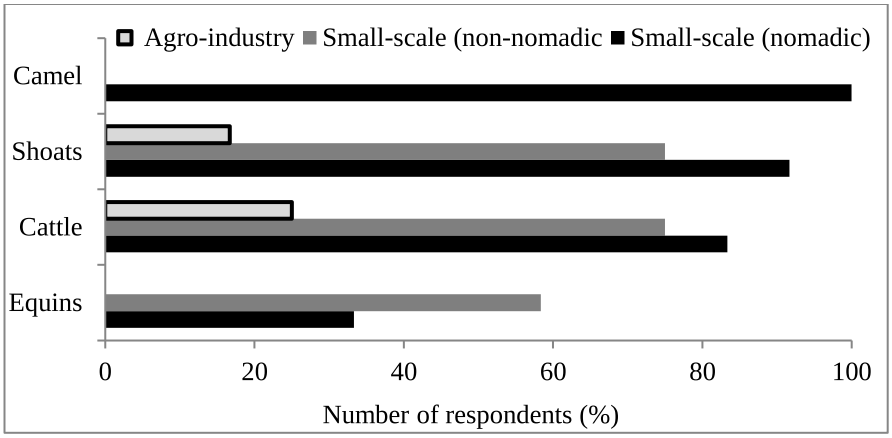

Figure 22. Relative number (percent) of experts mentioning livestock species under small- and large-scale ranching/herding systems in Ethiopia.

Wood & Pulp Plantations

All assessors agreed that Wood and Pulp Plantations have a high impact because they are planted by clearing natural forests and in wetlands. Two thirds of the expert assessors (67%, n= 12 experts over 18) see small-holder production of Eucalyptus as the plantation system affecting most biodiversity in Ethiopia, while 33% of the assessors declare that state-owned Eucalyptus plantation for industrial purposes have higher impacts on biodiversity. Only three experts mentioned that large-scale plantation of Cuppressus/Pinus has considerable impact on Ethiopia's biodiversity.

Logging & Wood harvesting

To the question whether harvesting trees (logging) and other woody vegetation for timber, fibre, or fuel poses threats to biodiversity and which harvesting scale(s) and harvesting method(s) pose greater impact on biodiversity, all the expert assessors confirmedthat logging poses considerable impacts on biodiversity. They also indicated that harvesting and selective logging of woody plant (trees and shrubs) for charcoal production, construction and fuelwood and of trees for timber production are mostly practiced on subsistence/small scale, while clear cutting of woods for timber are performed on large scale tree harvest. Finally, they commented that both harvesting systems (large/small scale) have detrimental impacts on biodiversity, although the magnitude and mechanisms of the impacts of the harvesting scales vary depending on the biodiversity components affected.

4.4. National Level Assessment – Non-Expert-based Threat perception

Assessors regarded as non-expert in this study own at least a MSc/MA degree in public policy studies, Agriculture, Development Economics, Applied biology, Biodiversity Conservation and Management, or Wildlife Management and Ecotourism. They indicated a minimum of 10 years of work experience in the regional state and federal governmental organizations and non-governmental organization functioning in various sectors, such as agricultural, forestry, biodiversity, wildlife conservation, natural Resource management, food security, Climate Change and system improvement, Project M & E Specialist, or Ethiopian Heritage Trust, Project Coordinator in Union of Ethiopian women and Children Association.

One of the two key questions addressed to them was to list out threats that arise from human activities they perceive as direct drivers of biodiversity loss in Ethiopia. Under this question, they were specifically asked to describe each threat they mentioned in their own words, the main biodiversity component affected by the threat (describing which species, taxa (i.e., family and genus), ecosystem, etc.) and where (region) in the country, and justification for this.

In this regard, we extracted 99 statements of threat description, 86 of which were direct human threats and 13 of which were indirect threats, such as driving Forces (e.g., high rate of human population growth), state of biodiversity (e.g., habitat degradation, fragmentation, etc), or threat impacts (e.g., loss of ecosystem services). Results of analysis of the 86 statements describing direct human threats to biodiversity shows that the following level 2 threats are perceived by assessors to having the greatest impact on Ethiopia's biodiversity: Logging & wood harvesting, Annual & perennial non-timber crops, Livestock farming & ranching Industrial & military effluents, Hunting & collecting terrestrial animals, Housing & urban areas, and Invasive non-native/alien species/diseases (Figures 23 & 24).

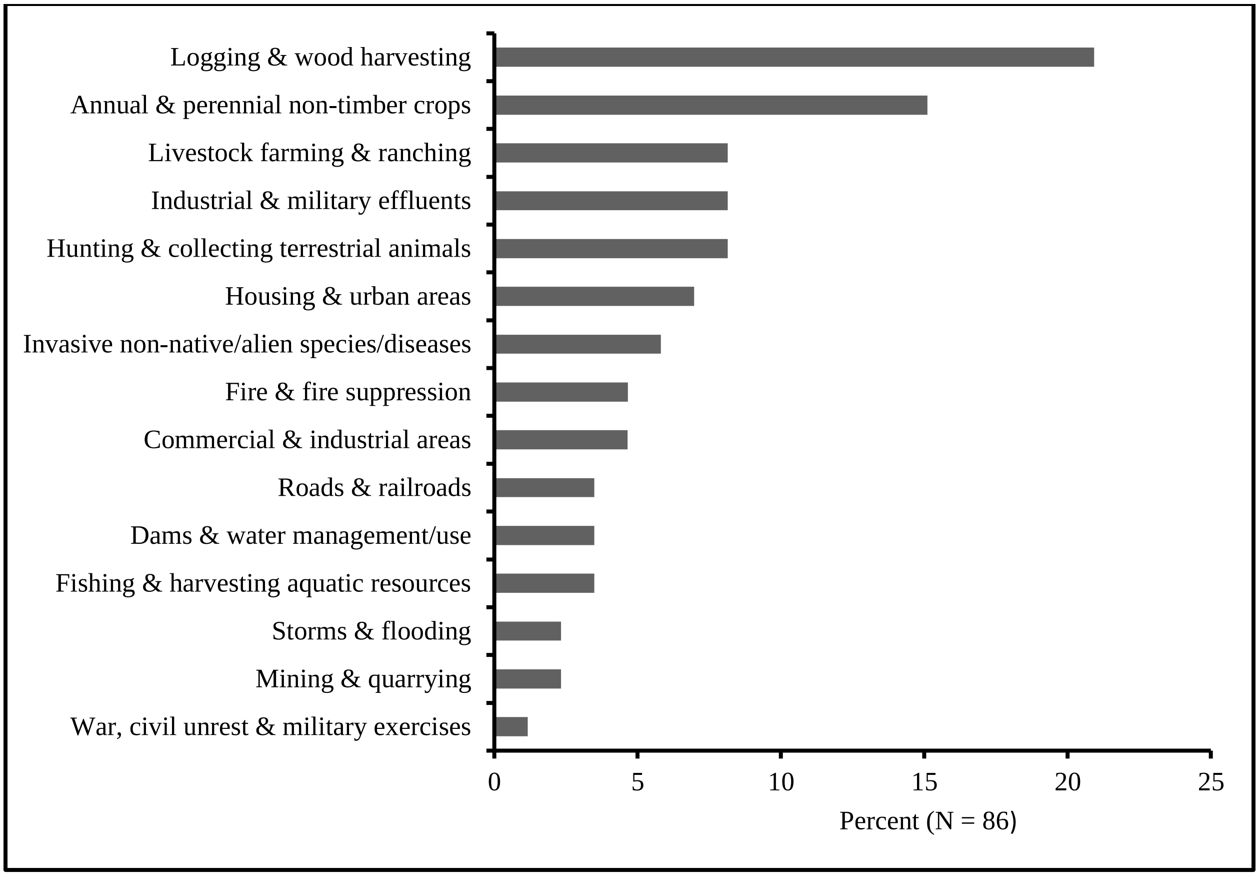

Figure 23. Relative frequency of biodiversity threats in Ethiopia as stated by non-expert assessors.

They stated that most threats affect almost all biodiversity components throughout the country, except some localized threats. The main justification to such statementwas that human population growth rate leads to increased land use for cultivation, grazing and natural resources. This leads to increased waste, deforestation, over exploitation, increaseduse of pesticides, herbicide and the release of other toxic compounds into the environment that contributes to pollutions. Nutrient Loads was ranked as having a 'Very High' impact on freshwater fish and considered to be a priority for conservation action.

The following quote is taken from the statement of one of the assessors:

"Human population growth in the Afar region [has caused] Wild Ass to be listed as critically endangered in IUCN red list due to habitat destruction and poaching, which now-a-days is rarely seen in the area, and various bird species especially the raptor species at Yangudirasa National Park are threatened due to road kill, habitat degradation and fragmentation, tribal conflicts…"

Anthropogenic pressures are particularly affecting ecosystem processes and are causing unusual changes, like changing in species composition and habitat degradation and habitat fragmentation and changes in habitat configuration. Ultimately, they have aggravated biodiversity decline and extinction of various mammal, bird and invertebrate species.

Another assessor stated about the impacts of agricultural expansion in the Abijata-Shalla Lakes National Park:

"… [as a result of] agricultural expansion in and around Abijata-Shalla Lakes National Park (ASLNP) huge amount of land (savannah woodland) has been converted into farmland which caused local extinction of species like lesser kudu, lion, leopard etc. Based on the information I got from elders, senior staff members and also written materials, previously the stated species were distributed in the area. However, nowadays they are not existed [existing] …"

In general, the statements from the non-expert assessors on the major threats can be summarized as follow:

- ***Logging/Tree Cutting***: is a major threat to biodiversity where people practice it for charcoal making, timber production and household fuelwood consumption.
- ***Annual & Perennial Crop Farming***: Although crop farming in the country is generally increasing rapidly, Large-scale Farming (both private- and state-owned) is currently increasing more rapidly relative to the proportion increase in small scale farming. While such large-scale agricultural practices represent an opportunity for the country economic developpement and job creation, it is important to consider how they are executed. First, most agricultural investments are located near or inside KBAs, such as National Parks and National Priority Forest Areas. This includes, for example, (i) cash crop plantations (tea, spice species such as ginger (*Zingiber officinale*) or turmeric/erd (*Curcuma longa*), coffee and rubber in the southwestern forests; (ii) Wonji/Metehara Sugar Factory and Amerti agroindustry (adjacent to Awash National Park), Tendaho Sugar Factory (around Yangudi Rasa National Park), and Omo Kuraz Sugar Factory (in the core wildlife habitats in the Omo National Park); and (iii) sesame, maize and surgouhm cultivation in the western Ethiopia, including those in and around Gambella National Park and forest priority areas in the Beneshangul-Gumuz regional state. Second, investment projects are implemented

without undertaking appropriate Environmental Impact Assessments. As a result, many hectares of forest and grassland habitats have been cleared, and many wildlife species made locally extinct, for example, from Omo, Awash and Hallaydeghie-Assebot National Parks, and at the Afdem-Gewane Controlled Hunting Area in the Afar region.

