CHAPTER **3**

STATUS, TRENDS AND FUTURE DYNAMICS OF BIODIVERSITY AND ECOSYSTEMS UNDERPINNING NATURE'S CONTRIBUTIONS TO PEOPLE

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EXECUTIVE SUMMARY

Africa has rich and varied biological resources forming the continent's natural wealth on which its social and economic systems are based *(well established).* Africa is home to almost one-quarter of the world's mammal species with their 1,160 species, including 194 species of primate and 91 species of antelope. It also has more than 2,500 species of birds–one-fourth of the world's total–and at least 5,445 species of fish, as well as 2,121 reptile species. The African mainland harbours between 52,000 and 73,000 plant species and about 150,000 known species of insects are known for sub-Saharan Africa. Nine of the world's 35 biodiversity hotspots are in Africa {3.3.1, 3.4.1, 3.4.2, 3.4.3, 3.4.4, 3.4.5}.

Most, if not all, terrestrial ecosystems in Africa have already experienced major biodiversity losses in the past 30 years, which has negative impacts on nature's contribution to people. The prospect is that this trend will continue in the future *(established, but incomplete)*. Africa's highly diverse terrestrial ecosystems, ranging from forests to arid/semi-arid ecosystems are being threatened by the increasing change in land-use, for example, conversion to agriculture and deforestation, leading to habitat fragmentation and destruction. Poaching and illegal trade has resulted in the significant decline of many species of wild fauna and flora, which has, for example, resulted in the near extinction of the wild northern white rhinoceros. To compound this, climate change will likely cause a 5–8% increase in arid/semi-arid lands and endanger 25–40% of mammal species in national parks. Forty-four million hectares of lowland humid forests, representing 25% of the total forest area, are under timber-harvest concession which negatively impacts biodiversity in these hotspots. For example, the Congo Basin is the second largest rainforest after Amazonia and includes more than 10,000 vascular plant species, many of them endemic to the region. These losses can affect local community's access to forest products such as medicinal plants and wild fruits {3.4.1.1, 3.4.2.1, 3.4.3.1, 3.4.4.1, 3.4.5.1}.

Freshwater biodiversity in Africa is currently under severe threat with an estimated 10% decline expected by 2050 *(established but incomplete)*. The inland waters of Africa support a high diversity of aquatic life. Highest levels of biodiversity are found in the Rift Valley Great Lakes (Lake Malawi, Lake Tanganyika, and Lake Victoria) and in the rivers of the Congo. Among 4,989 freshwater species assessed (fish, crabs, mollusc, dragonflies, aquatic plants), 21% are threatened within Africa and 91% endemic. The majority of threatened species are found in areas with high levels of development and demand on water resources, mainly along the Mediterranean and Atlantic coasts of Morocco, Algeria and Tunisia, in Upper and Lower Guinea, southern and eastern South Africa and in the Great lakes in eastern Africa. It is predicted that by 2050s, hydrological conditions for 80% of freshwater fish species will be substantially different from present-day conditions. Freshwater species are essential for supporting livelihoods, as 45% of fish and 58% of plant species are regularly harvested {3.4.1.2.2, 3.4.2.2.2, 3.4.3.2.2, 3.4.4.2.2, 3.4.5.2.2}.

Much of Africa's complex and unique marine and coastal biodiversity are increasingly threatened *(established but incomplete)*. The wide continental shelf along the northwest coast of Africa, mangrove forests of West and East Africa and adjacent islands, provide diverse habitats that support high levels of biodiversity of fish and invertebrate species. The Red Sea has a high degree of endemism and is an important repository of marine biodiversity including 12 of the world's 60 seagrasses, and 38 coral reef genera with 220 species. Africa contains 19% of mangrove cover, however, approximately 20–30% has been lost in the past 25 years, with average deforestation rates of 2%/year. With overexploitation, habitat degradation and loss, acidification, pollution from land-based sources, invasive alien species and sea level rise, highly valuable ecosystem services are being threatened {3.4.1.2, 3.4.2.2, 3.4.3.2, 3.4.4.2, 3.4.5.2}.

Current losses of genetic biodiversity due to climate changes and unsustainable resource exploitation in Africa are restricting future management and development options *(unresolved)*. Information on genetic diversity in Africa is largely lacking. However, few existing studies on genetic diversity have shown reduced genetic diversity of domesticated plant and animal species and of wild species. Modern crop varieties have also led to the decline in genetic diversity of traditional plants or crops, as out of the quarter million plant varieties available for agriculture, only 3% are in use. This includes large-scale monocultures such as 200,000 km^2 being used for industrial crops like sugarcane. Of the 150 indigenous breeds of African cattle, 47% are threatened, and 22% at risk of becoming extinct. Species with very specific habitat needs and or are climate sensitive (e.g., mountain gorillas and cheetahs) are especially under threat as the populations become increasing isolated through land-use transformation and climatic change {3.5}.

Healthy ecosystems can reduce socioeconomic vulnerability by supporting well-being *(well established)*. Healthy ecosystems are conserved socio-ecosystems, including those managed by communities, thanks to their knowledge of local environmental and socio-ecological conditions (cf examples from Indigenous Local Knowledge Task Force). Restored socio-ecosystems are beneficial for biodiversity recovery and livelihoods {3.5}.

Increases in protected areas and new conservation strategies are needed to curtail current unprecedented rates of biodiversity loss *(established but incomplete)*. The extent of protected areas in Africa has almost doubled in the last decades; protected areas now cover 14% of Africa with 4,358,096 km^2 in terrestrial area covered by protected areas and 345,917 km^2 in marine areas. Effectiveness of protected areas is poor in many areas due to a combination of factors, such as: climate change, overexploitation (over-hunting, logging, livestock herding), civil conflicts, and encroachment from local populations to sustain their livelihoods, and inadequate park design and administration. Land-grabbing is a major risk of environmental injustice and local communities' exclusion. The importance of transboundary protected areas and corridors is especially obvious for migratory species new governance types of protected areas, managed by local communities, are recognised and diffused all over African regions (cf Mangagoulack Indigenous and Community Conserved Area in Casamance). New financial and legal mechanisms for the preservation of ecosystem services (biodiversity offset, REDD+, PSE) are expanding, and provide emerging opportunities {3.3.3.1, 3.3.3.2}.

3.1 INTRODUCTION

This chapter synthesizes the status, trends and future projections of biodiversity and ecosystems, and their positive and negative effects on the provision of key ecosystem goods and services that contribute to economic growth, livelihoods and human well-being in the African region. The Assessment is based on a review of recent (past 10–15 years) scientific publications, reports and databases, and focuses on status and trends at the regional scale and on a subregional level covering East Africa and adjacent islands, West, Central, North and Southern Africa as classified by the United Nations. Some case studies using key species that are important for the functioning of ecosystems and livelihoods are also presented. For much of Africa, biodiversity is key to the delivery of nature's contributions to people. It is for that reason that the current trends of biodiversity decline have serious implications for economic growth, human well-being and livelihood security.

African ecosystems and biodiversity are biologically and ecologically unique, attract substantial tourism revenue, and provide significant ecosystem services at local, regional and global levels. However, the rates of biodiversity loss and ecosystem degradation are increasing. Under business-as-usual scenarios, it is predicted that a further 11% of biodiversity would be lost (OECD, 2008). Fifty-five species are extinct, with 1,781 threatened with extinction (Brooks *et al.*, 2016a). According to the IUCN Red List, 21% of the 4,539 freshwater species assessed in Africa are threatened. Ninety-one per cent of these freshwater species are endemic to the African continent and are therefore also globally threatened (Darwall *et al.*, 2011). Twelve per cent of birds, 19% of mammals and 26% of amphibians are threatened (Darwall *et al.*, 2011). From 1990 to 2015, Africa has experienced the biggest forest area loss compared to the rest of the world except South America. The rate of forest loss in Africa has decreased substantially in the past five years, average per capita forest area declined from 0.8 hectares to 0.6 hectares per person (FAO, 2015a).

In recent times, much effort has gone into designating protected areas in Africa, with the hope of saving areas of crucial importance for biodiversity conservation (UNEP-WCMC, 2008). As a result, for example, forested areas within protected areas in Africa have increased up to 4,133,459 km^2 from 2003 to 2015, representing about 14% of the total area (Brooks *et al.*, 2016a). In total, Africa contains 8,338 protected areas, including 374 marine protected areas, 44 natural World heritage sites, 72 Biosphere reserves, and 381 Ramsar sites (UNEP-WCMC *et al.*, 2017).

In order to achieve an effective and thorough documentation of the status, trends and future of biodiversity and ecosystem services in this region, it is essential to consider the unique history of African continent. For the human species (*Homo sapiens*), Africa provides many examples of human impacts–positive or negative–that point to the past, current and future of biodiversity and ecosystem services. Historically speaking, archaeologists have established that Olduvai archaeological grounds in Serengeti was one of the homes to earliest hominids, the human ancestors who relied on and interacted with the natural environment over two million years ago (Domínguez-Rodrigo *et al.*, 2009; Beverly *et al.*, 2014). Based on recent scientific findings, Africa was also a home to *Homo naledi*–presumably one of the closest members of the human family–*H. erectus,* H. *habilis* and ultimately *H. sapiens* (Callaway, 2015). As such, it is indisputable that Africa is one of the earliest locations for understanding how humans developed the culture of using ecosystem services. For example, oil palm (*Elaeis guineensis*, Least Concern) is an economic plant native to Africa and was introduced to Southeast Asia in the 19th century, where it has now become a source of both economic prosperity and ecological concern (Hai, 2002). That said, it is important to add that the commodification of biodiversity and ecosystem services pose serious risks to long-standing African management systems that view humans as inseparable part of biodiversity (Gerber *et al.*, 2007). Indeed, some studies found that upland areas of the East African Rift Valley system have helped in preserving plant species DNA for a period of up to 5,000 years (Boessenkool *et al.*, 2014). In Africa it is not only the physical environment that preserve biodiversity, but also social and economic systems that are well-connected to biodiversity and ecosystem services (Gerber *et al.*, 2007). Presently, there are increasing concerns over how human impacts, changing institutions, science and policy, habitat fragmentation, modernisation and urbanisation are undermining the present and future sustainability of biodiversity and ecosystem services in Africa (Anderson *et al.*, 2013; McGuinness *et al.*, 2014). As the Anthropocene age begins, it is imperative for scientists and policymakers to revisit strategies that will support transformation towards a better future that secures biodiversity, ecosystems and human well-being and prosperity.

3.2 METHODS AND INFORMATION SOURCES

Status, trends and future dynamics of biodiversity were examined at genetic, species and ecosystem levels. The genetic variations/trends within populations (see for example the FAO status of world genetic resources for food and agriculture and International treaty on plant genetic resources was used), and at the species and communities levels, indicators such as relative abundance, richness and uniqueness of species and their diversity including; wild relatives, threatened species, species vulnerability to climate change and other pressures etc. were examined. Sources of information about indicators include multi-lateral environmental agreements on biodiversity such as Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Convention on Migratory Species. Other sources of information include Summaries from State of Biodiversity in Africa, and Digital Observatory for Protected Areas.

The criteria that Chapter 3 used to evaluate species status and trends cover seven main questions: i) What are the data resources? ii) What are the biome-specific evaluation levels? iii) For what taxonomic groups is it important to have data? iv) What does present status mean and how can it be evaluated? v) What are the past trends – timescales and evaluation techniques? vi) What are the future dynamics of biodiversity looking towards the 2020 Aichi Biodiversity Targets (Chapters 4 and 5), and vii) What are the gaps? The seven overarching questions given above factored in: Habitats/ecosystems/landscapes, their extent and conditions relating to the ecosystem services that they provide. Ecologically and biologically significant areas, Important Bird Areas/Key Biodiversity Areas, hotspots, protected areas/Biosphere reserves/Ramsar sites, World heritage sites, fragile and vulnerable areas, degraded lands, agricultural lands; marine and other aquatic areas; land cover types, elevation zones, etc. The major ecosystem units of analysis taken into account are: deserts and drylands, savanna and grasslands, tropical dry and humid forests, mountains, islands and linear coastal systems, wetland and freshwater systems, urban and semi-urban systems, aquaculture-agriculture-sylviculture. Possible case studies include: Mountain Gorilla, Cheetahs, Fish of East African rift lakes, Mopane worms, Mangroves, Palms, *Ficus*, and Argan (*Argania spinosa*).

Presentation of the status and trends of key biodiversity features in focal case studies, covering both trends in the extent and quantity of key biodiversity components that play an important role in ecosystem structure and function or have iconic or spiritual/cultural value. Trends in quality and condition of biodiversity features crucial to the services/benefits/values highlighted in Chapter 2 and Chapter 4, including small-scale features with special ecological and cultural significance. ILK of the status and trends of biodiversity were documented through published literature and dialogue workshops undertaken in the context of IPBES to complement scientific methods and studies (Roué *et al.*, 2017). Trends in invasive species and their impacts were also examined.

3.3 OVERVIEW OF STATUS AND TRENDS OF BIODIVERSITY IN THE AFRICAN REGION

3.3.1 Status of species diversity

The African region holds an incredibly rich and unique flora and fauna containing over a quarter of the world's biodiversity, with the greatest concentrations occurring in the African equatorial ecosystems, South Africa and Madagascar (UNEP-WCMC, 2016; **Table 3.1**; **Figure 3.1**). The African region contains between 52,000 and 73,000 plant species (Schatz, 2002; UNEP, 2008), including 20% of the world's tree diversity (9,000–11,000 species) (Slik *et al.*, 2015). Madagascar has about 11,000–13,000 species of vascular plants, of which 90% are endemic (Gautier *et al.*, 2003). Africa is home to over one-quarter of the world's 5,450 mammal species. It also has more than 2,500 species of birds–one-fifth of the world's total–and at least 5,445 species of fish, alongside 1,134 described amphibian species (UNEP, 2008, UNEP-WCMC *et al*., 2016). Southern Africa alone has at least 580 families and about 100,000 known species of insects, spiders, and other invertebrates (UNEP, 2008). The African region also stands out for holding 40% of the global diversity of primate species (194 species), from human's closest relative, the chimpanzee, to the unique and diverse lemurs of Madagascar (Schwitzer *et al.*, 2013). While the rest of the globe underwent massive Pleistocene extinctions of large-bodied vertebrates (megafauna), Africa maintains an almost intact assemblage (Gill, 2015; Ripple *et al.*, 2016). These megafauna act as ecosystem engineers and play important roles in maintaining ecosystems (Malhi *et al.*, 2016).