- ***Livestock Grazing***: Over grazing has caused habitat changes (e.g., grassland to bushland in the Awash and Nech Sar National Parks and in the eastern and southern lowland rangeland areas of Ethiopia), resulting in declining populations or local disappearance of many grazer wildlife species.
- ***Poaching***: is one of the major human activities putting Ethiopia's wildlife at great risk of extinction. For example, species, such as Black Rhino has been extinct, and many other species, such as Elephants are significantly declining in distribution and abundance. Only in 2020, seven elephants were killed by poachers in and around Mago National Park, suggesting the high severity of this threat to biodiversity.
- ***Invasive Alien Plant Species***: Expansion of alien plant species, namely *Prosopis juliflora and Parthenium spp*., in the eastern and north-eastern lowlands of the Ethiopia displaces native vegetation and fauna, affecting rangeland quality and human livelihoods.
- ***Industrial Effluents (Pollution)***: This human activity is also another determinant threat that caused important loss or alteration of ecosystems/habitats of wildlife in Ethiopia. For example, Soda Ash Factory located near Lake Abijata has been blamed for its contribution to the lake's water dropand for changes in its chemistry, with dramatic consequences for the survival of several fish species from this lake. Gold mining in the southern Ethiopia, in addition to its destroying plants and animals, has caused soil acidification and contamination of ground and surface waters, all of which have led to health issues of the local community.

The second question was asking the assessors to indicate their top three threats (of their selection of the threats listed out in their response to question number1 above) they perceive as having the greatest impact on biodiversity in Ethiopia. As shown on 20 19, seven level 2 threats were the most frequently cited threats, with Non-Timber Crops production, Livestock Farming & Ranching, Invasive Alien Species, and Logging & Wood harvesting.

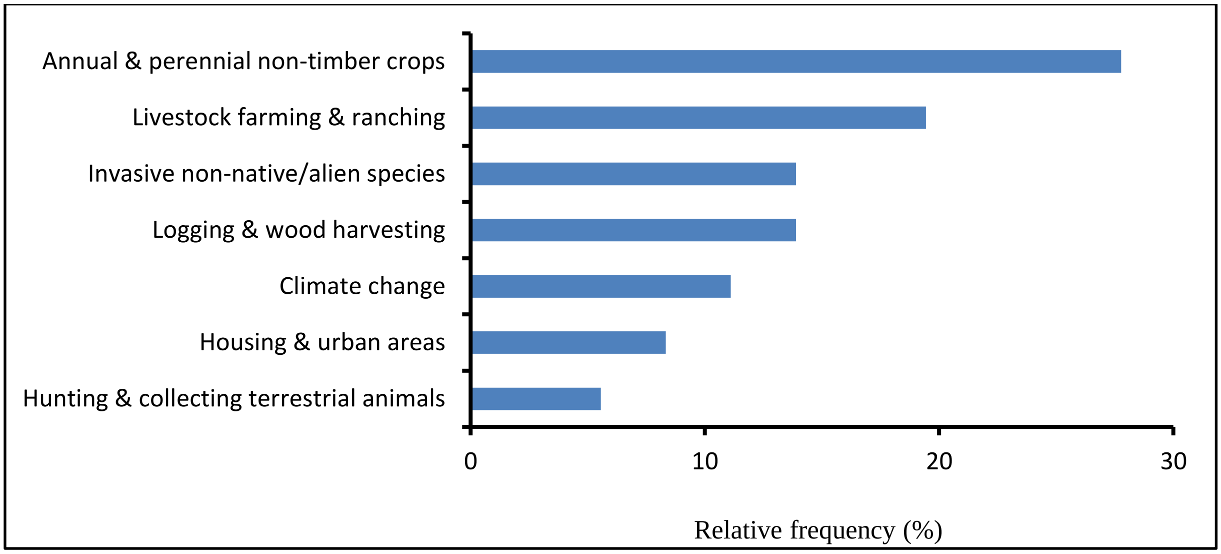

Figure 24. Seven threats to biodiversity of Ethiopia revealed via non-expert threat assessment data.

5. Discussion

This study was set out to (1) assess the state of biodiversity in Ethiopia, (2) identify, classify and rank the threats to Ethiopia's biodiversity from direct anthropogenic activities and (3) identify two to three key economic sectors associated with the main threats to Ethiopia's biodiversity for engagement with the BIODEV2030 project in Ethiopia. The state of biodiversity in Ethiopia was assessed following the ecosystem and species approaches and conservation tools in place (i.e., state of protected areas) to protect biodiversity of the country, while threats to biodiversity were assessed for six target taxonomic groups (mammals, birds, reptiles, amphibians, fish and plants). To achieve these objectives, we used a combination of approaches to acquire and synthesize data, including a review of the literature and relevant policy documents, analysis and use of the STAR metric and other IUCN data (national modified approach) and expert and non-expert questionnaire surveys.

5.1 Representativity of STAR Scores and Overall Findings of the Assessment

The STAR scores calculated for Ethiopia were based on IUCN Red List data for species of terrestrial birds, mammals and amphibians. . . Out of 115 species included in STAR scores for Ethiopia, a total of 43 were endemic birds, mammals and amphibians: 7 are near threatened species (NT), 15 vulnerable species (VU), 15 endangered species (EN), and 6 critically endangered species

(CR). Most of the species used for the STAR calculation are terrestrial or semi-aquatic for a few of them, which is representative of the mostly terrestrial Ethiopian ecosystems. Thus, it is assumed that the STAR metric is appropriate to measure threats to terrestrial ecosystems of Ethiopia.

The STAR metric calculated based on the 105 species for Ethiopia shows that habitat Restoration (STAR R) score is, by far, higher than the score for Threat Abatement component (STAR T; 94% vs 6% of the total score). This result indicates that restoration actions should be prioritized in Ethiopia in order to reduce species extinction risk. These actions, however, have to be complemented by threat reduction in the corresponding areas. But a careful examination of the STAR scores reveals that this is only due to 6 species with very high STAR R scores. Without those 6 species, we have a more classic country profile:

- STAR T score for Ethiopia = 71% of STAR (T+R) score Ethiopia (instead of 6%)
- STAR R score for Ethiopia = 29% of STAR (T+R) score Ethiopia (instead of 94%)

In addition, Threat Abatement STAR score for critically endangered species is about four times higher than their STAR R score (2,740.7 vs 710.6), suggesting that for those critically endangered species threat abatement measures are particularly more important than restoration.
Furthermore, the threat abatement scores of endemic species is 9893 which represents 84% of the country's STAR-T score. This also illustrates that Ethiopia has a very high responsibility in preserving its endemic biodiversity through threats abatement.

Our overall findings from analysis of STAR and assessors' data show that most ecosystems and KBAs of the country are under great pressure from human activities and experiencing degradation and habitat alterations. As a result, many species of plants and animals are generally experiencing declining population trends and exposed to extinction risks. Information synthesized from literature review also affirmed this fact: most ecosystems and flora and fauna species in Ethiopia are severely suffering from one or more types of anthropogenic-induced threats (see section 4.1).

Comparison of results of threat impact ranking made via the three main approaches (the STAR T analysis, expert-based assessment and non-expert assessment) showed that there is a high convergence (consistence) in threat rank order of level 2 threat categories revealed through the approaches (Table 22). Similarly, for the list of threats with STAR T and STAR R scores, and which have also been evaluated by experts (sums across the six taxonomic groups), we have applied a correlation analysis. Accordingly, we and found strong positive correlation between STAR T scores and threat ranking score by experts (Spearman's correlation coefficient = 0.77, n = 35, P <0.05) and also between the STAR T and STAR R scores (rs = 0.80, n = 35, P <0.05). These results likely suggest, despite some caveats on using the method (see section 5.6), the high reliability can be posed on results from the STAR analysis for applying in management decisions. They also suggest that species with high STAR threats abatement scores are also those with high STAR restoration scores, implying the need to take both abatement and restoration measures to mitigate the major threats and their impacts on biodiversity.

In sum, results of analyses of the STAR and expert/non-expert-based threat assessment data show that Annual & perennial non-timber crops, Livestock farming & ranching, Housing & urban areas and Logging & wood harvesting were consistently identified as the four highly ranked threats across the terrestrial taxonomic groups of Ethiopia (Table 22). These findings suggest that these primary threats form components of the same overarching impacts – namely the loss, reduction of quality, and fragmentation of the native habitats (e.g., forests, grasslands and wetlands) in which the majority of Ethiopia's endemic, rare and/or threatened species are restricted. Thus, for the BIODEV2030 project to reverse, or slow down, the IUCN Red List Index in Ethiopia then we clearly need to address all the threats contributing to loss/fragmentation and degradation of native habitats.

Table 22. Ten top ranked threats to biodiversity in Ethiopia based on assessments made through STAR T, STAR R, expert-based threat assessment data and non-expert-based assessment data.

Level 2 Threats	Threat Abatement (Rank)	Restoration (Rank)	Expert-based (Rank)	Non-expert (Rank)	Average (Rank)
2.3 Livestock farming & ranching	1	1	1	2	1
2.1 Annual & perennial non-timber crops	2	2	2	1	2
5.3 Logging & wood harvesting	3	6	5	3	3
1.1 Housing & urban areas	4	3	7	6	4
7.1 Fire & fire suppression	5	7	8		7
11.1 Habitat shifting & alteration	8	5	3		5
9.3 Agricultural & forestry effluents	10	4	14		9
11.2 Droughts	11	12	4	3	6

8.1 Invasive non-native/alien species/diseases	12	13	6	5	8
5.2 Gathering terrestrial plants	15	20	9		9

5.2 Major threat 1: Livestock Farming & Ranching

Livestock Farming & Ranching is identified as the highest threat to biodiversity of Ethiopia. This threat contributes to 59% to the total STAR score and 24% and 61% to the total STAR T and STAR R scores, respectively. Reports of several previous studies and assessments (e.g., Mckee, 2007; Demeke, 2008; SMNP-GMP, 2008; Vreugdenhil et al., 2012; EBI, 2014a; BMNP-GMP, 2017; Lavrenchenko and Bekele, 2017) on the impacts of livestock grazing on biodiversity in Ethiopia also show the deleterious effects of livestock overgrazing on ecosystems and species.

Ethiopia has the largest number of livestock in Africa and the 10th largest in the world (Mckee, 2007; Gezahagn, 2019).). The two common modes of livestock grazing systems, both small-holder ranching activities, in Ethiopia are nomadic grazing (pastoralists who are normally only present in a given area for part of the year) and permanent/non-nomadic/ grazing (mixed farming sedentary farmers who uses a given area for livestock grazing throughout the year). Agro-industry livestock farming and ranching activities have been relatively uncommon practices, but currently are fast growing, and are exercised by state or private investments. Nomadic grazing is the livestock herding system reported to posing the most detrimental impact to biodiversity of Ethiopia, followed by sedentary herding (Mckee, 2007; Vreugdenhil et al., 2012; EBI, 2014a, b; BMNP-GMP, 2017). Degradation of rangelands due to increasing number of livestock, poor rangeland management systems and lack of fodder supplements are the major driving forces for the current unregulated overgrazing encroachments into fragile ecosystems, such as Afroalpine and wetland ecosystems, resulting to ecosystem degradation and alterations (SMNP-GMP, 2008; Vreugdenhil et al., 2012; BMNP-GMP, 2017; EBI, 2020).

Specifically, wetlands are often a last destination for pastoralists during the dry season in most parts of the country. However, livestock population increases, fodder shortages and the simultaneous expansion of agricultural activities have contributed to exacerbating the grazing pressure on wetlands. The pressure from grazing has resulted in changes of the wetland characteristics; in some cases, wetlands have been transformed into rough grazing land (Mckee, 2007). Compaction of the wetland by livestock is also known to have a significant impact on the infiltration capacity of the soil hence affecting the hydrological system and balance of the wetland itself (Mckee, 2007). Overall, overgrazing is negatively affecting the physical, chemical and biological (loss of biodiversity) components of both terrestrial and freshwater ecosystems. The implication of findings is that unless issues related to the causes/drivers of overgrazing are identified and addressed, the future of state of biodiversity of Ethiopia will be worsening.