As also indicated in Chapter 1, there are eight recognised biodiversity hotspots in the African continent (Cape floristic region, Coastal forests of eastern Africa, Eastern Afromontane, Guinean forests of Western Africa, Horn of Africa, Madagascar and the Indian Ocean islands, Maputaland Pondoland Albany, and Succulent Karoo) plus the Mediterranean Basin which encompasses part of the Northern Africa and Southern Europe (Mittermeier *et al.*, 2004; Conservation International, 2011; **Table 3.3**).

Table 3 1 **Comparison of African regional freshwater biodiversity assessments. Source: Darwall *et al.* (2005); Smith *et al.* (2009); Darwall *et al.* (2009); García *et al.* (2010); Brooks *et al.* (2011).**

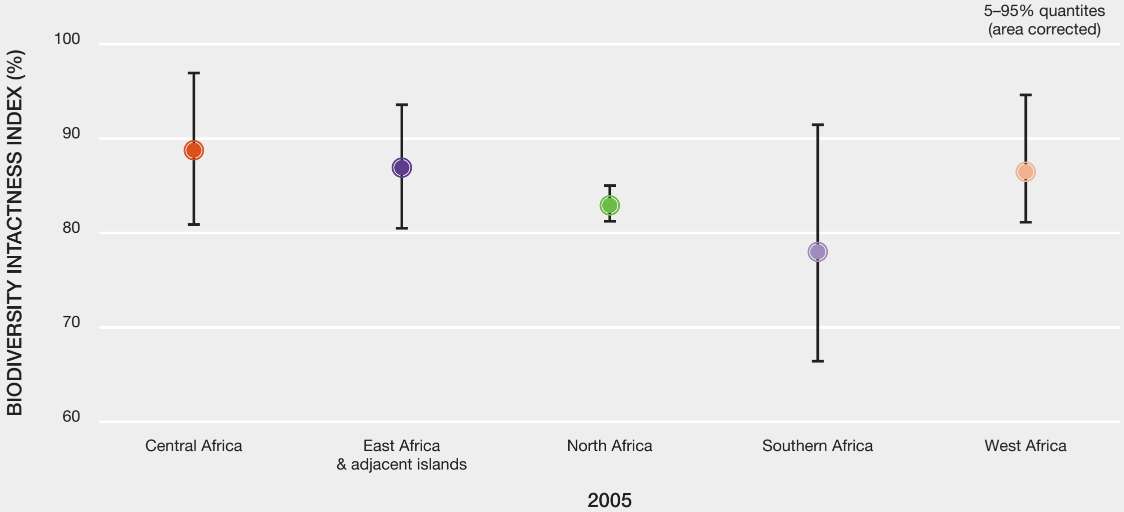
	Central Africa	East Africa and adjacent islands	West Africa	North Africa	Southern Africa
Number of taxa	2261	1661	1395	877	1279
% Threatened	15%	26%	14%	28%	7%
% Critically endangered	2.47%	2.25%	2.29%	7%	1.87
% Endangered	5%	7.5%	4.2%	8%	2.65
% Vulnerable	7.29%	16%	7.5%	13%	2.81
% Data deficient	21%	13%	16%	14%	15%

Table 3 2 **Estimated numbers of species by major taxonomic group. Source: Darwall *et al.* (2005); Darwall *et al.* (2009); Smith *et al.* (2009); García *et al.* (2010); Brooks *et al.* (2011); http://amphibiaweb.org; http://reptile-database.reptarium.cz/).**

Taxon	Central Africa	East Africa and adjacent islands	West Africa	North Africa	Southern Africa
Fishes	1,440	1,090	542	128	355
Mollusca	241	230	90	155	116
Odonata	504	304	287	82	272
Crabs	44	37	35	3	19
Amphibians	303	390	150	61	221
Mammals	22	135	16	126	13
Water birds	198	868	380	200	221
Turtles	4	N/A	3	8	15
Aquatic plants	435	N/A	472	509	N/A

Figure 3 1 **Biodiversity Intactness Index: The map and chart show the remaining populations of native species as a percentage of their original populations.**

From the map, blue areas are within proposed safe limits for the maintenance of ecosystem health, whereas red areas are beyond the safe limit. Map from: Newbold *et al.* (2016); and chart: GEO BON–PREDICTS, the figure prepared by Task Group on Indicators and Knowledge and Data Technical Support Unit.



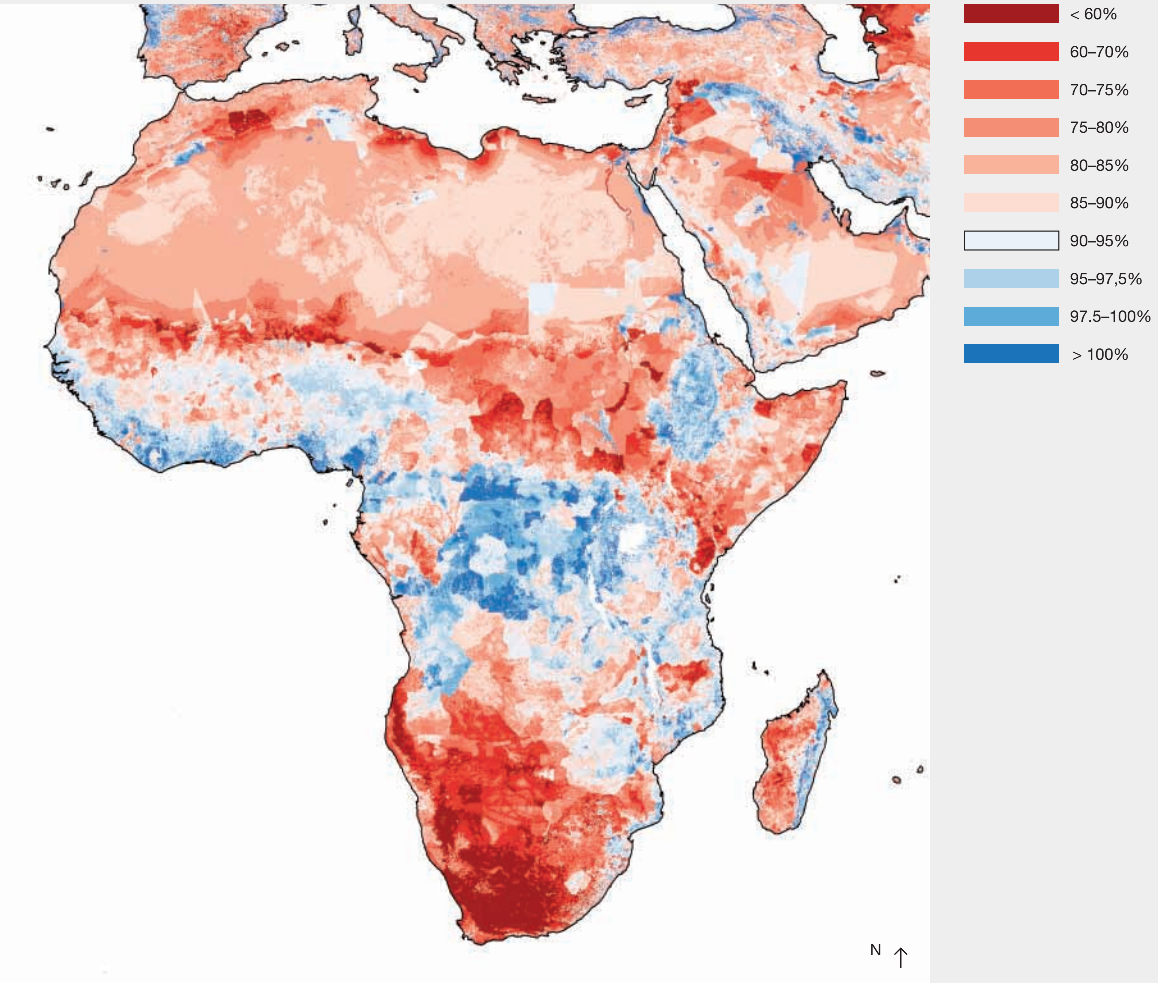


Table 3 3 **Biodiversity hotspots in Africa and their biological values.**

Hotspots	Human population density (people/km²)	Area (km²)				Endemic plant species	Threatened Endemic biodiversity			
		Original extent	Vegetation remaining	Protected area	Protected area: categories I-IV[2]		Birds	Mammals	Amphibians	Extinct species[1]
Cape Floristic Region	51	78,555	15,711	10,859	10,154	6,210	0	1	7	1
Coastal forests of eastern Africa	52	291,250	29,125	50,889	11,343	1,750	2	6	4	0
Eastern Afromontane	95	1,017,806	106,870	154,132	59,191	2,356	35	48	30	1
Guinean forests of western Africa	137	620,314	93,047	108,104	18,880	1,800	31	35	49	0
Horn of Africa	23	1,659,363	82,968	145,322	51,229	2,750	9	8	1	1
Madagascar & the Indian ocean islands	32	600,461	60,046	18,482	14,664	11,600	57	51	61	45
Maputaland Pondoland Albany	70	274,136	67,163	23,051	20,322	1,900	0	2	6	0
Succulent Karoo	4	102,691	29,780	2,567	1,890	2,439	0	1	1	1
Mediterranean basin[3]	111	2,085,292	98,009	90,242	28,751	11,700	9	11	14	5

1. Recorded extinctions since 1500.
2. Categories I-IV affords higher levels of protection.
3. The Mediterranean Basin expands from west to east from Portugal to Jordan and north to south from northern Italy to Morocco. Apart from the African States which are Morocco, Egypt, Libya, Tunisia and Algeria, it includes also parts of Spain, France, the Balkan states, Greece, Turkey, Syria, Lebanon, Israel, as well as around five thousand islands scattered around the Mediterranean Sea. West of the mainland, the hotspot includes the Macronesian Islands of the Canaries, Madeira, the Selvages (Selvagens), the Azores, and Cape Verde

3.3.1.1 Threat status

The IUCN Red List of Threatened Species has been disaggregated from the global scale by Brooks *et al.* (2016a & b) for the Africa region, and these data are presented below **(Table 3.4; Figure 3.2)**. Taxonomic groups for which comprehensive global assessments (>90% of species) have been done, were used. For these taxa, Brooks *et al.* (2016a & b) report an estimated 1,781 threatened species in the Africa region, representing 19% of the total number of extant species within these taxa. Of the 5,016 endemic species found in the region 23% are threatened with extinction **(Figure 3.2)**. The greatest proportion of threatened species are found in East Africa and adjacent islands with 17% of extant species considered threatened including 43% of the endemics occurring in the subregion. This is in part due to the high number of threatened endemic species in the regions hotspots, e.g., the Eastern Arc Mountains and coastal forests of Tanzania and Kenya (Gereau *et al.*, 2016), as well as those in Madagascar and the Indian Ocean Islands. Central Africa, however, has the highest proportion of threatened endemics at 50%. North Africa has the lowest proportion of threatened species (9%) and southern Africa the lowest proportion of threatened

Figure 3 2 **Extinction risk of species in the Africa region as a whole and per subregion. Source: Brooks *et al.* (2016a).**

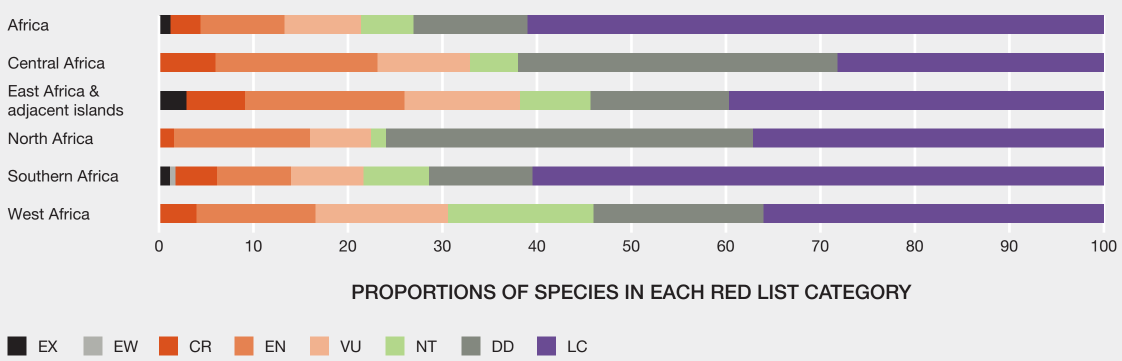


Table 3 4 **The number of species listed by CITES (on Appendix I, II or III) for birds, mammals, fishes, amphibians and plants (first column) in each of the regions of Africa and the corresponding percentage (second column) of the total for the taxon. Source: https://cites.org/eng/disc/ac_pc.php**