5.3 Major threat 2: Annual & Perennial Non-Timber Crops

Annual & perennial non-timber crops are identified to having the second highest impact to biodiversity of Ethiopia. It contributed 22, 19 and 17% to the total STAR, STAR T and STAR R scores, respectively. Both expert-based and non-expert-based data also showed similar ranking level for this threat. Agriculture remains the main driver of rapid economic growth and development in Ethiopia, but the current production system drives changes in land use practices due partly to rapid human population growth rate and increasing demand for small holder arable land, and partly to increasing engagement of private and state farms for the production of industrial and export crops (IBC, 2005; EBI, 2014b). Ethiopia's agricultural systems are highly dependent on climate and are vulnerable to more frequent and extreme droughts and floods, which challenges achievement of the intended transformation of Ethiopia from an agriculture-based economy into a manufacturing hub. Droughts alone can reduce total gross domestic product (GDP) by one to four percent, and rising population densities are placing added pressure on these fragile ecosystems through land degradation, forest loss, and increased water stress and soil erosion.

Subsistence (small holder) cropping is a matter of meeting the basic need of food although some small holders also produce a surplus that can be marketed to generate income for the families, while large scale farming investment activity should also be encouraged for the presumed contributions it makes up to national GDP, poverty reduction, creation of employment opportunities and biodiversity conservation. However, there are several challenges in these agricultural activities due to policy gaps or poor implementations and lack of coordination across sectors. For example, there is a lack of land use policy in the country and sectorial specific policies often dictate conflicting provisions. Furthermore, issuance of ownership of farmers' landholding certificate has only been started very recently, which is still going on. Consequently, areas set aside as protected areas are usually seen as free access resources where farmers illegally establish farming activities. Agricultural work on steep topography and on poor or degraded land reduces soil fertility and associated agricultural productivity. Similarly, large scale, private and state-owned, agricultural investments are also implemented, without environmental impact assessments, at the expense of native forests, such as the case of tea, spice and coffee cultivations in the south-western forests (Mckee, 2007; EBI, 2020) and inside legally established protected areas, such as the Omo and Gambella National Parks (EBI, 2014). In Ethiopia, rate of deforestation is between 1500 to 2000 km^2 per year between the period of 2006 and 2019 (Mckee, 2007; FAO, 2021), a rate which is expected to increase in the future to meet the ever-increasing demand for arable land by small-scale farmers attributed to high population growth rate. When considering other threats associated with agricultural activities such as effluents, the consequences are far reaching and severe, impacting terrestrial and freshwater biodiversity. Once in water systems, rivers eventually carry the effluents downstream into the lakes introducing harmful nutrients and chemicals to marine biota (Wafar et al., 2011).

In order to protect from human-induced impacts and preserve representative biodiversity of the country, Ethiopia has committed to designating about 12% of land mass as terrestrial protected areas (Gizaw and Gebretensae, 2019). However, areas in the country where intensive small scale crop farming is concentrated coincide with KBAs harbouring the highest species richness, endemic and/or threatened species and remaining indigenous forests in the north-eastern, south-western and south-eastern highlands. Thus, facilitating voluntary commitments focusing on intensive crop farming in these areas may have a high potential to conserve biodiversity. This is the "land sparing" option: intensification with higher yields may allow reducing opressure on clearing natural habitats for cultivation, which has to be complemented by other actions to guarantee the positive result. However, only some of the KBAs covered within protected areas are relatively effectively protected (Mckee, 2007; Vreugdenhil et al., 2012). In the absence of effective protection, even this small area is far from 'risk free' protected, which suggests that the type of complementary actions that are needed to protect effectively biodiversity, in addition to intensification on already cultivated fields, are more effective protection of PAs, and new and effective protection of today unprotected KBAs. Currently, several key PAs of the country (e.g., Bale Mountains, Awash, Semien Mountains, Awash, Omo and Abijata Shalla National Parks) are under sever impacts from small-scale and/or large-scale cultivation (Mckee, 2007; EBI, 2014a, b; BMNP-GMP, 2017). State-owned agro-industry intensive and extensive agricultural practices are also posing critical threats to biodiversity in many of formally protected areas, such as national parks (Tessema et al., 2019). Similarly, commercial agricultural investment in the National Priority Forest Areas has also resulted in clearance of hundreds and thousands of prime rainforests to give way to cash crop plantations of tea, spice species such as ginger (*Zingiber officinale*) or erd (*Curcuma domestic*), coffee and endod (*Phytolacca dodecandra*) (Mckee, 2007; EBI, 2014a, 2020).

Although the impacts of such agricultural encroachments into protected areas and other native forests and ecosystems on flora and fauna are little understood and not sufficiently monitored or documented, it is acknowledged to be a significant threat to Ethiopia's biodiversity and human well-being through habitat degradation, loss and fragmentation and species loss, which eventually has led to loss of ecosystem services (Mckee, 2007; EBI, 2014b; Tessema et al., 2019).

5.4 Major threat 3: Housing & Urban Areas

Housing & Urban Areas was identified as the third or fourth highest threat to biodiversity in Ethiopia. Obviously human settlement pattern coincides with areas with rich biodiversity. Most rural towns/urban lack management plans and residential and business buildings are constructed based on suitability and availability, regardless of their consideration of their environmental impacts. The same holds true in the rural village settlements. Settlement is often accompanied by cultivation, grazing, pollution and logging. As a result, many KBAs are highly threatened due to habitat loss, fragmentation and degradation (Mckee, 2007). They also directly impact wildlife through blockade of movement corridors and disturbance (IBC, 2005; Tessema et al., 2019). Furthermore, presence of humans within PAs also leads to frequent contact between humans (and their associated livestock) and wildlife, particularly large carnivores, resulting to escalated human-wildlife conflicts arising from livestock depredation (Tessema et al., 2021). Thus, enforcing land use policy is indispensable to curtail this ever-increasing threat and its impacts on biodiversity in Ethiopia.

5.5 Major threat 4: Logging & Wood Harvesting

The demand of raw materials for construction and fuel/domestic energy by rural and local town inhabitants in Ethiopia are largely met by forest products, which is expected to increase in the future as human population increases. As such, to mitigate the level of current logging and its impacts on biodiversity, effective measures should be in place to address the increasing reliance of people on forest products (timber, fuelwood, charcoal, etc) for construction and fuel. For example, establishing industrial plantations around urban areas would be useful to supply construction and energy materials, while encouraging agro-forestry and small-scale plantations in the rural areas would reduce their dependence on natural forests.

5.6 Study Limitations

There are several limitations of this study that could lead to bias and/or confounding arguments affecting our findings.

a) Data on KBAs and Ethiopia’s Protected Areas: confusions on extent, management category and governance. There is a problem with overlaps (double auditing) due to upgrading protection status, wholly or partially. As a result, it was difficult to reliably assess the status and trends and efficiency of KBAs and Protected Areas.

b) Expert assessors lack specialisations for each taxon, which may challenge the accuracy/validity of the questionnaire survey. Furthermore, experiences of the experts are limited to certain geographical regions (highlands, or lowlands).

c) The STAR metric relies only, at the moment, on 3 taxonomic groups (amphibians, mammals and birds), which may limit the comprehensiveness of the analysis in a given country. The use for STAR analysis of the 3 taxonomic groups itself is based on the assumtion that they are the most studied animal groups, but this may not be the case of Ethiopia although the STAR scores were positively correlated with expert assessors threat ranking scores. The main reason is that many endemic mammal (12 species; see Table 6) and amphibian (12 species; see Table 13) species of Ethiopia were discovered in the last decade, whose populations and IUCN Red List Threat category have not been evaluated (and thus, are not taken into account, yet, in STAR).

d) Species listed as Data Deficient in the IUCN Red Listare not included in the STAR analysis. Given that these are mainly endemic species with relatively restricted ranges, they would have contributed useful information to the STAR threat assessment.

e) Status and trend assessments for plant species are only available for endemic species, which represents a fraction of all plant species in Ethiopia.

5.7 Knowledge Gaps

The status and threats of KBAs/PAs, many species unknown; impacts of threats unknown; no systematic monitoring, data sharing; specifically:

a) Currently, data on KBAs and Protected Areas of Ethiopia available on national and global databases are incomplete and inconsistent. Such gaps make it difficult to assess the status and conservation relevance of KBAs and PAs and the country's commitment to achieving international agreements. It can also lead to inappropriate development decisions. Currently, an initiative led by the Ethiopian Biodiversity Institute is undergoing to solve this limitation. Overall, basic data (updated list, IUCN designation and management categories, extent and shape files/maps) should be compiled, organized in a database form to ease update and retrieval and shared with relevant stakeholders.

b) Many endemic species (recently discovered) are restricted range, their status unknown/ red list not evaluated; we don't know how many species have gone lost before they were known to the scientific community. As such, the distribution range, current population estimates, and threats should be established. Little known endemic smaller mammals and amphibians should be prioritized for assessment of threat status and population trend and conservation needs.

c) Climate change and invasive alien species were among the highly ranked threats. However, we found no empirical studies showing the effects of climate change on biodiversity (ecosystems/species), such as habitat shifting & alteration and changes in distribution of species. We suggest that the actual and potential impacts of climate change and current coverage, distribution, impact and control/eradication measures of the major invasive species are needed.

d) Despite the increasingly acknowledged importance of unprotected areas, including human modified ecosystems like agricultural lands, for biodiversity conservation and ecosystem service provision, threats impacting biodiversity of such areas are poorly known.

6. Conclusion

This study was set out to identify threats with the greatest impact on Ethiopia's biodiversity and the economic sectors driving them. Our findings show that Livestock Farming & Ranching, Annual & Perennial Non-timber Crops, Biological uses (Logging) and Urban & Housing are the major threats with greatest impact on biodiversity, followed by climate change related Habitat Shifting & Alteration and Drought, Invasive Alien Species and Fire. The economic sectors driving these threats were identified as agriculture, forestry, energy, and construction. These sectors are also prioritized in the current NDP to transform Ethiopia from an agriculture-based economy into a manufacturing hub, a plan that hinges on improved transport and energy infrastructure and greater agricultural-sector productivity. They are briefly described below.

It is evident that several medium or high impact threats (e.g., Pollution, Excessive Water Abstraction, Invasive Alien Species, etc) are linked either directly or indirectly to (i) Non-timber Crops and Livestock Farming & Ranching agricultural activities, (ii) Urbanization & Housing Activities, and (iii) Logging & Wood Harvesting, Hunting & Collecting Terrestrial Animals and Fishing related Biological Resources Uses. Thus, it can be concluded that the agricultural sector had the greatest impact on biodiversity in Ethiopia, followed by urban/settlement expansion and excessive use of biological resources. As such, the potential to reduce species declines is multiplied significantly by focusing on synergies between the agriculture, urban/rural settlement and forestry sectors.

Climate related Habitat Shifting & Alteration was the greatest ranked threat to the six target taxonomic groups (see Tabel 1), however abating these threats may be challenging. Numerous economic sectors contribute to green-house gas emissions and would require concerted efforts across sectors at global level to be effective.

Selection of Key Economic Sectors

A ranking excerice conducted based on average ranks obtained through the different methods, including the CMP global data for Ethiopia, showed that Livestock, Cultivation and Forestry sectors were, respectively, ranked the first, second and third key economic sectors driving bioidvesrity loss in Ethiopia. Results of sector ranking by key stakeholders during the validation worshop also selected these sectors as the top three economic sectors impacting biodiversity. Specifically, the workshop participants have unanimously agreed that agricultural production (cereal, coffee, vegetables & fruits) is the primary economic sector responsible for decline of biodiversity in Ethiopia, while livestock farming and ranching as the second and forestry sector as a third key economic sectors most impacting biodiversity in Ethiopia.

Overall, based on combined information obtained from the various sources and on criteria such as role for national GDP and local economy, institutional presence, impact of economic value chain and other key criteria used by the national stakeholders (validation workshop participants), the following two sectors and corresponding subscetors are finally identified and recommended for future interventions:

Under Agricultural sector, the following two subsectors were identified as key economic activities:

- Crop production, identified as the first sub-sector that also include coffee
- Livestock rearing, identified as the second key economic sub-sector

Under the broader forestry sector, the following key economic sub-sectors were identified:

- Small scale logging and wood harvesting, identified as the first key economic sub-sector
- Agro-forestry, identified as the second sub-sector

Below are our proposals of sub-sectors to be continued to work with, in the next steps of the BIODEV2030 project:

Major Subsector 1: Agriculture (coffee and cereal crops cultivation)

Coffee is the top export crop of Ethiopia. In the country, the majority of coffee farmers work their own farm with family labour. Coffee farming in the country takes four forms of management systems: garden, completely managed, semi-wild and wild (Denu et al., 2016). The completely managed coffee harvesting system is the one representing the most intense threat to biodiversity, followed by semi-wild management system. In the case the completely managed coffee harvesting system, intensification of coffee cultivation is through increasing the density of *C. arabica* shrubs, removal of canopy trees, and clearing of understory vegetation, which negatively impacts the vegetation structure and species diversity of the coffee forests (Geeraert, 2019). In the most extreme case, natural coffee producing forests are transformed into shade plantations consisting of high densities of *C. arabica* shrubs under sparse canopy trees. The area occupied by such coffee plantations is rapidly expanding at the expense of more natural coffee agroforestry systems (Geeraert, 2019). It is estimated that about 26-30% of the total coffee production of the country originates from wild and semi-wild coffee forests, with the value of wild coffee estimated at 130 million USD per annum. Commercial coffee farms make up about five percent of total coffee farms (USDA, 2020a).

The main coffee growing areas in Ethiopia (Figure 25) largely coincide with areas harbouring the highest species richness, endemic and/or threatened species and remaining indigenous forests, such as the Harenna forest in the southern slope of Bale Mountains and the and south-eastern montane forests. Area coverage of coffee has been increased from 529,000ha in 2016 to 540,00ha in 2020, showing annual increasing rate of 2,750ha (USDA, 2020a). Thus, facilitating voluntary commitments to focus on reduction of intensive (completely managed) coffee farming in these areas may have a high potential to conserve biodiversity. However, according to USDA (2020a), the replacement of coffee trees with khat (*Catha edulis*), a bushy plant with stimulant properties, has had an adverse effect on coffee production, which may lead coffee farmers to clear more forest land for coffee plantation. Thus, both khat and coffee production systems and practices need to move towards biodiversity friendly coffee production and khat techniques / practices to show that it is possible to reconcile economic production (coffee/khat) and biodiversity protection. Thus, improving (i) productivity and production systems, (ii) improving, post-harvest loss reduction and (iii) marketing linkages of coffee cultivation would be indispensible to mutually and sustainably enhance both economic gains from coffee and biodiversity conservation. As such, any planed actions in this regard should involve main stakeholders, including local communities, coffee exporters associations, Ethiopia Commodity Exchange Authority, Ministry of Trade and Investment, Forestry, Biodiversity and Wildlife.

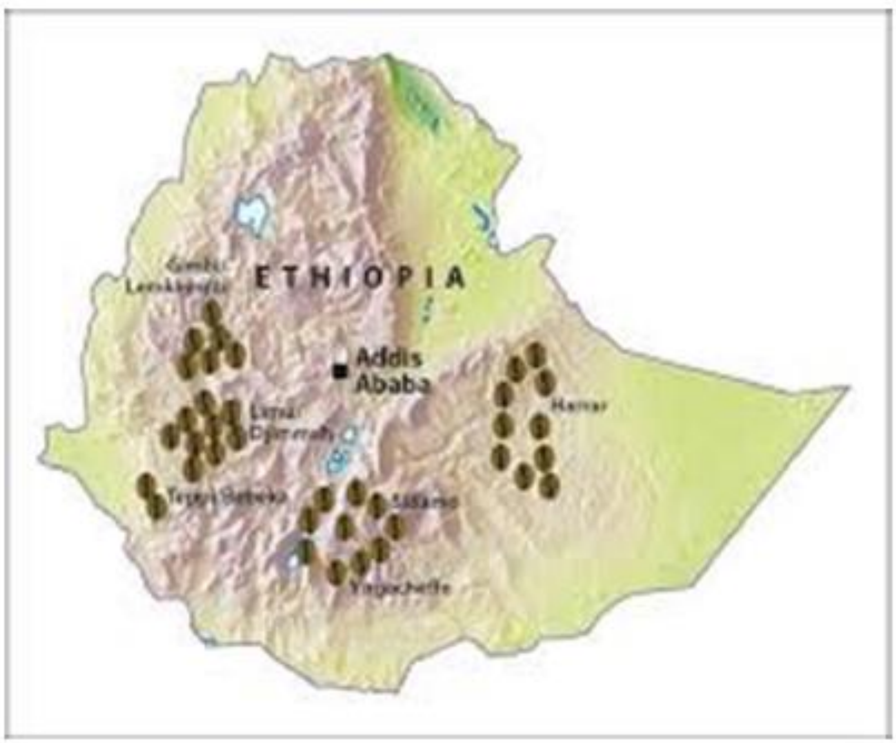

Figure 25. Coffee growing areas in Ethiopia (source USDA 2020a).

Major Subsector 2: Agriculture (Livestock Grazing, Farming & Ranching)

Ethiopia has the largest number of livestock in Africa and the 10^{th} largest in the world (Mckee, 2007; Gezahagn, 2019). International trade of living animals (cattle, sheep, camels and goats) is a steadily growing key economic sector for Ethiopia. According to the Ethiopian Revenues and Customs Authority (ERCA 2018/19 report[7]), Ethiopia is exporting meat and meat products to different African and Middle East countries. United Arab Emirates is the largest importer of meat buying 58% of the total meat exported followed by the Kingdom of Saudi Arabia with 30% and Bahrain (4%) in 2018/19 EFY. Yemen and Somalia stood 1st and 2nd importers of live animals; Somalia was primarily for re-export to other countries (ERCA, 2017/18). According to Bereda et al. (2016), in Ethiopia, in addition to significant contribution of export earnings, livestock are

[7] ERCA (2019). Ethiopian meat and dairy industry development institute annual reports, 2018/19

economic and social importance at household and national level. The country has an advantageous position in production and possessing of different products and by-products due to high and diverse number of livestock as compared to other African countries. Pastoral area of the country is the sole supplier for both formal and informal live animal and meat exports. The livestock are marketed from the major producing areas reaches to the final consumer passing through complex channels along the supply chains involving various actors. Despite fluctuations over years, the formal exports of meat (7,717 to 16, 500 tonnes) and live animals (163,000 to 680,000 head) have significantly increased in between 2006/7 and 2012/13 (Bereda et al., 2016).

However, almost all live animals (85%) are exported illegally smuggled to neighbouring countries of Djibouti, Somalia, Kenya and the Sudan, using illegal trade routes and re-export to Middle East. This illegal transaction has resulted to reduction in the contribution of livestock sector all Ethiopia's formal export earnings from 24% would have been attained in absence of smuggling to current estimated 11% (Tegegne and Feye, 2020). Consequently, both the herders and the Ethiopian government have lost substantial market share and foreign exchange. Lack of exporting routes and ports, illegal live animal trade, shortage of live animals and lack of appropriate breeding policy (that may promote better range land management and provision of improved livestock fodder) are some of the major challenges that hinder the smooth livestock trade of Ethiopia. This lack of access to trade market, in turn, has led the pastoralists to continually keep on herding large numbers of livestock heads, without benefiting both themselves (by migrating from pastorlist lifestyle to other forms, such as living and running other business types in towns) and biodiversity.

The ever-increasing number of livestock, poor rangeland management systems, lack of fodder supplements and low level of productivity and the consequently low level of economic benefits gained are the major driving forces for degradation of biodiversity in rangelands and KBAs. Although livestock grazing-induced biodiversity degradation is common throughout the country, there are some spatial and temporal variations in the grazing activities. For example, communities living in the north-eastern (Afar regional state), eastern (Somali regional state) and southern (Oromia regional state) lowland regions of Ethiopia practice nomadic herding system and thus impacting biodiversity throughout their ranging areas and the year (Demeke, 2008; Vreugdenhil et al., 2012; EBI, 2014, 2020). However, people living in the highlands and adjacent lowlands, who practice mixed farming system, are mostly sedentary livestock herders. The exception is that some of the latter communities also seasonally move up into KBAs in the Afroalpne regions, particularly during the wet season when the adjacent highland and lowland areas are covered by crops (SMNP-GMP, 2008; Vreugdenhil et al., 2012; BMNP-GMP, 2017; EBI, 2020). Although it is expected that the contributions of the impacts from different livestock types (cows, goats, sheep, etc) to biodiversity degradation vary across the livestock types, we could not find information elucidating the magnitude of these variations. In order to mitigate the impacts of livestock grazing on biodiversity in Ethiopia, it is imperative to promote more biodiversity-friendly herding practices such as reducing livestock numbers while increasing productivity, improving rangeland management systems and providing fodder supplements.

Major Subector 3: Domestic Energy

There seems to be no single sector driving Logging & Wood Harvesting in Ethiopia because this activity is practiced for various reasons, including for house construction, fencing, fuelwood, household equipments and furniture. Energy and construction sectors are the primary economic activities driving deforestation due to logging.

The Ethiopian energy supply and consumption pattern is dominated by traditional biomass fuels, which may remain to be so in the foreseeable future. Traditional biomass sources (wood, crop residues and cattle dung) supply 94% of the total energy requirement, with petroleum and electricity meeting the rest (Lakew, 2010). More than 95% of the bio energy is used for domestic cooking and lighting. In addition to using cattle dung and wood for cooking, many of Ethiopia's city dwellers and commercial establishments (i.e., bakeries, hotels, restaurants, local brewing businesses, etc) also use charcoal and kerosene as sources of energy (Lakew, 2010; MUDHC, 2014). In all cases, people use biofuels in inefficient traditional conversion technologies. Ethiopia's an annual economic growth rate of more than 11% is associated with an increased demand for energy supply of over 24%. Demand for bio energy in the country is generally projected to grow at the same rate as that of the population, i.e., at about 2.7% a year in rural areas and 4.5% a year in urban areas (MUDHC, 2014). Natural energy sources such as water, geothermal, solar and wind resources offer opportunities to meet the growing energy demand, and at the same time develop low greenhouse gas emission energy and shift towards a green growth path (CRGE, 2011). However, developing the necessary power capacity from renewable energy will be an enormous challenge. This has led to continued heavy reliance on biomass fuels, particularly woody biomass, contributing to deforestation and degradation of forest and associated fauna. This is partly because use of fuel wood in urban areas is an important source of cash income for people (CRGE, 2011; MUDHC, 2014).

Hydropower offers large potentials for Ethiopia's economy and opportunities to reduce poverty. There are currently many on-going activities that focus on increasing access to renewable energy, including building mega hydropower plants, such as the Grand Millennium/ Renaissance Dam. Successful completion of these hydro plant projects and exploitation of other potential alternative energy resources, i.e., solar, wind and geothermal resources, is important to relief the country from a part of the burden of usage of biomass and fossil fuel. Improving access to energy including the use of renewable energy is not satisfactorily promoted; for example, little is known about solar energy in both urban and rural areas. Improving traditional biomass use through energy saving and less pollutant stoves should be further promoted, as it would contribute to decrease the pressure on forests. Furthermore, plantation forestry has been practiced meeting these demands and reduce the pressure on native forests.