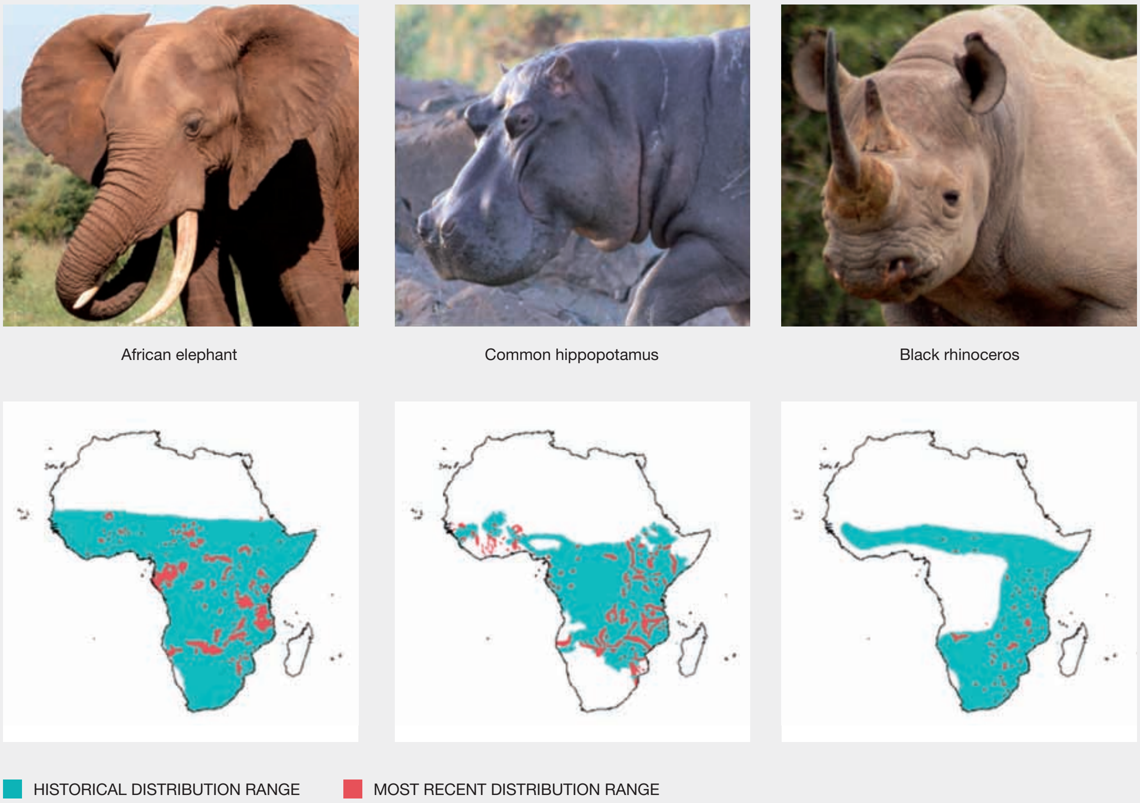
	Central Africa		East Africa and adjacent islands		North Africa		Southern Africa		West Africa	
	No.	%	No.	%	No.	%	No.	%	No.	%
Birds										
Appendix I	4	0.6	10	1.51	10	1.51	2	0.3	6	0.91
Appendix II	130	19.49	171	25.23	97	14.5	125	18.73	107	16.01
Appendix III	1	0.15	4	0.6	1	0.15	1	0.15	1	0.15
Total	**134**	**20.24**	**181**	**27.34**	**107**	**16.16**	**127**	**19.18**	**113**	**17.07**
Mammals										
Appendix I	25	4.5	86	15.47	21	3.78	29	5.22	26	4.68
Appendix II	97	16.55	84	14.57	41	6.29	74	12.77	73	12.41
Appendix III	5	0.9	3	0.54	6	1.08	3	0.54	4	0.72
Total	**122**	**21.94**	**170**	**30.58**	**62**	**11.15**	**103**	**18.53**	**99**	**17.81**
Fishes										
Appendix I	2	2.22	4	4.44	5	5.56	5	5.56	3	3.33
Appendix II	9	10	18	20	16	17.78	19	21.11	9	10
Total	**11**	**12.22**	**22**	**24.44**	**21**	**23.33**	**24**	**26.67**	**12**	**13.33**
Amphibians										
Appendix I	1	2.78	16	44.44	0	0	0	0	2	5.56
Appendix II	0	0	17	47.22	0	0	0	0	0	0
Total	**1**	**2.78**	**33**	**91.67**	**0**	**0**	**0**	**0**	**2**	**5.56**
Plants										
Appendix I	7	0.26	45	1.67	1	0.04	56	2.08	1	0.04
Appendix II	254	9.45	1303	48.46	49	1.82	836	31.09	137	5.09
Appendix III	0	0	1	0.04	0	0	0	0	0	0
Total	**261**	**9.71**	**1349**	**50.15**	**50**	**1.86**	**892**	**33.18**	**138**	**5.13**

endemics (23%). Trends in the IUCN Redlist Index over the last 28 years indicate that West Africa has the highest relative annual contribution to the overall change in the global Red List Index for the taxa assessed within the region and this is true in particular for amphibians. For mammals the highest relative annual contribution in the region came from Central Africa, whilst for birds it came from Southern Africa (Brooks *et al.*, 2016a). Considering the number of data deficient taxa, this number could be as high as 35% for the region with endemic threat status in Central Africa potentially being as high as 67%, highlighting the need for greater efforts to protect these taxa.

Africa is the last remaining refuge for megafauna worldwide, however their populations are at risk. Iconic African fauna such as elephants, hippopotamuses and rhinoceroses are currently restricted to a small percentage of their former ranges as a result of the international ivory trade, habitat loss, political instability, and the difficulties of enforcing anti-poaching laws **(Figure 3.3)**. The **figure 3.3** shows the range contractions over time for three iconic African herbivores (Ripple *et al.*, 2015). Between 2002 and 2011, forest elephant populations declined by 62%. Elephants are now a missing component from more than 75% of existing structurally intact rainforest in Africa where they once

Figure 3 3 **Range contractions over time for three iconic African herbivores.**

African elephant (ca. 1600 versus 2008), common hippopotamus (ca. 1959 versus 2008), and black rhinoceros (ca. 1700 versus 1987). The historical distribution ranges are in blue, whereas the most recent distribution ranges are represented by darker-colored polygons. For security purposes, the most recent black rhinoceros distribution range polygons (1987) have been moved it random directions and distances. The black rhinoceros distribution range has continued to shrink since 1987 across most of Africa, but has expanded locally in Zambia, South Africa, and Namibia through recent reintroductions, and the most current distribution range polygons are not shown because of the recent poaching pressure on the rhinoceros. Source: Ripple *et al.* (2015).



played a potentially important ecological role (Maisels *et al.*, 2013). Losing such megafauna from the second most expansive region of tropical forest in the world may have important consequences on local, regional and macro-scales that go beyond the loss of the species itself.

3.3.2 Status of ecosystem components

The African region consists of diverse habitats and ecosystems ranging from equatorial rainforests to grasslands to deserts with unique flora and fauna. This region contains nine of the world's 35 biodiversity hotspots **(Table 3.3; Figure 3.4)** and has three of the world's most biologically diverse countries (UNEP, 2008, 2013). These are Madagascar, South Africa and the Democratic Republic of Congo. The Ethiopian Highlands are one of the world's eight major centers of crop diversity (UNEP, 2013). Africa also holds the second largest rainforest (The Congo Basin) in the world after the Amazon. The estimated forest area in Africa was close to 6,750,000 km^2, accounting for about 17% of global forest area and 23% of the total land area of the region (FAO, 2011). Southern Africa's wetlands are among the most diverse, both physically and biologically of any in the world (Taylor *et al.*, 1995).

A total of 78 priority sites for important plant areas have been identified within the five North Africa countries in this project. In Algeria, 21 important plant areas have been selected within all the major vegetation zones from sea level to 2,300 metres and they are highly floristically diverse. In Morocco, the 19 important plant areas chosen are 2,500 metres above sea level with associated alpine and sub-alpine vegetation, these sites are also exceptionally rich in endemic species for example Toubkal National Park and Eastern High Atlas Park in the High Atlas mountains. The focus in Tunisia and Egypt has largely been on 13 and 20 important plant areas respectively, and in Libya 5 important plant areas have

Figure 3 4 **Classification of Africa's relatively stable, vulnerable and critically endangered biological hotspots. Source: UNEP (2013).**

been selected that represent the coastal belt, mountains and desert region, with a focus on Al Jabal Al Akhdar, the largest important plant area on the Cyrenaican Peninsula which contains 80% of the Libyan flora and is a region of exceptional plant endemism.

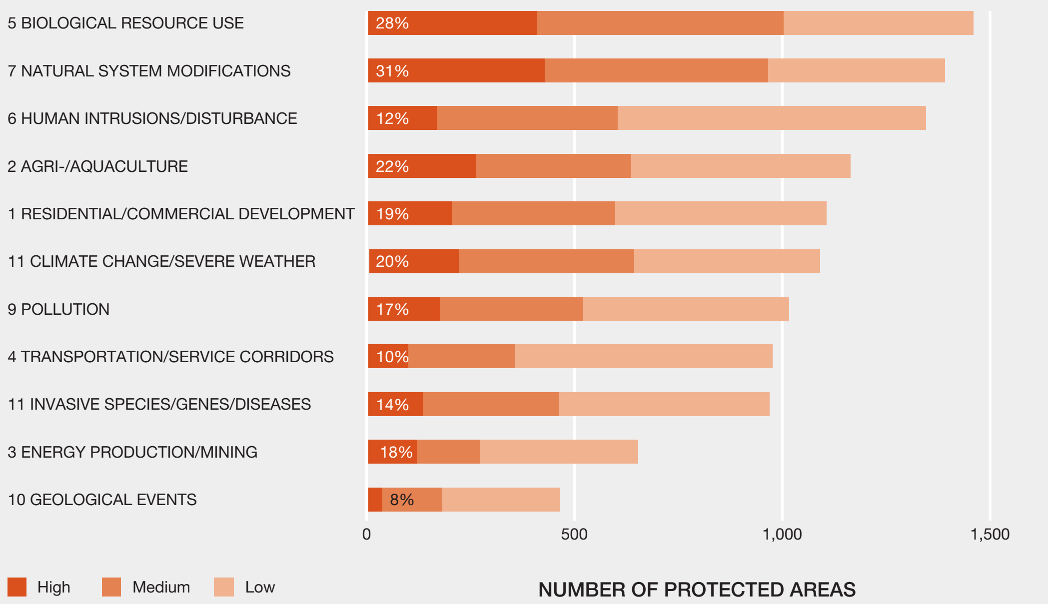
3.3.2.1 Protected area status

As the availability of natural resources in non-protected areas dwindles due violation of environmental laws (e.g., illegal hunting), the protected areas are becoming the sole remaining repositories of fuel-wood for local communities in and around protected areas, and forage, etc. (UNEP-WCMC, 2016). Unfortunately, protected areas are now becoming a focus for poaching, illegal grazing, fire and fire suppression, invasion of alien species and other human activities that affect their sustainability (Schulze *et al.*, 2018; **Table 3.5**; **Figure 3.5**). It is therefore crucial to improve the management effectiveness of the existing protected areas to better cope with the current level of their erosion. Africa has a number of large transboundary

Table 3 5 **The most frequently reported threats in Afrotropical realm (sub-Saharan Africa) and Palearctic realm (including North Africa). Source: Schulze *et al.* (2018).**

Realm	Biome group	Number of sites	Most frequently documented threat	2nd most frequently documented threat	3rd most frequently documented threat
Palearctic	Non-tropical forest	479	Recreational activities	Hunting and collecting terrestrial animals	Dams and water management/use
Palearctic	Non-tropical savannahs, shrub-and grasslands	51	Recreational activities	Hunting and collecting terrestrial animals	Livestock Farming and Ranching
Afrotropical	Tropical forests	150	Hunting and collecting terrestrial animals	Gathering	Logging and wood harvesting
Afrotropical	Non-tropical savannas, shrub- and grasslands	22	Invasive non-native/ alien species/ disease	Fire and fire suppression	Recreational activities
Afrotropical	Mangroves	7	Fishing and harvesting aquatic resources	Hunting and collecting terrestrial animals	Gathering terrestrial plants

Figure 3 5 **Ranked frequency of threats across protected areas. Source: Schulze *et al.* (2018).**



ecosystems, which are areas of land or sea that straddle one or more political boundaries. Some are officially protected areas which are of extreme importance for safeguarding the remarkable animal populations of Africa and their habitats. The importance of transboundary protected areas is especially obvious for migratory species. Examples of transboundary protected areas in Africa include Nyungwe forest (Rwanda)/Kibira National Park (Burundi); Mt Elgon national park (Kenya and Uganda) Great Limpopo Transfrontier Park (Mozambique, South Africa, and Zimbabwe); Tri-National Dja-Odzala-Minkébé network of protected areas in Cameroon, Gabon and DRC, and the W-Arly-Pendjari complex in Benin, Burkina Faso and the Niger.

3.3.3 Broad temporal trends in biodiversity and ecosystem components

Africa is rapidly losing its biodiversity due to uncontrolled exploitation and fragmentation of natural habitats (UNEP, 2013). Africa's Living Planet Index shows an overall reduction of 39% invertebrate abundances between 1970 and 2008 (WWF, 2012). This is higher than the estimated loss rates globally (30%) but much lower than the 59% loss across the tropics. Loss of biodiversity in Africa is occurring fastest in the species-rich forest zones, including Western and Central Africa and Madagascar (Craigie *et al.*, 2010). Impacts on smaller species, including invertebrates and rodents, are relatively unknown.

Ecosystems in the African regions are also declining rapidly. Over 3 million hectares of natural habitat are converted for other uses each year (COMIFAC, 2011). From 1990 to 2015, Africa has experienced the biggest forest area loss compared to the rest of the world except South America. The rate of forest loss in Africa has decreased substantially in the past five years, and average per capita forest area declined from 0.8 to 0.6 hectare/person (FAO, 2015a). Freshwater ecosystems, which provide the sole habitats for rich, endemic, and sensitive biota, and supply food and water to millions of people in Africa, are currently threatened by dams' constructions, unsustainable harvesting, wetland drainage for agriculture, invasive species and pollution that have resulted in degradation of these ecosystems continent-wide (Strayer *et al.*, 2010).

Studies suggest that climatic changes are already having negative impacts on ecosystems in Africa with altered rainfall patterns and temperature regimes (Chapter 4; section 4.2.2.2). Models predict future changes especially in the drier habitats of Africa including Northeast Africa, the West Sahel, and Southwest Africa (UNEP-WCMC, 2016). Africa's coral reefs in the Indian Ocean experienced massive bleaching in 1998, and again in 2016 as a result of extreme ocean warming events resulting in over 50% reef mortality in some regions (Obura, 2016). Damage to coral reef systems has far-reaching implications for fisheries, food security, tourism and overall marine biodiversity.

3.3.3.1 Protected area trends

In total, Africa contains 8,338 protected areas totaling 4,704,013 km^2 of which 4,358,096 km^2 is terrestrial and 345,917 km^2 marine (UNEP-WCMC *et al*., 2017). Much effort has recently gone into designating new protected areas in Africa with the hope of saving areas of crucial importance for biodiversity conservation (UNEP-WCMC, 2008).