To meet the ever increasing demand of raw materials for construction and fuel/domestic energy by rural and local town inhabitants in Ethiopia, and thus to mitigate the level of current logging and its impacts on biodiversity, effective measures should be in place. For example, establishing industrial plantations around urban areas would be useful to supply construction and energy materials, while encouraging agro-forestry and small-scale plantations in the rural areas would reduce their dependence on natural forests and income generation from sales to nearby urban dwellers.

7. Recommendations

The need for implementation of effective conservation of Ethiopia's biodiversity in a high sense of urgency is not only because of the need to minimize biodiversity extinction but also to ensure sustainability of the vital ecosystem services they provide and human wellbeing, such as supporting (e.g., lifecycle maintenance), regulating (e.g., regulation of water flows), provisioning (e.g., food) and cultural (e.g., recreation) (Millennium Ecosystem Assessment, 2005). As also has been suggested by the Convention on Biological Diversity post-2020 agenda[8] and UN Sustainable Development Goals[9], planning and implementation of effective biodiversity conservation actions should depend on assessment of status and threats of ecosystems and associated biological components.

Findings of this study show that Ethiopia's biodiversity is facing severe threats mainly from livestock grazing, cultivation, urban and settlement expansion and logging. These main threats form components of the same overarching impacts – namely the loss, reduction of quality, and fragmentation of the native forests, wetlands and grassland habitats (e.g., Mckee, 2007; Vreugdenhil et al., 2012) where the majority of Ethiopia's endemic and threatened species across taxonomic groups are restricted. The major economic sectors/subsectors driving these threats are Crop Farming (mainly cereals and cash crops such as coffee) and Livestock Farming subsectors of the Agricultural sector; Forestry sector, and Rural/Urban Land Administration sector. The areas where intensive small scale crop farming is concentrated coincide with areas harbouring the highest species richness, endemic and/or threatened species and remaining indigenous forests in the north-eastern, south-western and south-eastern highlands of Ethiopia. However, the current protected areas system of Ethiopia is not adequate /efficient enough to effectively buffer biodiversity from these direct human pressures. Thus, for the BIODEV2030 project to reverse, or slow down, the IUCN Red List Index in Ethiopia there is a need to address issues associated with protected area efficiency/effectiveness and the loss/fragmentation and degradation of native vegetation.

Based on our findings and focusing on NBSAP and the sustainable development goals plans (e.g., to reduce the use of insecticides for a positive impact on birds' populations, and to avoid area of habitat of threatened and endemic species of birds), we forward the following recommendations in four major areas:

1. The most impacting economic activities are:
    a) Livestock grazing, farming and ranching

[8] https://www.cbd.int/convention/bodies/intro.shtml
[9] https://www.undp.org/sustainable-development-goals

b) Non-timber crops (coffee, cereals, oily seeds, flowers, dried legumes)
c) Logging and wood harvesting
d) Housing and urban areas

For the purpose of the BIODEV2030 project, we recommend the following two economic sectorial activities in Ethiopia: livestock farming and non-timber crops mainly coffee and cereals.

2. Enhance KBAs' conservation and species conservation:

a) Increase protection via a better coverage by protected areas including:
   i. Community Conservation Areas and Other effective area-based conservation measures (OECM). As protected areas include OECM, private actors and local communities could be involved in their development.
   ii. Increase coverage by establishing new PAs. For the purpose of increasing protected area coverage, based on literature review and our experience, we recommend establishment of the following protected areas: Afar Depression National Park, Lake Abe National Park, Ogaden Desert National Park, Rift Valley Lake Shore Reserves and Turaco-Juniper Reserve (justifications for thus recommendation are presented in Appendix 10; see also Vreugdenhil et al., 2012).
   iii. An increase in protected area coverage should enhance protected area connectivity.
b) Revise boundaries of existing protected areas, by including representative ecosystems from adjacent areas, but excluding hardly reversible degraded areas, and ensure their legal status through gazettment.
c) Currently, data on KBAs and Protected Areas of Ethiopia available on national and global databases are incomplete and inconsistent. The Ethiopian Biodiversity Inistitute, in collaboration with the Ethiopian Wildlife Conservation Authority and other national and international partners, currently developing a revised geospatial data on PAs of the country. As such, basic data (updated list, IUCN designation and management categories, extent and shape files/maps) on PAs and KBAs should be compiled, organized in a database form for ease update and retrieval and shared to relevant stakeholders.
d) KBA Avoidance by development projects and by coffee plantations and livestock grazing.

e) Avoid the area of habitat (AOH) of threatened species and endemic species when planning for development projects or coffee plantations or livestock grazing areas.
f) To facilitate avoidances of KBAs and AOH of conservation significant species, effective law enforcement measures are needed. Given that, on top of lack of collaboration across sectors, current effective sectorial laws related to biodiversity and the sectors impacting biodiversity are not conducive for effective law enforcement, the following actions are needed:
    i. Assess whether policies relevant to biodiversity (i.e., land use, agriculture, forestry, protected areas, and investment) are harmonious, and identify conflicting provisions and gaps in their implementation, and
    ii. Propose amendments, get endorsements and implement accordingly.
g) Mainstream biodiversity conservation across coffee production and livestock grazing sectors, focusing on how production practices could be changed / evolve so as to reconcile economic production and biodiversity protection.

3. Prioritize restoration measures

a) Restoration measures may have more positive impact on biodiversity conservation in Ethiopia than threat reduction alone. However, restoration measures have to be combined with threat abatement.
b) Restoration measures, be it passive (e.g., protection from human disturbance/enclosures) or active (e.g., afforestation) restoration approach, should be taken based on scientific-based evidence selection of non-invasive indigenous/exotic species that are appropriate for the ecosystem/region under question.
c) Restoration measures should capitalize on currently available initiatives, such as the Green Legacy Movement (reforestation/afforestation of degraded habitats), the REDD+ program, the 30 million trees by 2030 campaign to reforest Ethiopia with native trees, fruit trees and exotic timber species (where applicable), and Trace Construction Campaign implemented by the agricultural sector for erosion control and biodiversity conservation.
d) Restoration measures should focus the habitats of critically endangered species, prioritizing birds and endemic species. Five endemic CR species should be prioritized: *Altiphrynoides osgoodi, Balebreviceps hillmani, Ericabatrachus baleensis, Heteromirafra archeri,* and *Crocidura harenna*.

e) Where possible and applicable, restoration measures can involve volunteer resettlement of inhabitants from exceptionally important KBAs PAs to nearby towns.

4. Threat abatement focused on agriculture and livestock farming

a) Reducing threats should prioritize agriculture, livestock farming, and human disturbance related to housing and urban expansion.
b) Promote Participatory Forest Management (PFM) systems by strengthening existing and establishing new PFMs, to promote sustainable management and use of forest resources
c) In promoting non-timber forest products use, focus on non-timber forest products (honey, cultivation of shade-tolerant crops such as Ethiopian and Indian cardamom and wild pepper and wild coffee harvesting). Such activities do not require deforestation or canopy tree removal and thus would contribute to strengthen existing forest Non-Timber Forest Products (NTFP) based livelihoods while facilitating forest protection and regeneration in certain forest buffer areas.
d) Assess the potential to use traditional regulatory systems for rangeland management that benefits biodiversity; a similar initiative is currently started with the Borena Oromo community in the southern Ethiopia in relation to the sustainable management and use of the Liban plain where a viable population of the critically endangered Liban Lark is persisting.
e) At protected areas where grazing use is an unavoidable (e.g., by indigenous communities living within or around protected areas), develop and implement grazing reduction strategies. Such strategies would help identify the rightful users, determine where and when and how often to use and all allowed and prohibited activities. This strategy is currently developed for the Simien and Bale Mountains National Parks and endorsed by local communities too.
f) In addition to poor rangeland management systems, lack of fodder supplements and low level of productivity and thus low level of economic benefits gained, illegal alive livestock trade is also a major challenge of the subsector (Mamo, 2019). As such, the following actions are needed to reverse the situation:
    - Banning illegal, while promoting legal, live animal export would be help improve revenue gained from livestock resorces.

- Government should be work on expanding market destinations for livestock products (meat, skin and hide, milk products), instead of live animal trading, to promote value chain add.
- The government should develop policies that focus on improving fodder provision and better husbandry systems and mimize the impact of the sector on biodiversity.

5. Reduce the dependence on forest resources for fuelwood and construction

a) Plantation of fast growing, non-invasive and low impact exotic tree species for timber, construction and fuelwood demand;
b) Promote energy efficient stoves in rural and urban;
c) Promote the use of alternative energy sources from solar and hydroelectric energies.

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9. Appendices

Appendix 1. List of species included in the STAR analysis and their red list category and STAR scores.

English Name	Scientific Name	Taxonomic Group	Redl Lst Category	Threat Abatement	Restoration
Osgood's Ethiopian Toad	Altiphrynoides osgoodi	amphibians	CR	400.00	144.96
Bale Mountains Treefrog	Balebreviceps hillmani	amphibians	CR	400.00	55.19
Bale Mountains Frog	Ericabatrachus baleensis	amphibians	CR	400.00	64.49
Clarke's Banana Frog	Afrixalus clarkei	amphibians	EN	300.00	56.45
Malcolm's Ethiopia Toad	Altiphrynoides malcolmi	amphibians	EN	300.00	33.45
Susana's Forest Treefrog	Leptopelis susanae	amphibians	EN	300.00	211.31
Smallest Grass Frog	Ptychadena nana	amphibians	EN	300.00	46893.00
Sidamo Clawed Frog	Xenopus largeni	amphibians	EN	300.00	157.60
Erlanger's Grass Frog	Ptychadena erlangeri	amphibians	NT	100.00	24.15
Ethiopian Banana Frog	Afrixalus enseticola	amphibians	VU	200.00	47.78
Ragazzi's Tree Frog	Leptopelis ragazzii	amphibians	VU	200.00	114.71
Yalden's Tree Frog	Leptopelis yaldeni	amphibians	VU	200.00	5319.32
Liben Lark	Heteromirafra archeri	birds	CR	392.98	14.61
Rueppell's Griffon	Gyps rueppelli	birds	CR	63.98	8.75
Hooded Vulture	Necrosyrtes monachus	birds	CR	38.89	4.91
White-backed Vulture	Gyps africanus	birds	CR	22.45	4.80
White-headed Vulture	Trigonoceps occipitalis	birds	CR	8.61	26.69
Sociable Lapwing	Vanellus gregarius	birds	CR	0.02	0.06
White-winged Flufftail	Sarothrura ayresi	birds	CR	0.01	13.45
Yellow-throated Seedeater	Crithagra flavigula	birds	EN	300.00	70.29
Black-fronted Francolin	Pternistis atrifrons	birds	EN	300.00	0.45
Stresemann's Bush Crow	Zavattariornis stresemanni	birds	EN	300.00	0.37
Northern Bald Ibis	Geronticus eremita	birds	EN	58.37	80.79
Basra Reed Warbler	Acrocephalus griseldis	birds	EN	48.98	10.33
Egyptian Vulture	Neophron percnopterus	birds	EN	25.70	2.70

Lappet-faced Vulture	Torgos tracheliotos	birds	EN	23.84	3.21
Steppe Eagle	Aquila nipalensis	birds	EN	15.92	2.15
Saker, Saker Falcon	Falco cherrug	birds	EN	8.83	2.39
Abyssinian Longclaw	Macronyx flavicollis	birds	NT	100.00	843.64
Moorland Francolin	Scleroptila psilolaema	birds	NT	100.00	90.18
Rouget's Rail	Rougetius rougetii	birds	NT	93.60	90.65
White-winged Collared Dove	Streptopelia reichenowi	birds	NT	62.15	0.25
Mountain Buzzard	Buteo oreophilus	birds	NT	41.28	16.76
Little Brown Bustard	Heterotetrax humilis	birds	NT	39.40	0.18
Kori Bustard	Ardeotis kori	birds	NT	10.02	0.48
Bateleur	Terathopius ecaudatus	birds	NT	7.60	0.83
Pallid Harrier	Circus macrourus	birds	NT	5.15	0.56
Bearded Vulture	Gypaetus barbatus	birds	NT	4.92	2.38
Crowned Eagle	Stephanoaetus coronatus	birds	NT	4.78	0.81
Red-footed Falcon	Falco vespertinus	birds	NT	2.31	0.44
Curlew, Eurasian Curlew	Numenius arquata	birds	NT	1.98	0.39
Cinereous Bunting	Emberiza cineracea	birds	NT	1.83	0.00
Curlew Sandpiper	Calidris ferruginea	birds	NT	1.76	0.51
Denham's Bustard	Neotis denhami	birds	NT	1.20	0.03
Lesser Flamingo	Phoeniconaias minor	birds	NT	0.65	0.20
African Skimmer	Rynchops flavirostris	birds	NT	0.16	0.04
Arabian Bustard	Ardeotis arabs	birds	NT	0.15	0.00
Bar-tailed Godwit	Limosa lapponica	birds	NT	0.04	0.03
Black-winged Pratincole	Glareola nordmanni	birds	NT	0.04	0.01
Ankober Serin	Crithagra ankoberensis	birds	VU	200.00	3484.93
Salvadori's Seedeater	Crithagra xantholaema	birds	VU	200.00	1.45
Ruspoli's Turaco	Tauraco ruspolii	birds	VU	200.00	1.19
White-tailed Swallow	Hirundo megaensis	birds	VU	200.00	0.14
Somali Ostrich	Struthio molybdophanes	birds	VU	69.49	1.89
Black Crowned-crane	Balearica pavonina	birds	VU	25.07	6.06

Tawny Eagle	Aquila rapax	birds	VU	15.69	1.68
Secretarybird	Sagittarius serpentarius	birds	VU	11.89	1.91
Martial Eagle	Polemaetus bellicosus	birds	VU	11.55	1.46
Wattled Crane	Bugeranus carunculatus	birds	VU	10.24	779.05
Teita Falcon	Falco fasciinucha	birds	VU	7.80	1.11
Eastern Imperial Eagle	Aquila heliaca	birds	VU	1.71	0.52
Shoebill	Balaeniceps rex	birds	VU	1.04	0.28
Greater Spotted Eagle	Clanga clanga	birds	VU	0.62	0.07
Harenna Shrew	Crocidura harenna	mammals	CR	400.00	21.55
African Wild Ass	Equus africanus	mammals	CR	213.40	4.15
Black Rhino	Diceros bicornis	mammals	CR	0.44	0.01
Ethiopian Wolf	Canis simensis	mammals	EN	300.00	102.03
Bale Shrew	Crocidura bottegoides	mammals	EN	300.00	413.56
Guramba Shrew	Crocidura phaeura	mammals	EN	300.00	28.14
Mount Chercher Brush-furred Rat	Lophuromys chercherensis	mammals	EN	300.00	125.94
Giant Mole Rat	Tachyoryctes macrocephalus	mammals	EN	300.00	6142.81
Mountain Nyala	Tragelaphus buxtoni	mammals	EN	300.00	82.57
Beisa Oryx	Oryx beisa	mammals	EN	159.48	1.88
Heuglin's Gazelle	Eudorcas tilonura	mammals	EN	143.42	9.32
Grevy's Zebra	Equus grevyi	mammals	EN	23.19	0.38
African Wild Dog	Lycaon pictus	mammals	EN	8.80	0.24
Mountain Reedbuck	Redunca fulvorufula	mammals	EN	8.11	10.23
Nile Lechwe	Kobus megaceros	mammals	EN	4.17	1.09
Speke's Gazelle	Gazella spekei	mammals	EN	2.13	0.00
Blick's Grass Rat	Arvicanthis blicki	mammals	NT	100.00	95853.42
Macmillan's Shrew	Crocidura macmillani	mammals	NT	100.00	22.62
Short-tailed Brush-furred Rat	Lophuromys brevicaudus	mammals	NT	100.00	121.56
Glass's Shrew	Crocidura glassi	mammals	NT	100.00	55.15
Gerenuk	Litocranius walleri	mammals	NT	39.14	0.27
Lesser Kudu	Tragelaphus imberbis	mammals	NT	37.00	0.41

Striped Hyaena	Hyaena hyaena	mammals	NT	12.82	1.27
Burchell's Zebra	Equus quagga	mammals	NT	5.48	0.05
Cape Clawless	Aonyx capensis	mammals	NT	4.51	0.61
African Buffalo	Syncerus caffer	mammals	NT	2.08	0.13
Speckle-throated Otter	Hydrictis maculicollis	mammals	NT	1.62	0.20
African Straw-coloured Fruit-bat	Eidolon helvum	mammals	NT	1.58	0.17
Striped Leaf-nosed Bat	Macronycteris vittatus	mammals	NT	0.99	0.03
White Rhino	Ceratotherium simum	mammals	NT	0.22	0.03
Walia, Walia Ibex	Capra walie	mammals	VU	200.00	110.30
Bale Monkey	Chlorocebus djamdjamensis	mammals	VU	200.00	66.21
Lucina's Shrew	Crocidura lucina	mammals	VU	200.00	31532.41
Yalden's Desmomys	Desmomys yaldeni	mammals	VU	200.00	46.51
Ethiopian Thicket Rat	Grammomys minnae	mammals	VU	200.00	26.15
Nikolaus's Mouse	Megadendromus nikolausi	mammals	VU	200.00	23.93
Scott's Mouse-eared Bat	Myotis scotti	mammals	VU	200.00	46.88
Black-clawed Brush-furred Rat	Lophuromys melanonyx	mammals	VU	200.00	53.70
Clarke's Gazelle, Dibatag	Ammodorcas clarkei	mammals	VU	160.79	0.09
Soemmerring's Gazelle	Nanger soemmerringii	mammals	VU	135.85	6.94
Harrisonn's Rat	Otomops harrisoni	mammals	VU	121.03	12.33
African Lion, Lion	Panthera leo	mammals	VU	29.66	0.97
Giraffe	Giraffa camelopardalis	mammals	VU	13.45	0.23
Cheetah	Acinonyx jubatus	mammals	VU	12.05	0.33
Leopard	Panthera pardus	mammals	VU	10.64	4.19
Hippopotamus	Hippopotamus amphibius	mammals	VU	5.21	0.49
African Elephant	Loxodonta africana	mammals	VU	1.60	0.06
Temminck's Pangolin	Smutsia temminckii	mammals	VU	1.53	0.03
Dorcas Gazelle	Gazella dorcas	mammals	VU	1.23	0.03
Beira	Dorcatragus megalotis	mammals	VU	0.30	0.10
thiopian Water Mouse	Nilopegamys plumbeus	mammals	CR	400.00	347.95
Sheko Forest Brush-furred Rat	Lophuromys pseudosikapusi	mammals	EN	300.00	61.25

Appendix 2. Snapshot of the questionnaire used for the expert-based biodiversity threat assessment in Ethiopia.

A1 GUIDELINE: Please indicate your response on impact of a given threat category on each taxon as: Low; Medium; High; V

GUIDELINE: Please indicate your response on impact of a given threat category on each taxon as: Low; Medium; High; Very High. If a given threat is not exisiting in Ethiopia in dicating that by marking "x" under the column "Not exist in Ethiopia"

Main threat	Threat category	Not exist in Ethiopia	Plants	Mammasl	Birds	Reptiles	Amphibians	Fish
1 Residential & commercial development	1.1 Housing & urban areas							
	1.2 Commercial & industrial areas							
	1.3 Tourism & recreation areas							

Guideline | Threats1 | Threat2 | Threat3 | Threats4 | Threat5 | Threats6 | Threat7 | Threat8 | Threat9 | Threats10

Ready

Appendix 3. The questionnaire used for crop-related expert-based biodiversity threat assessment in Ethiopia.

Dear Researchers/Experts,
Expert-based questionnaire designed to specifically assess the nature/types, extent/scale and systems of crop production, livestock grazing and logging and their impacts on biodiversity in Ethiopia.

1. Annual & perennial Non-Timber Crops productions are one of the major threats to biodiversity in Ethiopia. Do you agree with this statement? (*Please indicate your appropriate choice by highlighting*)

    a. Yes
    b. No, I don't agree
    c. I don't know

2. If your response to question no. 1 above is "Yes", in the following table please indicate for each specific crop(s) type which type of farming activity among the 3 that are indicated below, is, according to you, contributing mostly to biodiversity erosion (*Please indicate your appropriate choice by putting "X"*)

	Shifting Agriculture	Small-holder Farming	Agro-industry Farming	Remark
a. Teff				
b. Wheat/barley				
c. Sorghum/maize				
d. Coffee plantations				
e. Fruit (banana, mango, avocado, etc)				
f. Oily seeds: Sesame				
g. Oil seeds: Niger				
h. Oily seeds: Soybean				
i. Cut flower (horticulture)				
j. Sugar cane plantations				
k. Chat/Khat (Catha edulis) plantation				
l. Tea plantations				
m. Any other (please specify):				
n. Any other (please specify):				
o. Any other (please specify):				
p. Any other (please specify):				

3. Which coffee production systems do you think are negatively impacting biodiversity in Ethiopia? (*Please indicate your appropriate choice by highlighting*)

a. Completely managed coffee cultivation/harvesting
b. Wild (naturally grown) coffee harvesting
c. Semi-natural/(semi-managed) coffee growing
d. Any other production systems (please specify):

4. Please rank the relative impacts of the following three coffee production systems on biodiversity in Ethiopia (*Please indicate your response by printing/writing letter "X" under appropriate column*)

	Rank			
Production system	1st rank	2nd rank	3rd rank	Remark
a. Completely managed coffee growing				
b. Wild (naturally grown) coffee harvesting				
c. Semi-natural/(semi-managed) coffee growing				

5. Do you agree with the statement "Livestock Farming & Ranching affects biodiversity in Ethiopia."

a. Yes
b. No, I don't agree
c. I don't know

In order to answer this question 6, use these definitions.
Nomadic Grazing: Pastoralists who are normally only present for part of the year, usually after good rains have improved the grazing. **Non-nomadic/permanent grazing**: Sedentary farmers who uses a given area for livestock grazing throughout the year. **Animal farming**: Raising domestic terrestrial animals in one location on farmed or non-local resources. In farming, animals are kept in captivity. **Animal ranching**: raising domestic or semi-domesticated animals while allowed to roam in the wild and supported by natural habitats.
6. If your response to question no. 5 above is "Yes", based on the concepts/definitions provided above, please list the specific animal species raised under the different scale of farming activities listed in the table. (For each livestock species listed, indicate the appropriate scale of farming activity by marking with "X").

	Scale of farming						
Livestock species	Nomadic Grazing	Small-holder (non-nomadic/ permanent) Grazing	Small-holder Ranching	Agro-industry Ranching	Small-holder Farming	Small-holder Farming	Remark

7. Harvesting trees (logging) and other woody vegetation for timber, fibre, or fuel have been presumed to pose threats to biodiversity. Do you agree with this statement? (*Please indicate your appropriate choice by highlighting*)

a. Yes
b. No, I don't agree
c. I don't know

8. Wood & Pulp Plantations are stands of trees planted for timber or fibre outside of natural forests, often with non-native species. Plantation forestry activities are one of the major biodiversity threats in Ethiopia. Do you agree with this statement? (*Please indicate your appropriate choice by highlighting*)

a. Yes
b. No, I don't agree
c. I don't know

9. If your response to question no. 8 above is "Yes", in the table below, indicate the which of the 2 plantation types indicated below is, according to you, most contributing to biodiversity erosion (*Please indicate your response by putting letter "X"*).