The first Indigenous and Community Conserved Area (ICCA) included Conservancies in Zimbabwe, Namibia, Kenya and South-Africa, and their main benefits for local people were from non-consumptive tourism. Now, there are more and more community-based management areas, included (or not) in the category VI of IUCN, oriented towards sustainable use of natural resources (Aubertin *et al.*, 2011). For instance, in Casamance, Senegal, the ICCA of the Rural Community of Mangagoulack, created in 2004, known as *Kapoye Wafwolale Wata Nanang* (a joola expression meaning 'Our heritage, for us all to preserve') is oriented towards sustainable use of the mangrove forests and rivers to the benefit of the local fishers and directly managed by them (Cormier-Salem, 2014).

Despite these advances in habitat protection, rapid population growth coupled with globalisation and an increasing demand for food, shelter and income over the last century have led to the increased loss of habitat and ecological isolation of protected areas (DeFries *et al.*, 2005). In Africa, this trend has been exacerbated by large-scale land-use changes financed by foreign and local capitals interested in the extraction of natural resources and the production of agricultural crops for international markets (Hilson *et al.*, 2004; Yelpaala *et al.*, 2005; Cotula *et al.*, 2009).

3.3.3.2 Environmental health trends

This theme contributes to the assessment of the risk that diseases cause to human well-being and animal. It encompasses the health of the environment or the ecosystem where humans and animals live in harmony with nature in a balance necessary for human well-being but sensitive to extrinsic influences. It is a symbiotic lifestyle in which each party benefits from the existence of the other. While parasitic cohabitation proves harmful for one of the living beings concerned. Thus, pathogens occur under certain conditions and harm human, animal or plant health. These agents are either of viral, bacteriological or mycotic origin. Climatic and ecological disturbances promote their virulence even though they are harmless in a healthy natural environment.

Man is as sensitive as the animal or vegetal aggressions of those agents that become pathogenic. This is the case for serious human illnesses such as Ebola, HIV, influenza or rabies and in cases of plague, foot-and-mouth disease or catarrhal fever with high economic impact. While the plant suffers from other infections rather caused by parasitic agents that appear under certain climatic conditions (high heat, too much humidity or high density). This is the case of Bayoud disease in olive tree, the caterpillar *Paysandisia archonqui* infects the palm in the Mediterranean (North Africa). The cork oak is attacked every dry season by a parasite that ravages the forests. Eucalyptus is vulnerable to attacks caused by *Phoracantha semipunctata*.

As for fungal diseases caused by fungi whose development is linked to disturbances of aeration or oxygenation of living beings in sites exposed to their aggressions (mildews, ergot of rye or maize) and other pathogens of legumes or arboriculture. The knowledge of these pathologies has evolved considerably since the vaccine against rabies was manufactured by Louis Pasteur or *Penicillin* was discovered by Alexander Fleming in the last century. However, newly emerging pathogens (e.g., Ebola and HIV) are the subject of intense research to find the cure necessary to neutralize their aggression. The repeated frequency of these human epidemics or animal epidemics affect either the vulnerable human populations or their food stocks or impact the rich biodiversity of the continent hindering the food security of the countries (FAO, 2015a; WOAH, 2017). Wildlife suffers from the human awkwardness that invades the remote territories of these animals introducing livestock-borne pathogens. Wild animals unimmunized against these agents contract the disease and develop epizootics that eliminate a large proportion (rabies, foot-and-mouth disease, rinderpest, avian influenza (WOAH, 2015), to name but a few examples) and other agents carried by domestic animals such as anthrax, blue tongue or coryza.

The role of birds and insects in the dissemination of pathogens is crucial in the contamination of constituents of African and even global biodiversity. To mention also the role of bees in the pollination of plants for the welfare of man and nature but these workers of nature are threatened by the man who introduces into his hives dangerous diseases such as the varroosis that threatens bee industry (WOAH, 2017). The loss of a species has no equivalent value in nature and its restoration remains in the realm of the impossible.

3.3.3.3 Urbanisation, agriculture and biodiversity in Africa

There are five major trends in the process of urbanisation that affect biodiversity and ecosystem services. These trends include: fast spatial expansion of urban areas; impacts of urban expansion on quality of ecosystem services; impacts of urban expansion modifies local climate and affects quality of biodiversity; land for urban agriculture; and impacts on biodiversity hotspots; Seto *et al.* (2013). It is projected that world urban population would increase to five billion by 2030 and this rapid change associated with land conversion threatens biodiversity and ecosystem productivity (Seto *et al.*, 2012). The pressure on African biodiversity is not limited to the continuous loss of species and habitat, the escalating human-driven changes, climate change and land-use and land cover change (UNEP-WCMC, 2016).

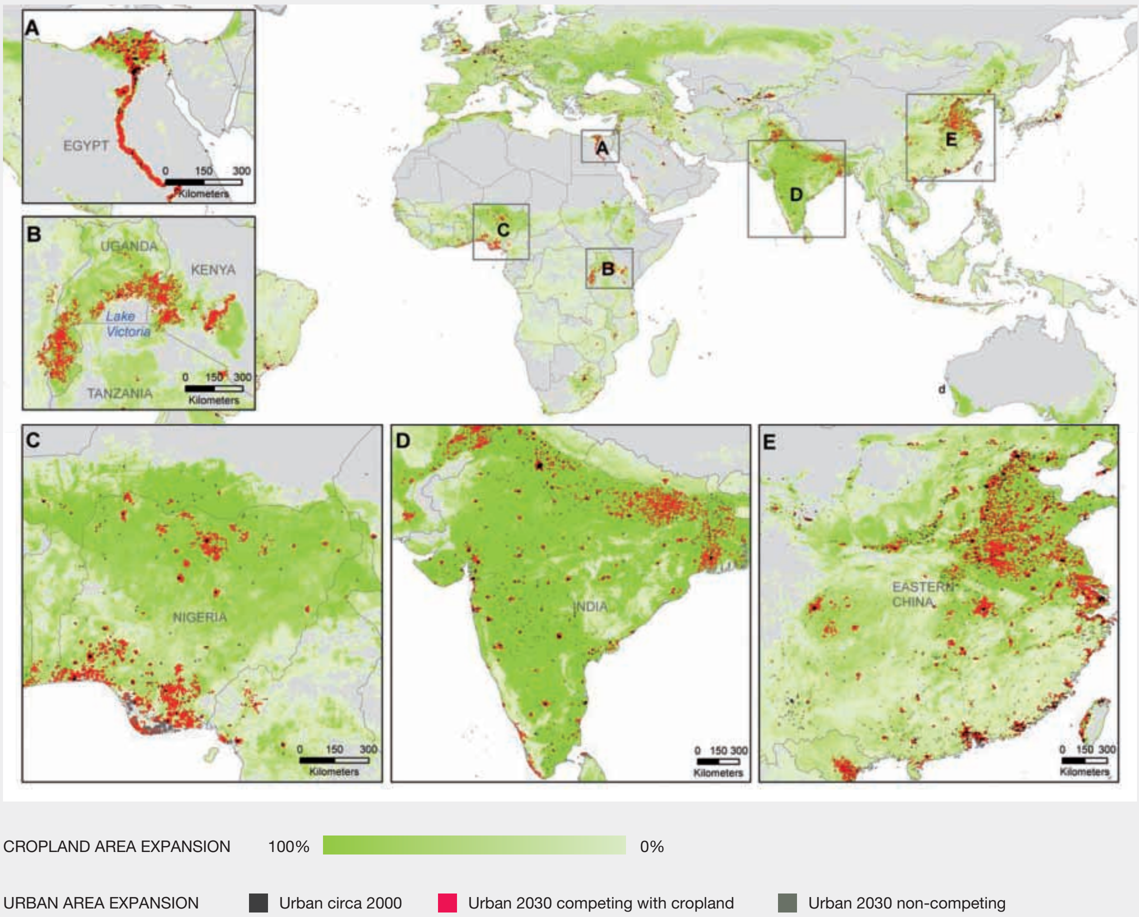
One fundamental issue is the challenge of invasive and non-native species in African cities. For instance, Gaertner *et al.* (2016) found that introduction of some exotic species Cape Town South Africa grey squirrels (*Sciurus carolinensis*, Least Concern), Himalayan tahrs (*Hemitragus jemlahicus*, Near Threatened) have contaminated urban biodiversity composition. In West Africa, cultivation of Okra in urban and peri-urban is shown to be responsible for introduction of some invasive weed species that harm ecosystem services particularly pollination and pest control (Stenchly *et al.*, 2017). Similarly, the use of industrial wastewater in West African urban areas, intensive cultivation of spinach (*Spinacia oleracea* L.) kills soil-dwelling arthropods. In other words urban agriculture dictates trends of species diversity depletion. Sometimes, the distribution of exotic species goes hand in hand with agriculture intensification and urbanisation. For instance, in Bujumbura, the capital city of Burundi, researchers found that out of the 404 tree species they recorded in the city 57% are native while 43% were introduced (Bigirimana *et al.*, 2011).

Here, it is important to note that although urbanisation threatens biodiversity in Africa and elsewhere, **table 3.6** outlines some of the most critical ecological zones in Africa that is likely to be affected by increasing urbanisation. Comparison of changes over time come through projections undertaken in various research laboratories as shown in **figure 3.6**.

Table 3 6 **Biodiversity hotspots and projects threats by urban growth. Source: van Vliet *et al.* (2017).**

Biodiversity hotspot	Hotspot area not threatened by urban expansion (km²) (% of hotspot)	Urban expansion in hotspot (km²) by probability quartile range (% of hotspot)				Urban extent in hotspots ca. 2000 (km²) (% of hotspot)
		>0–25	>25–50	>50–75	>75–100	
Cape Floristic Region	80,400 (97)	175 (0.2)	25 (0.0)	0 (0.0)	1,100 (1.3)	875 (1)
Coastal Forests of Eastern Africa	287,575 (95)	9,775 (3)	275 (0.1)	300 (0.1)	5,350 (2)	800 (0.3)
Eastern Afromontane	902,950 (86)	99,775 (10)	8,400 (1)	6,500 (0.6)	28,400 (3)	1,500 (0.1)
Guinean Forests of West Africa	482,775 (75)	101,950 (16)	5,800 (1)	3,775 (0.6)	43,675 (7)	4,725 (1)
Horn of Africa	1,597,450 (96)	57,275 (3)	2,650 (0.2)	4,650 (0.3)	5,300 (0.3)	1,575 (0.1)
Madagascar and the Indian Ocean Islands	590,525 (99)	6,050 (1)	350 (0.1)	75 (0.0)	2,100 (0.4)	275 (0.0)
Maputaland-Pondoland-Albany	260,125 (94)	6,300 (2)	1375 (1)	1,475 (0.5)	7,225 (3)	1,075 (0.4)
Mediterranean Basin	1,687,550 (80)	302,825 (14)	23,750 (1)	16,650 (1)	54,675 (3)	33,450 (2)
All hotspots	21,666,625 (91)	1,325,225 (6)	100,750 (0.4)	77,200 (0.3)	436,175 (2)	203,900 (1)

Figure 3 6 **Projected urban expansion and its implications for croplands in Africa. Source: d'Amour *et al.* (2016).**



3.4 SUBREGIONAL ANALYSIS

3.4.1 North Africa

3.4.1.1 Terrestrial

3.4.1.1.1 Mediterranean Forest

Status: The Mediterranean woodland and forest ecoregion of North Africa stretches from the coastal plains to the hills of northern Morocco, Algeria and Tunisia, and eventually surrounds the Atlas Mountains; it extends approximately 358,936 km^2 (Olson *et al.*, 2001). Key protected areas include El Feija National Park, Châambi, Boukornine, Ichkeul, Bouhedma, Jebel Serj National Parks in Tunisia, Chrea, Djurdjura, Tlemcen, Theniet El-Had, Gouraya, Taza, El Kala, Belzma National Parks and biosphere reserve in Algeria, and Talassemtane, Al Hoceima, Tazekka, Ifrane, Khenifra, Eastern High Atlas, Toubkal, Souss Massa and Khenifiss National Parks in Morocco. The Biosphere Reserves are represented in Morocco by *Argania spinosa*, Southern Oasis Morocco, Cedar Biosphere Reserve and Intercontinental Biosphere Reserve of the Mediterranean between Morocco and Andalusia (Spain); in Algeria by Tassili N'Ajerr, El-Kala, Djurdjura, Chrea, Gouraya, Taza Biosphere Reserves; in Tunisia by Ichkeul, Djebel Bou-Hedma, Zembra and Zembretta, Djebel Chambi Biosphere Reserves; in Egypt by Wadi Allaqui and Omayed Biosphere Reserves; in Sudan by Dinder and Radom Biosphere Reserves and the Transboundary Biosphere Reserve of the Senegal River Delta between Mauritania and Senegal. Morocco holds the greatest amount of protected Mediterranean forest in North Africa. The Mediterranean Basin is the third richest biodiversity hotspot in the world (Mittermeier *et al.*, 2004). However, recent biodiversity studies in the North African region are limited.

The Mediterranean forests of Morocco and Algeria are two centres of high plant diversity with a high degree of endemism

Figure 3 7 Number of vascular plants in the countries of North Africa. Source: El Oualidi *et al.* (2012).

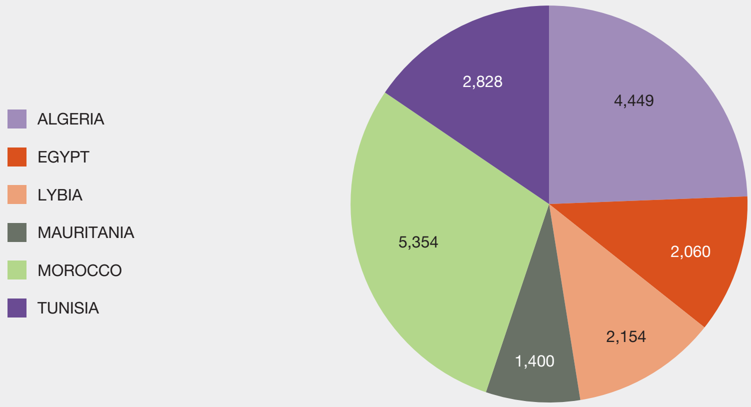
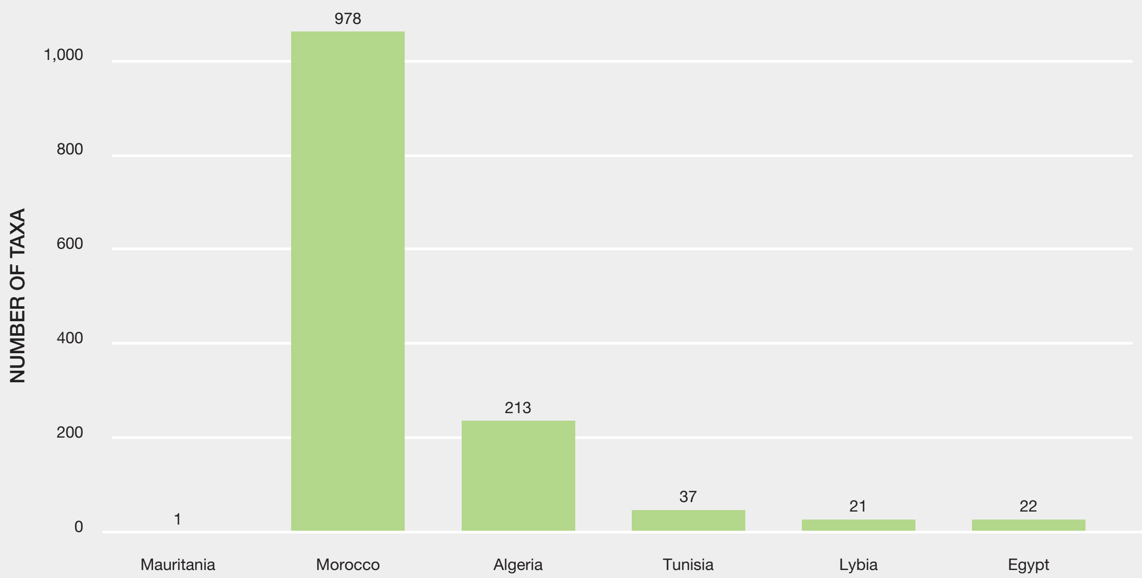


Figure 3 8 Endemic vascular flora in North Africa. Source: Dobignard *et al.* (2013).



and rarity **(Figures 3.7 & 3.8)** because of their position at the crossroads of two continents, and transitions between tropical and temperate climates (Médail *et al*., 1999). They hold several types of forest represented by fir, cedar, argan tree, atlas cypress, xeric pine, Berber thuya, cork oak, holm and holly oak, red juniper, thuriferous juniper and carob species. There are approximately 70 species of mammals in this region and some species are endemic, including some charismatic taxa such as Barbary leopards (*Panthera pardus panther*, Critically Endangered), Monk seal (*Monachus monachus*, Endangered), and Barbary macaque (*Macaca sylvana*, Endangered) and birds such as the Waldrap Ibis (*Geronticus eremita*, Endangered), the only world wild colony in Morocco (Butynski *et al.*, 2008; Karamanlidis *et al.*, 2015; BirdLife International, 2016; Stein *et al.*, 2016).

The flora and fauna diversity of Mediterranean forest habitats are highly threatened and highly endemic and need urgent research and implementation of the legislation for protection. The forests provide a rich source of products that provide sustenance and income for communities living in and around the forest (M'Hirit, 1999), however, recent human encroachment and overuse of resources are currently threatening these rich primary forests considered as national heritage (M'Hirit, 1999).

The original forest cover of this ecoregion has been dramatically reduced for agricultural and pastureland (Zaimeche, 1994). In Algeria, only 1,000 km^2 of the original 10,000 km^2 of wild-olive and carob forests remain, and only 6,800 km^2 of the original 18,000 km^2 of holm oak forest remains. In Morocco, 5,000 km^2 of the estimated 36,240 km^2 original wild-olive and carob forests remain, and 14,320 km^2 of the original 24,500 km^2 holm oak forest remains. The original extent of the cork oak forests in North Africa is estimated to be 30,000 km^2, (3,500 km^2 in Morocco, 4,500 km^2 in Algeria, and 455 km^2 in Tunisia). Removals of wood and non-wood forest products for economic purposes also threaten this ecosystem; for example, firewood collection dominates 80–100% of total wood forest product removals in Tunisia, Morocco and Lebanon (Croitoru, 2007). Net carbon losses in these three countries vary within 0.08–0.53 tons of Carbon/hectare/year (Croitoru, 2007).

The protected areas in this ecoregion are generally lacking in management plans and those that do have management plans lack resources to implement them. Recent biodiversity studies in this habitat are limited and there is an urgent need for research to better understand the current conservation status and trends affecting the Mediterranean forests, including biodiversity and ecosystem services, in this region (Médail *et al.*, 1999).

3.4.1.1.2 High mountain habitats

Status: North Africa's mountain ranges include the Atlas and Rif mountains, and their highest peaks include Morocco's Jbel Toubkal (4,167 metres) and Ighil M'Goun (4,071 metres). Mediterranean conifer and mixed forests grow in high elevations of the major mountain massifs, and small, isolated relict stands of fir and pine forests are endemic (Olson *et al.*, 2001). The mountain regions' high endemism includes 91 endemic plant species in the Tell Atlas Mountains, at least 190 in the Rif Mountains, and 237 endemic species in the Middle Atlas Mountain range (FAO, 2015a). Flagship species include the argan tree (Sapotaceae) and the endangered Mediterranean fir (*Abies marocana*) (Alaoui *et al.*, 2011; **Table 3.7**). One of the few known remaining habitats of the striped hyena (*Hyaena hyaena*, Near Threatened) is found in the Djurdjura Mountains (Arumugam *et al.*, 2008). Only 1% of mountain areas are found within protected areas.

The region's mountains have an average human density of 15 people/km^2 (Pfeifer *et al.*, 2012), representing a 2% increase since 2000. Humans' greatest service from the region's mountain ecosystems is their 'water tower' function. Although dominated by desert, the tallest peaks hold snow for weeks to months and meltwater contributes to and regulates water flow that benefits agriculture from late winter to early summer (UNEP, 2014). Snowmelt from the High Atlas Mountains contributes approximately 25% of streamflow in its catchments (Boudhar *et al.*, 2009), and the region supplies the headwaters for the Sebou River, the Oum Errabiaa and Oued Moulouiya. The region's mountain ecosystems also provide grazing and tourism (trekking and skiing), and hold important sacred sites such as Egypt's Mount Sinai (UNEP, 2014) and Zaouia in Atlas mountain.

Trends: Historical pressures to the region's mountain ecosystems include habitat transformation for agriculture, which has increased markedly between 1984 and 2013, especially around the Oued N'Fis (UNEP, 2014). Wastewater pollution generated by growing urban areas is compromising river water quality (Perrin *et al.*, 2014). Atlas cedar forests found among the Aures Mountains and the Djurdjura Mountains are under pressure from climate change, fire and pastoralism, though wood harvest rates are low (Djema *et al.*, 2009). The Rif Mountains are exceptionally vulnerable to soil erosion, losing an average of 10 m^3/hectare/year (Croitoru *et al.*, 2005). Forest cover, although limited, has increased by 6% overall and by 78% within national parks (2000–2009) (Pfeifer *et al.*, 2012). The region holds some of the Mediterranean basin's highest proportions of threatened terrestrial amphibians, mammals, dragonflies and reptiles (Cuttelod *et al.*, 2008).

Future dynamics: Climate change poses the most serious threat to North Africa's mountain ecosystems in the future. Predicted temperatures increase, precipitation declines and longer dry season (Pfeifer *et al.*, 2012) will lead to declines in snow and hence in 'water tower' function. Resulting water shortages are projected to decrease agriculture by 8% by the end of the 21st century (Montanari, 2013).

In Libya, forest ecosystems cover 217,000 hectares and are found in the area of Jabal Al Akhdar in the north-east, comprising the following: moist forest, with *Quercus calliprinos, Laurus nobilis, Arbutus pavarii* (Vulnerable), *Olea europaea, Ceratonia siliqua* (Least Concern), *Quercus coccifera* (Lower Risk/near threatened), *Cupressus sempervirens* (Least Concern); secondary moist forest, with *Juniper phoenicea, Pinus halepensis* (Least Concern), *Olea europaea, Arbutus pavarii* (Vulnerable); forests in semi-arid regions, with *Sarcopoterrium spinosium, Pinus halepensis* (Least Concern), *Juniper phoenicae, Pistacia lentiscus* (Least Concern), *Rhus tripartitum, Periploca laevigata;* and forests to the south of Jabal Al Akhdar, with *Rhus tripartitum, Pistacia lentiscus* (Least Concern), *Periploca laevigata*. In Egypt, forest ecosystems cover 67,000 hectares. The main natural ecosystems are organised by *Acacia raddiana*, *Balanites aegyptiaca*, *Tamarix sp*., and *Salvadora persica*. In Sudan, the main forest ecosystems are represented by *Acacia raddiana* Savi, *Acacia mellifora* (M. Vahl) Benth, *Balanites aegyptiaca* Delile and *Boscia senegalensis* Poiret in Lam. In Mauritania the forest ecosystems cover 267,000 hectares. The main natural ecosystems are organised by *Acacia raddiana*, *Acacia ehrenbergiana* (Least Concern), *Acacia nilotica* (Least Concern), *Balanites aegyptiaca*, *Leptadenia pyrotechnica*, *Boscia senegalensis* and *Euphorbia balsamifera*.

Table 3 7 **List of main terrestrial forest ecosystems in North Africa.**

Main Forest Ecosystems	Area (hectares) in Morocco(1)	Area (hectares) in Algeria(2)	Area (hectares) in Tunisia(3)
***Quercus rotundifolia* Lam.**	1,415,201	354,000	83,000
***Cedrus atlantica* (Endl.) Carrière**	133,653	23,000	Absent
***Argania spinosa* L.**	871,210		Absent
***Quercus suber* L.**	377,482	480,000	100,000
Quercus coccifera	+	+	+
Juniperus phoenicia, Juniperus thurifera	244,837	227,000 (*Juniperus phoenicea*)	+
Reforested	490,518		?
Other	102,207		
***Tatraclinis articulata* (Vahl) Masters)**	565,798	191,000	22,000
Pinus sp.	82,115	804,000	?
Pin d'Alep (*Pinus halepensis* Miller)			297,000
***Pinus pinaster* Aiton**	+	+	?
***Quercus faginea* Lam.**	9,091	65,000 (*Quercus afares*)	6,414
***Abies maroccana* Trabut**	3,174	Absent	Absent
***Acacia raddiana* Savi**	1,000,000	+	+
***Acacia ehrenbergiana* Hayne**	+	+	+
***Ceratonia siliqua* L.**	+	+	+
Other	5,764	143,000	
Total	**5,301,050**	**3,050,000**	
***Stipa tenacissima* L.**	3,000,000	3,037,000	+
Total forest area	5,719,000 (without alfa grass)	1,492,000	1,056,000

+: present
(1) Morocco (Source: Le grand livre de la forêt marocaine. Editions Mardaga, 1999)
(2) Forêt méditerranéenne t. XV, n° 1, janvier 1994
(3) République Tunisienne, Ministère de l'Environnement et du Développement Durable, Agence Nationale de Protection de l'Environnement. Guide forêts durables. 2005

3.4.1.1.3 Savannah and grassland

Status: Savannah and grasslands in North Africa are located in arid and Saharan areas (Savannah) and in High mountain areas (grasslands). The Siwa protected areas (Northwest Egypt, near Libya border) include 53 plant species, 28 wild mammals including 7 rare species threatened with extinction (namely cheetah, Striped hyena, Egyptian gazelle, white gazelle, red fox, wild cat and Fennec fox), 32 reptile species, 164 bird species and 36 insects and number of other invertebrates areas (Taleb *et al.*, 2013). In Wadi El Gemal and Hamata (Egypt), 140 plant species, including 32 used in traditional medicine, 24 mammal species, 29 species of reptiles and amphibians and 45 bird species were recorded areas (Taleb *et al.*, 2013).

Grassland ecosystems are common in Morocco especially in High Atlas and Middle Atlas areas (Taleb *et al.*, 2013). They are herbaceous and based on hemicryptophytes, geophytes, mesophiles and hygrophile associations of important forage value (Ouhammou, 2013). Their existence is conditioned by water availability (Ionesco *et al.*, 1962). These grasslands are floristically rich, with many rare, threatened and/or endemic flora. They are characterised by species such as *Agropyrum festucoides*, *Poa alpina*, *Lolium perenne*, *Holcus lanaus*, *Ranunculus acris* (Least Concern), *Trifolium repens*, *Campanula mairei* (Vulnerable), *Rorippa atlantica*, *Rumex pulcher*, *Eryngium variifolium* (Vulnerable) and *Aconitum lycoctonum*. Various types of grasslands can be distinguished according to altitude. In the High Atlas, Ouhammou (2013) distinguished four grassland types: Grassland with *Lolium perenne*, *Holcus lanatus*, *Inula viscosa*, *Ranunculus acris* (Least Concern), and *Trifolium repens*; localised between 1,300 and 2,300 metres. Grassland with *Eryngium variifolium* (Vulnerable), *Alchemilla arvensis* and *Rumex pulcher*, found in wet places. Grassland with *Cirsium chrysacanthum* (Near Threatened), *Campanula mairei* (Vulnerable) and *Rorippa atlantica*; extends up to the high mountains.

Trends and future dynamics: The subregion is vulnerable to desertification and drought. *Argania spinosa, Arbutus pavari, Cedrus atlantica* (Endangered), *Abies pinsapo var. marocana, Euphorbia echinus, Euphorbia resinifera, Senecio antieuphorbium, Thymus algeriensis,* and *Thymus broussonettii* are endangered. In Sudan populations of the red-fronted gazelle, Dama gazelle, Barbary sheep, Nubian ibex and lion have declined to critical levels and number of threatened species is increasing. Dorcas, which was considered the most abundant species in Sudan, is threatened by habitat fragmentation and poaching. The 2017 IUCN Red List Animals listed Dorcas gazelle as Endangered in Morocco and Libya, Algeria as Probably Vulnerable, Tunisia and Egypt as Vulnerable and Sudan as Probably Near Threatened or Vulnerable. The 2017 IUCN Red List Animals listed Scimitar-horned Oryx (*Oryx dammah*) as Critical, Extinct in Algeria, Egypt, Libya, Mauritania, Senegal, and South Western Sahara of Morocco, and probably extinct in Sudan and Tunisia. The 2017 IUCN Red List Species listed the Scimitar-horned Oryx as Extinct in the wild. It now survives only in zoos and in protected area, as Sous Massa National Park in Morocco. The 2017 IUCN Red List Animals listed the Addax (*Addax nasomaculatus*) as Critically Endangered.