	Small-holder Plantations	Agro-industry Plantations	Remark
a. Eucalyptus plantations			
b. Pinus plantations			
c. Any other species (please specify):			
d. Any other species (please specify):			

Appendix 4. List of experts and non-experts (and their institutional affialations) identified and invited (questionnaire sent) to participate in the biodiversity threat assessment survey. Non-experts are shown in **BOLD.**

A. Academic/Research Institutions

1. Dr Habte Jabessa, Associate Professor of Biodiversity, Addis Ababa University (AAU)
2. Dr Anagaw Atickem, Assistant Professor of Ecology and Systematic Zoology, AAU
3. Dr Girma Mengesha, Associate Professor of Wildlife Conservation and Management, Hawassa University (Wondo Genet College)
4. Dr Zerihun Girma, Assistant Professor of Wildlife Conservation and Management, Hawassa University (Wondo Genet College)
5. Dr Lamessa Debissa, Assistant Professor of Biodiversity Management, AAU
6. Dr Aramde Fetene, Associate Professor of Environmental Management, AAU
7. Simeneh Admasu, PhD candidate in Environmental Management, AAU
8. Dr Seyoum Leta, Addis Ababa University Science Center

B. Public Organizations

9. Gebremeskel Gizaw, Protected Area Management, Ethiopian Wildlife Conservation Authority (EWCA)
10. Kahsay Gebretesae, Wildlife Ecologist, EWCA
11. Dr Fekede Regassa, Wildlife Research and Research Director, EWCA
12. Aklilu Kebede, Wildlife Research and Monitoring Expert, EWCA
13. Endaweke Wondim, Wildlife Research and Monitoring Expert, EWCA
14. Mihret Ewnetu, Wildlife Research and Monitoring Expert, EWCA
15. Fedlu Abdella, Wildlife research and Monitoring Expert, EWCA
16. Girma Ayalew, Wildlife Research and Monitoring Expert, EWCA
17. Sena Gashe, Wildlife Research and Monitoring Expert, Bale Mountains National Park
18. Shimelis Wondimu, Wildlife Research and Monitoring Expert, Bale Mountains National Park
19. Lalisa Mekonnen, Wildlife Research and Monitoring Expert, Abijata Shalla Lakes National Park
20. Bekele Gizaw, Wildlife Research and Monitoring Expert, Awash National Park
21. Tolera Sori, Wildlife Research and Monitoring Expert, Abijata Shalla Lakes National Park
22. **Mohammednur Jemal, Wildlife Director, Oromia Forest & Wildlife Enterprise**
23. Chemerie Zewudie, Wildlife Expert, Oromia Forest & Wildlife Enterprise
24. **Abreham Manaye, Wildlife Director, Amhara Region Wildlife Authority**
25. **Kabtamu Girma, Environment, Forest and Climate Change Commission (EFCCC)**
26. Abreham Assefa, Ethiopian Biodiversity Institute
27. Dr Misikir, Ethiopian Biodiversity Institute (EBI)
28. **Daniel Worku, EWCA**
29. **Dr. Birhanu Belay, Gulelle Botanic Garden**
30. **Teketel Adefris, MoWIE**
31. **Zewdu Abekulu, MoA**
32. Befekadu Kefelegn, EBI
33. Zerihun Tsegaye, EBI
34. Asefa Gudina EFCCC
35. Dr. Tesfaye Awas, EBI
36. **Dr. Misikire Tessema, NBSAP Coordination/EBI**
37. **Esayas Lema MoA**
38. **Dr. Feleke Woldeyes, EBI**
39. **Desta Bedasso, EWCA**
40. **Atrag Gebre, Southern NNPS Culture and Tourism Bureau**
41. **Kalkidan Debebe, Southern NNPS Land Administraion Bureau**

C. NGOs

42. **Arega Mekonnen, Project Manager, GEF6/UNDP**
43. **Dr Fanuel Kebede, Project Coordinator, GEF6/UNDP**
44. **Abebayehu Kassaye, Project Coordinator, Public Health and Environment (PHE-ETHIOPIA CONSORTIUM)**
45. Mengistu Wondafrash, Director, Ethiopian Wildlife & Natural History Society (BirdLife International Partner)
46. **Kassahun Abera, GIZ**
47. **Lakew Berhanu, GIZ**
48. **Gebeyaw Dilnessa, African Wildlife Foundation (AWF)**
49. **Husein Umer, Frankfurt Zoological Society (FZS)**
50. **Fetene Hailu, International Fund for Animal Welfare (IFAW)**
51. **Shewaye Deribe, Ethio-wetlands**
52. Dr Tadese Woledemariam, Ethiopia Forest Coffee Forum
53. Dr. Bezawork Afework, Ethiopian Biological Society
54. **Billy Guta, GGGI**
55. **Dr. Gemedo Dale, GGGI**
56. **Dr. Melesse Mariyo, CBD FP**

D. Private Sectors

57. Dr Yirmed Demeke, Owner of Awash Fall Lodge
58. Dr Zelealem Tefera, Private Biodiversity Consultant
59. **Wubie Mengiste, Ethiopian Chamber of Commerce and Sectoral Association**

Appendix 5. Questionnaire used for non-expert-based biodiversity threat assessment in Ethiopia.

Ethiopia National biodiversity threat assessment Questions

Dear Respondent,

We, Dr. Mekbeb Tessema, Ato Yilma Delellegn and Ato Addisu Asefa, are undertaking assessment of Ethiopia's Biodiversity Threats. As such, we kindly request your unreserved collaboration to answer the following three questions. Please base your answers on the instruction given below.

Instruction: In this assessment, Biodiversity threat is defined as "**direct human** actions/economic activities that directly impact biodiversity (i.e., animals, plants and ecosystems) at present or in the coming 10 years".

Please note that we expect respondents to return the questionnaire to us until 10 September 2021.

If you have any question or need clarification, please don't hesitate to contact us via our email or calling on 0911360355.

Thank you in advance for your time and input!!

Question #1: Would you please describe your educational and expertise background (including where you work, your past and present position(s) and roles and responsibilities)?

Question # 2: Please list out threats that arise from human activities you perceive as being a direct driver of biodiversity impact on biodiversity in Ethiopia

Threat description with your words	What biodiversity component does it affect principally (describe which species, taxa, ecosystem, etc.) and where (region) in the country?	How do you justify this? (What is your story?)

Question # 3: Please indicate your top three (of your selection of the threats listed out in the above table) threats you perceive as having the greatest impact on biodiversity in Ethiopia.

S/N	Threat name	Comments (if any)
1		
2		
3		

Appendix 6. Questionaire used during the validation workshop

Mainstreaming Biodiversity into the economic sectors in Ethiopia: Selection of Sub-Sectors in Agriculture, Livestock and Forestry sectors.

National assessment has been undertaken by a consultant tasked to identify key threats and drivers of biodiversity loss in Ethiopia which pin-pointed key economic sectors contribute for the loss.

To validate assessment report prepared by the consultant, a one-day stakeholders validation workshop has been organized on 28 January 2022. After presented the assessment findings, stakeholders have selected two major economic sectors primarily contribute to biodiversity decline in the country. Accordingly, the Agriculture, livestock and Forestry sectors are being selected/confirmed by the participants of this workshop.

Given the broad nature of these two sectors, the objective of this template is to further engage you to the selection of sub-sectors under the main economic sectors for further analysis and initiation of voluntary commitment of stakeholders including the private sector actors in the identified sub-sectors.

This form is divided into two parts with questions from 1-4 focusing on agriculture and questions 5-8 on forestry related questions. We would greatly appreciate your inputs into the two areas.

Kindly take into consideration the following criteria while filling in your responses.

- pressures on biodiversity by the sub-sectors
- importance and size of the sub-sector for economic development (+ perspectives of development which could further increase the pressures)
- Sufficient structure of the subsector allowing for mobilization of stakeholders for BIODEV2030 dialogue process.
- Impact on land use change -indication that it comprises wider activities that affect natural ecosystems with high ecological and heritage value
- Impacts on soil-impact of activities in the sector/sub-sector on soil due to use of chemicals
- Impact on water-pressure posed by activities under this sector/sub-sector on aquatic life

1. Given that the agriculture (economic) sector is quiet broad, which subsector (crop, livestock, coffee etc…) in you view should BIODEV2030 project focus to mainstream in their voluntary commitments (please select 1-3 by rank)

a. Cereal crop production
b. Livestock Production
c. Vegetable and Fruit Production
d. Coffee Production
d. other (please specify)
Note:____

____

2. Kindly provide reason for the selection of the sub-sector you have proposed?

____

____

3. Which are the key biodiversity related challenges in each sub-sector that you have identified?

____
____

4. Are there existing networks, associations, cooperatives or forums in the proposed sub-sectors- that the BIODEV2030 project can engage with? If yes please list them below.

____

____

5. Given that the forestry economic sector is quiet broad, which sub-sector (example, small scale logging, large scale logging, agroforestry, etc..) in you view should BIODEV2030 Project focus to mainstream in their voluntary commitments? (Please select 1-3 by rank)

a. Small scale logging and wood harvesting
b. large scale logging
c. agroforestry
d. other (Please specify)

____

____

6. Kindly provide reason for the selection of the sub-sector you have proposed?

____

7. Which are the key biodiversity related challenges in the sub-sector you have identified?

____
____

8. Are there existing networks, associations, cooperatives or forums in the proposed sub-sectors that the BIODEV2030 project can engage with? If yes please list them below.

____
____

9. During the threat assessment, national level interviews and desk review processes were mainly used to identify challenges pose biodiversity loss in Ethiopia. Throughout the process: protected areas, other natural ecosystem, agricultural ecosystem and other man-made ecosystems were being considered. Do you think the sub-sector analysis should involve further sub-national and local level interviews and specific key biodiversity areas? If yes please share your suggestion below and why?

____
____

10. Do you have any additional comments or feed back regarding the sub-sectors for prioritization in the BIODEV2030 project?