Small gazelles have also declined drastically in the Sahara. The Slender-horned Gazelle or Rhim (*Gazella leptoceros*), native to North Africa, is now extinct in Western Sahara, and endangered throughout its range, according to the 2000 IUCN Red List Species. The endangered Dama Gazelle (*Nanger dama*), also a heavily hunted species, is extinct in Algeria, Libya, Mauritania and Morocco. Cuvier's gazelle (*Gazella cuvieri*) is endemic to mountains and hills of the Atlas and neighbouring ranges of north-west Africa. According to the Red List/IUCN (2016), the species survives in endangered populations in Algeria, Morocco and Tunisia.

3.4.1.1.4 Dryland and desert

Status: The desert comprises much of North Africa, excluding the fertile region on the Mediterranean Sea coast, the Atlas Mountains of the Maghreb, and the Nile Valley in Egypt and Sudan. The Sahara desert covers large parts of: Algeria, Egypt, Libya, Morocco, Sudan and Tunisia. The flora of the Sahara desert in North Africa is relatively poor but very remarkable, composed mainly of *Phoenix dactylifera* (Least Concern), *Acacia raddiana, Acacia ehrembergiana, Balanites aegyptiaca, Retama retam, Genista saharae, Gymnocarpos decander, Convolvulus trabutianus, Foleyola billotii, Zilla macroptera, Spergularia tomentosa, Fredolia aretioides, Traganum nudatum, Boscia senegalensis, Maerua crassifolia, Anastatica hierochuntica*. Several species of fox live in the Sahara desert including: the fennec fox, pale fox and Rüppell's fox. The Addax, a large white antelope, can go nearly a year in the desert without drinking. The Dorcas gazelle is a North African gazelle that can also go for a long time without water. Other notable gazelles include the Rhim gazelle and Dama gazelle. The Saharan cheetah (northwest African cheetah) lives in Algeria. There remain not more than 250 mature cheetahs in Sahara desert. The other cheetah subspecies (northeast African cheetah) lives in Sudan. There are approximately 2,000 mature individuals left in the wild (Belbachir, 2008; BBC News, 2009). Other animals include the monitor lizards, hyrax, sand vipers, and small populations of African wild dog (Borrell, 2009; Woodroffe *et al.*, 2012) and red-necked ostrich. Other animals exist in the Sahara (birds in particular) such as African Silver bill and black-faced fire finch, among others. Dromedary camels and goats are the domesticated animals most commonly found in the Sahara.

Two-thirds of the area of Sudan is arid or in semi-desert zone and desert ecosystem capers almost 35% of the country. The historical distribution of temporary presence of the movements of the Scimitar-horned Oryx includes all of Saharan and sub-Saharan North Africa between the Atlantic and the Nile. From the 1950's data Scimitar-horned Oryx is probably now extinct in Sudan (Wilson, 1980). The last precise data are of groups of up to 50 individuals in the Wadi Howar region and on the temporary gizu pastures north of the Wadi Howar in 1964 (Lamprey, 1975), and the capture of an individual at the westernmost part of the Sudanian Wadi Howar in 1973 (Lamprey, 1975). Newby (1982, 1988) estimates that extinction of Scimitar-horned Oryx took place in the 1970's. Dorcas gazelle occupies two allopatric habitats (i.e., west and east of the Nile). In Morocco, Oryx was documented in the regions south of the Oued Drâa (Loggers *et al.*, 1992) and perhaps in Oued Noun (Joleaud, 1918). The Scimitar-horned Oryx was reintroduced in Morocco within large enclosures (Reserved'Arrouais: about 1000 hectares) in Souss Massa National Park.

In Egypt's dry and sub-humid habitats cover over 90% of the territory, combining different ecosystems **(Table 3.8)**. The Egyptian desert was home to 6 species of antelopes until the mid-1940s: Mountain gazelle (*Gazella gazella*, Vulnerable), Dorcas Gazelle (*Gazelle dorcas*, Vulnerable), Scimitar Horned Oryx (*Oryx dammah*, Extinct in the Wild), Rhim Gazelle (*Gazella leptoceros*, Endangered), Addax (*Addax nasomaculatus*, Critically Endangered) and African Wild Ass (*Equus asinus*). As a result of hunting activities and drought, the Mountain Gazelle, Scimitar Horned Oryx,

Table 3 8 **Types and status of main ecosystems in North Africa. Source: Radford *et al*. (2011).**

Type of Ecosystem	Current state	Evolution of habitat (past 20 years)	Future trend	Nature of ecosystem services for the population	Impact on the population	Threats (various)
Forests and shrublands	Very clear, in continued deterioration	No reference state but the continuing deterioration in response to increasing pressure	Degradation of forests and shrublands, loss of biodiversity, depletion of species etc.	Firewood, construction and carpentry wood, harvesting of mushrooms, lichens, medicinal plants, paths etc.	Reduction of pastoral resources and the number of livestock, increased poverty, rural exodus etc.	Fuelwood harvesting, construction and woodworking, harvesting mushrooms, medicinal plants, grazing etc.
Steppes tree	Very marked deterioration	No reference state but the continuing deterioration in response to increased pressure	Tendency to purely steppe formations from degradation	Firewood, construction and carpentry wood, medicinal plants, paths etc.	Decline in resources for livestock, rural exodus, poverty	Pasture, expansion of agricultural land
Steppes of high mountains	Enough conserved	No great change	Increasing human pressure leading to resource degradation in forests and shrublands	Firewood, background, harvesting of medicinal plants.	No significant negative impact	Grazing, firewood, expansion of agricultural land
***Stipa tenacissima* steppes**	Enough conserved	No great change	Loss of biodiversity	Mainly grazing	No significant negative impact	Grazing, hunting
Meadows and lawns Pasture	Too grazed	Regressing	Regression in terms of area and biodiversity	Grazing	Reduction of pastoral resources	Grazing
Wetlands	Regressing in terms of area and biodiversity	Regressing	Regression in terms of area and biodiversity	Grazing, fishing, and drinking	Losses of some ecosystem services for local people	Draining, pollution, agriculture, overfishing in control, tourism
Grasslands	Regressing in terms of area and biodiversity	Dysfunction and regression	Ecosystems dysfunction, degraded habitats, loss of biodiversity, poverty, etc.	Grazing, harvesting of wood, agricultural land extension, urbanisation, climate change	Poverty, diseases, rural exodus, etc.	Grazing, poverty, diseases, rural exodus, expansion of agricultural land, plants harvesting, in control tourism etc.
Drylands and desert	Regressing in terms of area and biodiversity	Dysfunction and regression	Ecosystems dysfunction, degraded habitats, loss of biodiversity, etc.	Grazing, harvesting of wood, agricultural land	Poverty, diseases, rural exodus, etc.	Grazing, expansion of agricultural land, plants harvesting, tourism, poverty, diseases, rural exodus.
Mountains	Regressing in terms of area and biodiversity	Dysfunction and regression	Ecosystems dysfunction, degraded habitats, loss of biodiversity, etc.	Grazing, harvesting of wood, agricultural land extension, urbanisation, climate change	Poverty, diseases, rural exodus, etc.	Grazing, fuelwood, expansion of agricultural land, plants harvesting, tourism, poverty, diseases, rural exodus, erosion etc.

Addax and African Wild Ass have disappeared completely. Only the Dorcas Gazelle (*Gazelle dorcas*, Vulnerable) and Rhim Gazelle (*Gazelle leptoceros*) are still present today.

Trends: Northeast African cheetah is currently extinct in the wild in Egypt and Libya. In Egypt, the El Omayed deserts protectorate, includes 251 plant species (1 Endemic, 11 Threatened, 17 Endangered with Extinction) and 324 animal species including 39 bird species (4 Endemic, 1 Globally Endangered, 19 Rare); 10 mammals (1 Endemic, 2 Endangered with Extinction, 4 Rare); 33 reptiles (3 Endangered with Extinction, 12 Under environmental threats); and 242 insect species (2 Endangered with Extinction). In the Wadi Allaqi protected area, biodiversity is represented by 139 plant species (98 of them became extinct between 2000 and 2006 and 6 species are threatened due to over and random grazing). The Dorcas Gazelle (*Gazelle dorcas*) and Rhim Gazelle (*Gazelle leptoceros*, Vulnerable) are threatened with extinction.

3.4.1.1.5 Cultivated lands

Status and trends: A total of 5,780 crop plants and their Crop Wild Relative (CWR) taxa found in cultivated fields in North Africa have been recorded (Lala *et al.*, 2017). About 9% (502) CWR taxa is identified as a priority for conservation based on their (i) economic value, (ii) the degree of relatedness of wild relatives to their crop, (iii) threat status using IUCN red list assessment, and (iv) the centre of origin and / or diversity of the crop. Those assessed as threatened using IUCN Red list and national assessment represent approximately 2% (119 taxa) of the CWR in the region. However, 21 taxa are assessed as Critically Endangered, 53 as Endangered, and 45 as Vulnerable (**Figure 3.9**; Lala *et al.*, 2017).

The main characteristics of major farming systems in North Africa is the dominance of dryland mixed farming system which contains an agricultural population of 13 million people with 17 million hectares of cultivated land (FAO, 2001a). Other farming systems found in North Africa include irrigated, highland mixed farming and rain-fed mixed farming systems (FAO, 2001a). The prevalence of poverty within the mentioned farming systems ranges from moderate to high (FAO. 2007b).

Future dynamics: Human population in 2050 for Egypt in particular is estimated to be 142 million (Awad *et al.*, 2005). Rapid population growth could continue to be an important impediment to achieving improvements in food security in North Africa. Apart for growth in human population, future disease trends and climate change have substantial effects on North Africa livestock sector, either through impacting the distribution of disease vectors and water availability (Thornton, 2010). This has obvious implications for policymakers and the sheep and cattle industries and raises the need for improved diagnosis and early detection of livestock parasitic disease, along with greatly increased awareness and preparedness to deal with disease patterns that are manifestly changing.

3.4.1.2 Aquatic (Freshwater, Marine and Coastal)

3.4.1.2.1 Wetlands

Status and trends: North Africa is characterized by poor freshwater resources, but there is a good representation of aquatic and wetland habitats along the coast **(Figure 3.10)**. However, these ecosystems are threatened due to anthropogenic activities. For example, the Moroccan and Tunisian wetlands are highly impacted by farming and direct human use that has increased in the past two decades (Birks *et al.*, 2001). Lagoon Mariut in North Egypt is also currently polluted with sewage, industrial waste and agricultural runoff (Adb El-Hady, 2014). Mangroves in North Africa are marginal ecosystems, but remarkable because of the extreme natural conditions, very dry and hot. Only a few groves of mangroves forests are found in the south of Mauritania, in the Senegal Delta and in Sudan. The major species is *Avicennia germinans* (Least Concern) which has remarkable vitality according to its biogeographical limit (Dahdouh-Guebas *et al.*, 2001). Mangrove lagoons and channels are occupied by numerous fish species including many commercially important species (e.g., *Acanthopagrusberda, Chanoschanos, Crenidenscrenidens*, and some mugilid species). Sudan boasts a significant number of diverse and relatively pristine wetlands that support a wide range of plants and animals and provide extensive ecosystem services to the local populations. The principal wetlands are the Sudd, which is a source of livelihood for hundreds of pastoralists and fishermen, Dinder, the Machar marshes, Lake Abiad and coastal mangroves. In addition, there are large numbers of smaller and seasonal wetlands that host livestock in the dry season and are important for migrating birds. The rivers and wetlands in Sudan support significant amount of inland fishes which are exploited for sustenance as well as commercial purposes.

Figure 3 9 **Threat status of Crop Wild Relatives in North Africa. Source: Lala *et al.* (2017).**

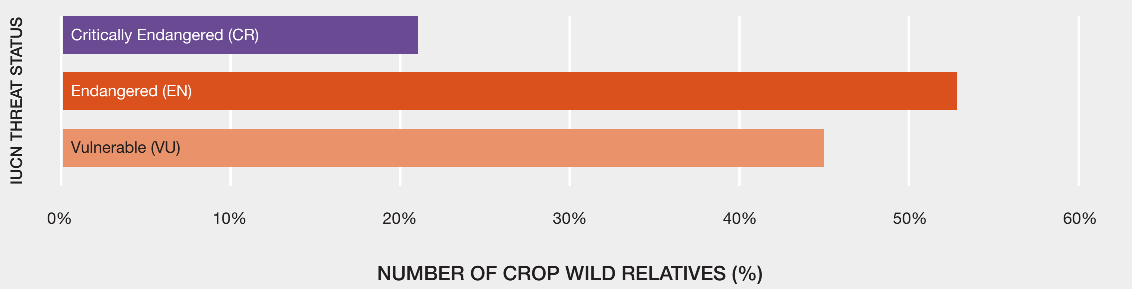
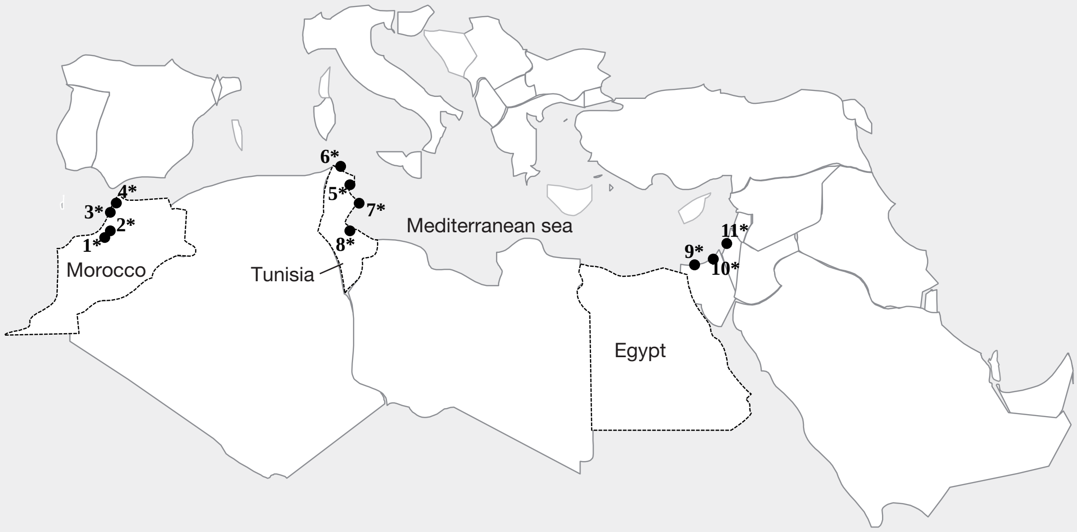


Figure 3 10 **The distribution of the wetland lake sites across North Africa selected for the CASSARINA Project.**

Nine (*) of these twelve initial sites were used for monitoring and palaeolimnological investigations: 1, Merja Sidi Bou Rhaba*; 2, Merja Bokka*; 3,Merja Zerga*; 4,Merja Khala; 5, Garaet El Ichkeul*; 6, Megene Chitane*; 7, Lac de Korba*; 8, Sebkha Kelbia; 9, Edku Lake*; 10, Burullus Lake*; 11, Manzala Lake*; 12, Qarun Lake. Source: Flower (2001).



3.4.1.2.2 Inland surface waters and water bodies/freshwater

Status and trends: Assessment of the status and distribution of northern African freshwater biodiversity to evaluate the quality of northern African basins was based on five freshwater taxa: fish, molluscs, dragonflies, crabs and aquatic plants representing a range of trophic levels within the food webs that support wetlands (García *et al.*, 2010). Among 877 species and subspecies of freshwater biodiversity that have been evaluated, 247 are categorised as Threatened with Extinction, out of which 61 are Critically Endangered, 72 are Endangered and 114 are Vulnerable (García *et al.*, 2010).

Habitat loss, degradation induced by human activities and pollution are the most important threats. In addition, natural disasters (inundation, earthquake etc.) are severely affecting freshwater species and have a direct impact on populations. These threats are expected to worsen in the future due to the impacts of climate. Therefore, these freshwater basins must be monitored for the assessment for their ecological status based on ecosystem criteria (Biotic indices) in order to avoid loss of this ecosystem and its services (Chapter 6).

Total natural renewable water resources in Sudan are estimated to be 149 km^3/year, of which 20% is produced internally from rainfall and 80% flows over the borders from upstream countries (UNEP, 2007). These water resources are subject to variations in environmental and climate change, with the share of rainfall erratic and prone to drought spells. Sudan also possesses significant groundwater resources (the deep Nubian sandstone aquifer and the Umm Rawaba systems). These freshwater ecosystems provide significant development benefits as it provides energy in the form of electricity and irrigation for agricultural practices. However there has been a decrease in inland waters due to harsh climatic conditions over the years.

Identification and protection of key biodiversity areas will help prevent decline in habitat quality and species. Sustainable agricultural practices, wastewater treatment, sustainable utilization of freshwater bodies, both in the short-term and long-term, is essential in the management of these ecosystems. There is a need to raise awareness on the usefulness of these water resources and how to manage them. Finally, further research should be undertaken to fill the lack of information on some data deficient species in the region (García *et al.*, 2010).

3.4.1.2.3 Shelf ecosystem

Status and trends: Self-ecosystems current and future status are stable in Sudan and in progress in Mauritania. In Mauritania, only a few groves of mangroves forests are found in the south of Mauritania, in the Senegal Delta, along the estuary of Ntiallakh. The major species is *Avicennia germinans* (Least Concern). Its vitality is remarkable according to its biogeographical limit (Dahdouh-Guebas *et al.*, 2001). Archaeological sites (kjokkenmodding) testify more extended mangroves in the past, and harvesting of cockles (*Anadara senilis*) and oysters (*Crassostrea gazar*), notably in Chat Tboul.

Mangroves have been largely destroyed by the Diama and Manantali dams, built along the Senegal River, but now they are recovering, thanks to their protected status (belonging to Diawling National parks) – a programme of restoration conducted by IUCN in the 1990s (Hamerlynck *et al.*, 2003) and more recently, thanks to the intrusion of salty water, due to the breach across the Barbarie Tongue opened in 2003 (Sy *et al.*, 2015). The Senegal River delta is home of over 3 million wintering shorebirds; at least 108 bird species of nesting piscivorous birds and is one of the 3 transfrontier Biosphere Reserves of Africa (Bouamrane *et al.*, 2016). In Sudan, mangroves are dominated by *Avicennia marina* (Least Concern), along the coast from Mohammed Qol north of Port Sudan to Shabarango-Gafud south of Suakin. Mangrove lagoons and channels are occupied by numerous fish species including many commercially important species (e.g., *Acanthopagrus berda* (Least Concern), *Chanos chanos* (Least Concern), *Crenidens crenidens* (Least Concern), *Hypoatherina temminckii, Leiognathus equulus* (Least Concern), *Terapon jarbua* (Least Concern), *Pomadasys commersonni* and some mugilid species). Most of the Sudan Mangroves are included in the national parks of Red Sea and could be stable (but no data available on the trends).

Future dynamics: Mangrove surfaces, still stable in Sudan or recovering in Mauritania, will expand thanks to saline intrusions, linked to the breach across the Barbarie Tongue in Mauritania (Sy *et al.*, 2015) and limited pressions.

3.4.1.2.4 Open Ocean

Status: North Africa is bordered by the Atlantic Ocean and the almost landlocked Mediterranean and Red seas that are connected by the Straits of Gibraltar and the Suez Canal. Morocco has a productive, nutrient-rich upwelling area off its Atlantic coast. The Mediterranean Sea is considered to be a low productivity ecosystem with intensive fishing its primary driving force (NOAA, 2003). It is relatively poor in marine resources except around the Nile Delta, where high nutrient outflows increase productivity (FAO, 2003). The reefs of the Red Sea provide some of the most productive coastal fisheries (UNEP, 2005a).

Trends and future dynamics: Reported marine fish production has increased overall during the period 1980–2003, totalling about 1.4 million tons in 2001 (FAO, 2005). Morocco (Atlantic and Mediterranean) is by far the largest producer. In 2001, its total marine fish production was 933,197 tons–a six-fold increase since 1961. In 2015, its production reached 1,355,393 tons (Arneri *et al.*, 2011). Among the pelagic fish, *Sardina pilchardus* (Least Concern) is the species most fished and Merluccidae for white fish (Arneri *et al.*, 2011). Egypt (Mediterranean and Red Sea) is the second largest producer (FAO, 2005). Generally in the Mediterranean, total fish landings have increased steadily, not only due to greater fishing pressure, but also to higher nutrient input into a formerly low-nutrient sea (Alm, 2002). In the Red Sea, where the total fish landings amount to about 22,800 tons/year with 44% of the landings are coral reef-based (PERSGA/GEF, 2003).

The recent marine biota in the Mediterranean Sea is primarily derived from the Atlantic Ocean, but the wide range of climate and hydrology have contributed to the co-occurrence and survival of both temperate and subtropical organisms (Sara, 1985; Bianchi *et al.*, 2000). Approximately 17,000 marine species occur in the Mediterranean Sea, with 20.2% endemic (Coll *et al.*, 2010). Artisanal fisheries are still important in the Mediterranean and Red seas, but industrial fishing including foreign fleets is becoming prevalent (UNEP, 2005a). The Mediterranean Sea has a set of emblematic species of conservation concern, such as sea turtles, several cetaceans, and the Critically Endangered Mediterranean monk seal (*Monachus monachus*). It is the main spawning grounds of the eastern Atlantic bluefin tuna (*Thunnus thynnus*, Endangered). There are several unique and endangered habitats, including the seagrass meadows of the endemic *Posidonia oceanica* (Least Concern), vermetid reefs built by the endemic gastropod *Dendropoma petraeum* (Gabrié *et al.*, 2012). The invasion of alien species is a crucial factor that will continue to change the biodiversity of the Mediterranean, mainly in its eastern basin that can spread rapidly northwards and westwards due to the warming of the Mediterranean Sea. Most of the fish species, such as Tuna are ranking from fully exploited to overexploited, and are at a risk of falling into the category of depleted (FAO, 2016).

3.4.1.2.5 Deep sea

Status: The Mediterranean basin has been proposed as a hotspot of terrestrial and coastal marine biodiversity but has been supposed to be impoverished of deep-sea species richness. Benthic biodiversity (Prokaryotes, Foraminifera, Meiofauna, Macrofauna, and Megafauna) in different deep-sea ecosystems of the Mediterranean Sea (200 to more than 4,000 metres depth), including open slopes, deep basins, canyons, cold seeps, seamounts, deep-water corals and deep-hypersaline anoxic basins are evaluated and analysed overall longitudinal and bathymetric patterns (Danovaro *et al.*, 2010). The overall deep-sea Mediterranean biodiversity (excluding prokaryotes) reaches approximately 2,805 species of which about 66% is still undiscovered. Among the biotic components investigated (prokaryotes excluded), most of the unknown species are within the phylum Nematoda, followed by Foraminifera, but an important fraction of macrofaunal and megafaunal species also remains unknown (Danovaro *et al.*, 2010).

Trends and future dynamics: In contrast to what was expected from the sharp decrease in organic carbon fluxes and reduced faunal abundance, the deep-sea biodiversity of both the eastern and the western basins of the Mediterranean Sea is similarly high (Danovaro *et al.*, 2010). All of the biodiversity components, except Bacteria and Archaea, displayed a decreasing pattern with increasing water depth, but to a different extent for each component. Unlike patterns observed for faunal abundance, highest negative values of the slopes of the biodiversity patterns were observed for Meiofauna, followed by Macrofauna and Megafauna.

3.4.2 Central Africa

3.4.2.1 Terrestrial

3.4.2.1.1 Tropical and subtropical dry and humid forest

Status: The rainforests in Central Africa (178,564 million hectares) account for up to 89% of Africa's tropical rainforests (Mayaux *et al.*, 2013), constituting approximately 20% of the total global tropical rainforest area (FAO-ITTO, 2011). This is largely concentrated in the Congo Basin, which is the second largest rainforest in the world after the Amazon (FAO, 2011; Mayaux *et al.*, 2013). Much of Congo Basin rainforest falls within the Democratic Republic of Congo (DRC), accounting for some 53.6% of Africa's rainforests. There are, however, also significant areas of forest in Gabon, the Republic of Congo, Cameroon, the Central African Republic and Equatorial Guinea (Mayaux *et al.*, 2013). Currently, approximately 22.96 million hectares of Central Africa's forests have been designated as protected areas, and six of these are classified as United Nations World Heritage Sites (UNESCO, 2010). Cameroon, for example, has 18 national parks, some of which provide key protection in forest areas for flora and fauna species (a number of which are threatened–see below) (Mallon *et al.*, 2015). The Congo Basin rainforest is home to 493 species of mammals, 1,100 species of birds (including 5 families endemic to Africa), and 288 species of amphibians (Mayaux *et al.*, 2013; European Commission, 2015). The lowland forests in Central Africa contain around 10,000 plant species, 30% of which are found nowhere else in the world, while the Afromontane forests contain approximately 4,000 species (70% are endemic) (European Commission, 2015). Central Africa's rainforests store an estimated 39.2 GT of carbon in their vegetation and tree trunks, corresponding to 78.5% of the total aboveground carbon storage in Africa (Mayaux *et al.*, 2013). Approximately 30 million people, belonging to over 150 different ethnic groups, live in the Central African rainforests (UNESCO, 2010).

Trends: The extent of Central African rainforests has been decreasing, with an annual deforestation rate of 0.11%, accounting for 50-60% of the total deforested area in Africa from 2000–2010 (Mayaux *et al.*, 2013) (as well as previous deforestation rates of 0.16% for the 1990–2000 period, which may show some improvement at a regional scale). The area showing the most rapid change has been northern Congo, where a substantial increase in the rate of road construction has been observed; as well as major pressures around mining and primary industries (Mayaux *et al.*, 2013; Mallon *et al*., 2015). The biodiversity in Central Africa associated with forest areas is also declining. Specifically, 11.4% of mammal species, 1.4% of bird species and 15.3% of amphibian species are threatened with extinction (Mayaux *et al.*, 2013). Central Africa currently has the most striking rates of decline/loss of large vertebrates (defaunation) in tropical rainforests (Malhi *et al.*, 2013). For instance, 62% of Central Africa's forest elephants (*Loxodonta cyclotis*, Vulnerable) are being lost from 2002 to 2011 (Maisels *et al.*, 2013), ape populations declined by 50% in Gabon over 1984–2000 (Walsh *et al.*, 2003), and about 178 species are affected by bushmeat hunting (Abernethy *et al.*, 2013). Up to 4.5 million tons of bushmeat are estimated to be extracted annually from the Central African forests, with an estimated annual value of up to $205 million (European Commission, 2015).

Future dynamics: Given the current known state and the trend in the past decades, the biodiversity of the tropical region of Central Africa may decline at an alarming rate in the near future, particularly given emerging changes in drivers (Chapters 4 & 5; SPM section B). Such a decline is likely to have critical repercussions for both ecological and human communities. For example, recent studies have already shown that the loss of large mammals, due to hunting, results in the decrease of seedling establishment for commercially important tree species in the Afrotropical forest of Gabon (Rosin *et al.*, 2016).