____

____

Appendix 7. Summary of participants' remarks compiled from Stakeholders Workshop to validate National Diagnostic report and selection of key economic sub-sectors feedbacks obtained and remarks made by participants on the key findings of the assessment presented by the consultants during the validation workshop

	Issue/s	Discussions made	Direction set
1	% of PA to country landmass mentioned in the report is discrepant with what EWCA previously reports	Different reports mentioned different figure, it needs to be checked	A technical personnel from EWCA and EBI should sit together with the consultants to clarify, the PAC to supervise the action
2	The report analysis, especially the STAR metric has more emphasized animals, not plants	STAR has preliminary made for three taxa (Mammal, Bird and Reptile), but the assumption is that EbTA and non-expert questionnaire has covered all ecosystems and AoH is also assumed to be all inclusive	It is agreed to increase some reflection on agro-biodiversity in the report to give full flavour of complete biodiversity of the country
3	Why the report hasn't reviewed policy conflict, institutional condition and fragmentation of mandates on biodiversity	Institutional context, capacities and policy and strategy issues will be analysed in the next in-depth scenario analysis	The project officer has taken note to make sure that these issues are sufficiently reflected in the next study
4	Had it not be possible to sufficiently apply quantitative data and other tools such as GIS information to increase credibility of the assessment?	The ToR of this assessment is not to gather large primary data and to undertake mapping exercises such as GIS based satellite imaging, but to apply STAR based on CMP database and EbTA to measure level of threat by key economic sectors	STAR has been applied to review existing information with comparison of EbTA and the assignment is not expected to go beyond that
5	Citation was sufficiently made to data available with EBI, but there are missed citation(e.g EBI2014a, EBI2014b, EBI2019) in the Babiliography	It is agreed to include those citations in the Reference section	Let the consultants communicate for further additionalt relevant literature with Dr. Tesfaye and other EBI colleagues to solicit remaining information, if any.
6	Terms 'taxa' and species are exchangeable used	It is discussed and agreed to make the edit work	

7	Woodland of Gambela has been mentioned as 'grassland' on page33	The consultants has agreed to edit the page accordingly	
8	Why other threats such as climate change and IAS are not been mentioned	All the threats are mentioned in the report by they are ranked below 3, but the report prioritized top 2-3 sources of threat for following actions	
9	On page 4 of the report please give the list of 06 species	Agreed to revisit	
10	On page 33 of the report please show the positive aspect of fire in Combretum Terminalia forest	Agreed to re-visit	
11	On page 33 of the report the title mentioned 'wood land ecosystem ' should be changed to Low land ecosystem	Agreed to re-visit	
12	On page 70 of the report, please change the term '**Curcuma Longa'** to **Curcuma Domestic**		
13	Threats posed from Sudan and Somali refugees has to be indicated on list of biodiversity threats	The report is only intended to pinpoint top threat drivers, otherwise it is not intended to put long list of threats	It is possible to highlight refugee as a threat in the report, though not as major threat
14	Growing need of Food and Energy are the underlying causes of biodiversity loss, therefore, please indicate these both as root causes of the threat	Both Food and Energy are embedded in the broad sectors of Agriculture and Forestry respectively. Therefore, this is why we ranked these sectors as top threats	
15	Placement of road infrastructure is also one of the threats, please mention it in the report	It has already been mentioned under a standard classification of CMP (transportation & service corridor)	
16	Figures related to number of plant species, endemic birds and so on should be revised and come to		Arrange time between EBI&EWCA and the consultants to make the edition

	convergence with previously used figures by leading institutions		

Selection of Key Economic Sectors

Participants of the workshop has made serious discussion on what the priority looks like regarding key economic sectors that drive loss of biodiversity.

As a conclusion, participants have unanimously agreed that agricultural production (cereal, coffee, vegetables & fruits) is the primary economic sector responsible for decline of biodiversity in Ethiopia. In the same way they have ranked livestock farming and ranching as the second key economic sector responsible for loss of biodiversity.

As a third key economic sector important for biodiversity decline in Ethiopia, the participants have selected the forestry sector followed by housing and urban areas.

Remark: CMP global data for Ethiopia has ranked livestock farming & ranching as the first key economic sector that affect biodiversity. Moreover, the average value of the diagnostic report has also brought livestock farming & ranching as the first sector responsible for biodiversity in Ethiopia.

Nevertheless, national stakeholders have selected annual and perennial non-timber crop production as the primary sector responsible for biodiversity loss in the country.

Accordingly:

- Annual and Perennial non-timber crop production- is selected as the first threat for biodiversity in Ethiopia
- Livestock farming & ranching-the second threat for biodiversity loss
- Forestry-as the third threat, and

Based on criteria such as role for national GDP and local economy, institutional presence, impact of economic value chain and other key criteria, national stakeholders have selected key economic sub-sectors under those main key economic sectors.

Under the agricultural sector the following top two key economic sub-sectors have been selected:

- Crop production as the first sub-sector that also include coffee
- Livestock rearing as the second key economic sub-sector

Under the broader forestry sector, the following key economic sub-sectors are being identified

- Small scale logging and wood harvesting as the first key economic sub-sector
- Agro-forestry has been identified as the second sub-sector

Appendix 8. List of participants of the validation workshop held at RedissonBlu Hotel, Addis Ababa (28 January 2022).

Appendix 9. Orders and families of birds found in Ethiopia.

Order	Family	No. species	Order	Family	No. species
ACCIPITRIFORMES		60	PASSERIFORMES		423
	Accipitridae	58		Acrocephalidae	12
	Pandionidae	1		Alaudidae	26
	Sagittariidae	1		Buphagidae	2
ANSERIFORMES		27		Campephagidae	4
	Anatidae	27		Certhiidae	1
BUCEROTIFORMES		15		Cisticolidae	29
	Bucerotidae	8		Corvidae	10
	Bucorvidae	1		Dicruridae	2
	Phoeniculidae	5		Emberizidae	9
	Upupidae	1		Estrildidae	27
CAPRIMULGIFORMES		25		Fringillidae	16
	Apodidae	11		Hirundinidae	18
	Caprimulgidae	14		Hyliotidae	1
CHARADRIIFORMES		93		Laniidae	12
	Burhinidae	5		Leiothrichidae	8
	Charadriidae	20		Locustellidae	7
	Glareolidae	10		Macrosphenidae	5
	Haematopodidae	1		Malaconotidae	13
	Jacanidae	2		Monarchidae	1
	Laridae	21		Motacillidae	15
	Pluvianidae	1		Muscicapidae	53
	Recurvirostridae	2		Nectariniidae	19
	Rostratulidae	1		Oriolidae	4
	Scolopacidae	27		Paridae	4
	Stercorariidae	1		Passeridae	11
	Turnicidae	2		Phylloscopidae	5
CICONIIFORMES		8		Pittidae	1
	Ciconiidae	8		Platysteiridae	4
COLIIFORMES		3		Ploceidae	38
	Coliidae	3		Pycnonotidae	4
COLUMBIFORMES		22		Remizidae	3
	Columbidae	22		Sturnidae	22
CORACIIFORMES		26		Sylviidae	14
	Alcedinidae	10		Turdidae	6
	Coraciidae	5		Vangidae	1
	Meropidae	11		Viduidae	12
CUCULIFORMES		15		Zosteropidae	4
	Cuculidae	15	PELECANIFORMES		28
FALCONIFORMES		17		Ardeidae	17

	Falconidae	17
GALLIFORMES		16
	Numididae	2
	Odontophoridae	1
	Phasianidae	13
GRUIFORMES		24
	Gruidae	6
	Heliornithidae	1
	Rallidae	14
	Sarothruridae	3
MUSOPHAGIFORMES		5
	Musophagidae	5
OTIDIFORMES		9
	Otididae	9
STRUTHIONIFORMES		2
	Struthionidae	2
SULIFORMES		3
	Anhingidae	1
	Phalacrocoracidae	2
TROGONIFORMES		1
	Trogonidae	1
	Balaenicipitidae	1
	Pelecanidae	2
	Scopidae	1
	Threskiornithidae	7
PHOENICOPTERIFORMES		2
	Phoenicopteridae	2
	PICIFORMES	26
	Indicatoridae	5
	Lybiidae	11
	Picidae	10
PODICIPEDIFORMES		3
	Podicipedidae	3
PSITTACIFORMES		6
	Psittacidae	3
	Psittaculidae	3
PTEROCLIFORMES		6
	Pteroclidae	6
STRIGIFORMES		16
	Strigidae	14
	Tytonidae	2
	Total	881

Appendix 10. Description of areas recommended for new protected area establishment in Ethiopia.

1. Afar Depression National Park

Due to volcanic activity, the Afar Depression has some of the most colourful geiser-like activity in the world, at Assale Lake. The hot sulphur springs are in exuberance comparable to Mammoth Springs in Yellowstone National Park in the USA. Not far from there, one finds dramatically shaped salt hoodoo formations. With Salt pillars up to 40 m high these salt formations at the southwest flank of Dallol Mountain are some of the most impressive geological features in the area. Many volcanoes exist in the region, several of which being very active, including Erta Ale and the Dabbahu Volcanoes. Erta Ale has one of the five permanent lava lakes in the world and is increasingly visited by foreign tourists.

It is also home to wildlife, including a heard of about 25 individuals of African Wild Asses, Equus africanus somaliensis, Ostriches, Struthio camelus, Cheetah, Acinonyx jubatus, and Oryx, Oryx gazella. As geomorphological highlights and cultural traditions would be the primary focus of the proposed national park, inhabitation and traditional grazing would be part of the management objectives.

As is equals Yellowstone National Park – the worlds' most famous national park - in many aspects, including the Afar Depression in the Ethiopia's Protected Areas System combines dramatic geological phenomena with the exceptional desert biodiversity, while the cultural elements of the traditional salt mining, the camel caravans and the culture of the Afar desert people put the icing on the cake from a tourism point of view.

2. Lake Abe National Park

Shared with Djibouti, Lake Abe is the last of several lakes in a chain of endorheic saline lakes into which the Awash River drains in the northeast corner of the country. Surrounded by extensive salt flats which can cover an area of more than 10,000 ha, the lake is connected to Lake Afambo via internal flows and wetlands that carry surface water from one lake to another. Lake Abbe is known for its hot springs and limestone chimneys, which reach heights of 50 meters and from which steam vents. The area is inhabited by the nomadic Afar people.

Rare and threatened species of mammals around the lake include the Beira Antelope, *Dorcatragus megalotis*, Dorcas Gazelle, *Gazella dorcas*, and Speke's Gazelle, *Gazella spekei*. Other wildlife of special concern includes Hippopotamus, *Hippotragus amphibius*, Hamadryas Baboon, *Papio hamadryas*. It is recommended to gazette the area as a national park.

3. Ogaden Desert National Park

The region is notoriously different from all other regions of Ethiopia, and a major protected area is paramount for the representativeness of the Ethiopian biodiversity in the national protected areas system. The area would focus on the conservation of Dibatag, but other wildlife populations are still well-represented, and it would protect a very representative suite of the Ogaden wildlife. This area would coincide with the WWF Somali Acacia-Commiphora bushlands and thickets ecoregion.

4. Rift Valley Lake Shore Reserves

A number of Rift Valley lakes are important water bodies for endemic fish species and for aquatic birds. Particularly important are Lakes Awassa, Ziway, and Koka Reservoir. They altogether hold hundreds and thousands of aquatic birds and several fish and aquatic plant species. They also have a potential both with the presence of biological and cultural attributes, to become a centre for ecotourism activities in the future. Given that the adjacent Abijata and Shalla Lakes are deteriorating in area and quality and in supporting biodiversity, it is recommended that all Rift Valley lakes be studied for zones, such as shallow areas and reed lands for the protection of spawning areas of endemic fish and migratory birds that need to be included as lake shore biodiversity reserves.

5. Turaco-Juniper Reserve

Prince Ruspoli's Turaco, *Tauraco ruspoli*, is endemic to southern Ethiopia, where its range may be smaller than 8,000 km^2. The bird overlaps with the main Juniper forests in the south: the Negele, Genale, Kibre Mengist and Arero forests each within the species' range. Although Prince Ruspoli's Turaco was still present at all localities during an assessment in 2003, a dramatic habitat degradation had taken place since 1995 and conservation measures are urgently needed.

The Prince Ruspoli's Turaco lives in the region of the south-eastern Juniper forests, even though its preferred habitat is not the Juniper forests, but the surrounding woodlands. As they exist in neighbouring areas, it is probably possible to find areas that combine both Prince Ruspoli's Turaco habitat and Juniper forests, some areas with optimal conditions for Prince Ruspoli's Turaco, such as some woodlands at lower altitudes (around Negele). The co-occurrence of the Prince Ruspoli's Turaco and some of the best Juniper forests in south-eastern Ethiopia, make it desirable to conserve these forests within the EPAS. The selection of the required forest as well as surrounding woodlands where Prince Ruspoli's Turaco lives and their delimitation should be subject to further study to identify optimal areas.