3.4.2.1.2 High mountain habitats

Status: The Albertine Rift Mountains ecoregion is an area of exceptional faunal and moderate floral endemism. These mountains also support the Mountain gorilla (*Gorilla beringei*, Critically Endangered), one of the most critically threatened large mammals in Africa (Mayaux *et al.*, 2013; Mallon *et al.*, 2015). The mountain chain comprising the Albertine Rift straddles the borders of five different nations, providing significant challenges for effectively transboundary management of high mountain forest found here (Mallon *et al.*, 2015). The Albertine Rift forms the epicentre of Africa's montane rainforest circle. Both its fauna and flora have links to the west and southwest with Cameroon and Angola, to the northeast with the Kenyan Highlands, and the southeast with the Eastern Arc Mountains, and ultimately via the Malawi Rift with southern Africa (Dowsett, 1986, Kingdon, 1989). The Albertine Rift is dominated by a series of mountain chains, originating on the Lendu Plateau in northern Uganda/DRC (Bober *et al.*, 2001), and running south through the Ruwenzori mountains of Uganda and the eastern part of the Democratic Republic of Congo (03°N, 30°E), western Rwanda and Burundi, to some isolated massifs on the shores of Lake Tanganyika (to 08°S). The mountain chain is a World Wide Fund Ecoregion, and is considered by Birdlife International to be an endemic bird area (Plumptre *et al.*, 2006). It is dominated by montane rainforest and medium altitudes (White, 1983), but in the west, marginal fringes of the Guineo-Congolian rainforest impinge on the lower slopes (down from 500–800 metres), and forest/savanna mosaic habitats border it to the east in Uganda, Rwanda and Burundi. At altitudes above 3,500 metres, montane rainforest grades through Juniper forest and Ericaceous Heathland into the tussock grass and Giant Lobelia dominated altimontane vegetation of the Ruwenzori-Virunga Montane Moorland ecoregion. Some details of the vegetation composition in the Albertine Rift Mountains are found in Lind *et al.* (1974), Langdale-Brown *et al.* (1964) and White (1983); as well as in Plumptre *et al.* (2006).

The ecoregion is the most species-rich region in Africa for vertebrates, and contains a number of endemic and threatened species (Plumptre *et al.*, 2006). For example, Bwindi Forest in Uganda supports an estimated 1,000 plant species; eight of these are tree species only found locally (WWF *et al*., 1994). Endemism is found at all altitudes, and extends markedly into the lower altitude forests on the western margins, which form a border with the Congo Basin lowland forests (Prigogine, 1985; Vande weghe, 1988a & b). The amphibians with 32 strict endemics spread across 12 genera, and a further seven near endemics, have the highest number of range-restricted species. The bulk of these endemics consist of the highly variable Reed Frogs (*Hyperolius*, 9 strict endemics), the Screeching frogs (*Phrynobatrachus*, 7 strict endemics) and the River Frogs (*Anthroleptis*, 5 strict endemics) and Clawed Toads (*Xenopus*, 3 strict endemics). Birds also possess exceptional levels of endemism in this area, with 30 strict endemics and another 16 near endemics (Bober *et al.*, 2001 and references therein). The endemic mammalian community contains 25 strictly endemic species and a further 11 species regarded as near-endemics (WWF *et al*., 1994). The endemic mammal fauna is dominated by small-mammals, with 10 of the species being shrews, and 12 species being rodents. One of only two species of the family Tenrecidae on mainland Africa is also strictly endemic to these mountains, the Ruwenzori otter shrew (*Micropotamogale ruwenzorii*, Least Concern). The primate fauna further includes the owl-faced monkey (*Cercopithecus hamlyni*, Vulnerable) which has an endangered subspecies (*C. h. kahuziensis*) in the ecoregion, and L'Hoest's monkey (*Cercopithecus lhoesti*, Vulnerable).

Some of the easternmost populations of chimpanzee (*Pan troglodytes*, Endangered) also occur in this ecoregion (Harcourt *et al.*, 1983; Aveling *et al.*, 1984; Aveling *et al.*, 1989; McNeilage, 1996; Hall *et al.*, 1998a & b). The Albertine Rift endemic duiker *Cephalophus rubidus* may also venture into the upper parts of this ecoregion from the higher altitude heathland areas that are its more typical home. In comparison to the other vertebrate groups, the number of endemic reptiles is relatively low, with 11 strict endemics. These include four species of chameleons (*Chamaeleo* spp.) and four species of skinks in the genus *Leptosiaphos*. However, given the very high rates of endemism in other vertebrate groups, the number of endemics may more reflect the relatively low rates of biological collecting, rather than the true numbers of reptile endemics.

Trends: Key threats in this area are largely anthropogenic, including war, civil conflict, growth of extractive industries (including conversion to agriculture and artisanal mining), and hunting (Plumptre *et al.*, 2006). A number of large mammals in this area have been hunted to low populations or to extinction (Plumptre *et al.*, 2006). Conversion to crop-land has been evident in parts of the area in recent decades. Interestingly, Mayaux *et al.* (2013) observed that Central Africa's forests remain largely intact (Mallon *et al.*, 2015). However, in parts of the high mountain forest region where rural populations are increasing, we see an expansion of agricultural activities and increases in deforestation (Mallon *et al.*, 2015). Bushmeat hunting has had further significant impacts in this area (Mallon *et al.*, 2015); exacerbated by increases, in certain areas, of extractive activities (largely mining and timber) (Chapters 4 & 5; SPM sections B & D). Significant challenges in this area, including a key site such as the Virunga Landscape (one of the most species-rich regions on earth; Plumptre *et al.*, 2006), include taking a landscape approach, and managing connected protected and non-protected areas (Plumptre *et al.*, 2006; Mallon *et al.*, 2015). Where Rwanda, Uganda and the DRC meet, for example, provides a key example of the challenges in taking such an approach–three different countries with valuable areas of high mountain forest, yet different trends in driving forces of change, in hunting and extractive industries, and different approaches to environmental governance.

Future dynamics: There is largescale agreement amongst climate models for increases in minimum, maximum and average temperature across all seasons under climate change (Niang *et al.*, 2014; Conway *et al.*, 2015; SPM section B). In addition, primary industry activities are likely to increase in many areas (see, for example, the example of Virunga National Park above); without increased intervention and management. The coupled impact of increased temperatures on High Mountain Forest, with altitudinal shifting of habitat, together with increased extractive activities in certain areas, increases the likelihood that existing species loss in these areas may worsen (Niang *et al*., 2014; SPM sections B & D).

3.4.2.1.3 Savannah and grassland

Status: The savannah region in Central Africa extends from the Congo watershed to the Cameroon highlands; and extends east through the Central African Republic and north-eastern Democratic Republic of Congo (WWF, 2017b). The woodland savanna is dominated by *Acacia albida*, *A. senegal*, and *A. nilotica*. Other species include: *Balanites aegyptiaca, Ziziphus spp., Crateva adansonii, Celtis integrifolia, Ficus spp.,* and *Khaya senegalensis* (Culverwell, 1998). Key savannah and grassland mammals present in these areas include African elephant (Savanna elephant) (Mallon *et al.*, 2015; Figure 2.2), the Striped Hyaena, and the Lion (*Panthera leo*).

Trends: This terrestrial unit of analysis is currently decreasing due to increasing human population, political instability and civil wars, habitat conversion, overhunting and commercial logging (WWF, 2017b). A number of species within savannah and grassland areas is Central Africa show decline, including the Striped Hyaena (Mallon *et al.*, 2015) and the Lion (*Panthera leo*). Henschel *et al.* (2014) indicate that Lions are likely to now be extinct in the Congo Basin's rainforest –savannah mosaics. The African Wild Dog (*Lycaon pictus*) is now also considered to be extinct in the same area (Henschel *et al.*, 2014). Savanna elephants have been further significantly impacted, as in other areas, through increases in poaching and shrinking and shifting habitat (Mallon *et al.*, 2015).

Future dynamics: The future trend of biodiversity in this ecosystem unit of analysis will depend, for example, on the future dynamics of population growth, political stability and habitat conversion (WWF, 2017b). Political instability in the region remains a significant problem, as evidenced by the crisis in the Central African Republic. Habitat loss is also increasing within the region (WWF, 2017b), hence it is expected that the savannas and grasslands within the region will continue to decline in extent with associated biodiversity loss. Extractive industries in this area (largely mining) is likely to continue to impact habitat loss and associated effects on ecosystem services, complicated by climate change (Niang *et al.*, 2014; Chapter 4; SPM sections B &D).

3.4.2.1.4 Dryland and desert

Status: In Central Africa, drylands and deserts are represented by the Sahelian transitional zone which covers an area of 20,000 km^2, in which the major portion is located in Chad–thus not within Central Africa (WWF, 2017b). The region supports endemic flora and fauna and provides important habitat for larger antelopes such as Addax (*Addax nasomaculatus*, Critically Endangered), Dama gazelle (*Gazella dama*, Critically Endangered), Dorcas gazelle (*Gazella Dorcas*, Vulnerable) and red-fronted gazelle (*Gazella rufifrons*, Vulnerable) (WWF, 2017b).

Trends and future dynamics: Most large animal species are declining due to competition with livestock (WWF, 2017b). In the part of the Sahelian transitional zone that falls within what we consider as Central Africa in IPBES, we see similar challenges around habitat fragmentation, cultivation and extractive industries as described above (Mallon *et al.*, 2015). For example, the Striped Hyaena, as mentioned previously, is distributed sparsely and declining (Mallon *et al.*, 2015), while the Common Leopard (*Panthera pardus*, Vulnerable) has undergone a marked range reduction throughout the Sahelian transitional zone (Mallon *et al.*, 2015). With increases in extractive industry activity, complicated by climate change, we would expect such trends to continue in absence of increasingly effective landscape scale and transboundary approaches (Niang *et al.*, 2014; Chapters 4 & 5; SPM sections B & D).

3.4.2.1.5 Urban/Semi-urban

Status and trends: In the Central African region, the number of cities sized at 1.5 million has increased between 1970, 1990 and 2014 by 10 million inhabitants (Seto *et al.*, 2012). In 2014, Kinshasa was established as a megacity; and currently stands as the only megacity in this region at present (Seto *et al.*, 2012). In 2013, Kinshasa's urban extent stood at 45,681 hectares, with an annual average increase rate of 3.5% since 2000. Density in Kinshasa has increased at 3.7% as an annual average since 2000; and is expected to continue (Seto *et al.*, 2012).

Future dynamics: Future projections for Central Africa show a likely increase in the number of cities sized at 1.5 million (Chapter 4, section 4.4.4.1; Chapter 5; SPM sections B & D). Seto *et al.* (2012) indicate the northern shores of Lake Victoria in Kenya and Uganda) as one of five regions in Africa where rates of increases in urban land cover are predicted to be the highest on the continent–at 590% relative to 2000 levels (Seto *et al*., 2012). Such projected increases are likely to have significant implications for biodiversity in the Great Lakes region, with both terrestrial and aquatic impacts (particularly concerning in an area with such rich and diverse fish fauna, and one so central to food and livelihoods security).

3.4.2.1.6 Cultivated lands

Status and trends: As in other subregions of the continent, agrobiodiversity in the Central African region is of great significance, as it is the largest contributor to food production. Central Africa is home to a variety of crops, such as cereals, oilseeds, roots and tubers, pulses, fruit and vegetables and other cash crops; with oil seeds constituting the biggest fraction of crop production in the subregion (OECD-FAO, 2016). Poultry in Central Africa contributes extensively to the sub-Saharan livestock production value, with up to 45% contribution to the total value (OECD-FAO, 2016). In the subregion, agroforestry systems are equally important, as they may be an effective means to ensure rural livelihoods while maintaining forest cover and biodiversity (Asaa *et al.*, 2011). A number of species in the subregion form part of agroforestry systems. Fruit trees include African bush mango (*Irvingia gabonensis*), Safou/butterfruit (*Dacryodes edulis*, Lower Risk/Near threatened), Kola nut, Bitter kola (*Garcina kola*), and Njangsa (*Ricinodendron heudelotti*) (Asaah *et al.*, 2011).

Future dynamics: The overall extension of crop production area is projected to slow in the sub-Saharan Africa region, due to the increasing costs of converting arable land to production land (OECD-FAO, 2016). Additional crop area is mostly allocated to staple crops such as coarse grains. However, cultivated land in Central Africa is projected to expand, with the greatest increase being attributed to rice, roots and tubers crop production areas (OECD-FAO, 2016).

3.4.2.2 Aquatic (Freshwater, Marine and Coastal)

3.4.2.2.1 Wetlands

Status and trends: The wetlands in the Central Congo Basin, the Cuvette Centrale depression, forms one of the most extensive regions of swamp forest, extending at approximately 145,500 km^2 (Dargie *et al.*, 2017). The Cuvette Centrale depression stores approximately 30.6 pentagrams of carbon below ground, similar to the above-ground carbon stocks of the tropical forests of the entire Congo Basin (Dargie *et al.*, 2017). Collectively, Central African countries host approximately 4,214 km^2 of mangroves, with only a few being protected. Fish, wood, charcoal for domestic cooking and fish smoking and poles for housing are key uses of mangroves, among others. The delta of the Ogooué River in Gabon is Africa's second largest delta after the Niger, covering over 5,000 km^2 of flooded forests, swamps, lagoons, lakes and mangroves. The delta of the Ogooué River in Gabon is among the world's most important site for nesting marine turtles, particularly leatherbacks (Mayaux *et al.*, 2013). Despite the economic and ecological importance of wetlands, however, there are many uncertainties as to their extent, distribution, ecological and physical functions (Junk *et al.*, 2005). Political instability in most of the humid tropical countries during the last five decades, poor infrastructure, and as well as difficult access may account in part for the scientific inattention (Campbell, 2005).

Future dynamics: Climate change is projected to impact mangrove and wetland ecosystems significantly, with changes in temperatures, as well as coastal sea level rise and saline intrusion dynamics (Niang *et al.*, 2014; Chapter 4, section 4.2.2.2; SPM sections B & D). For example, Niang *et al.* (2014) show robust evidence for projected dieback of the seaward edges of mangroves in the Cameroon, with sea level rise as the potential driver. As always, climate change occurs in tandem with changes in other stressors, including human settlement dynamics, and increases in extractive industries (Mallon *et al.*, 2015; Chapter 4).

3.4.2.2.2 Inland surface waters and water bodies/freshwater

Status and trends: The major waterways in Central Africa range from the Niger-Benue, Chad and Upper Nile drainage systems, to the mouth of the Congo and other rivers from Equatorial Guinea and DRC (Darwall *et al.*, 2009). The Congo Basin and its territories carry about 30% of Africa's surface flow due to high rainfall and less evaporation (Thieme *et al.*, 2010). Some of the well-known rivers of Central Africa are the Goose, Sanaga, Mungo and Wuori rivers (Staissny *et al.*, 2007). Besides the extensive networks or rivers. Central Africa has several lake systems e.g., Lake Nyos, Lake Tele, Lakes Tsumba and Mai Ndombé in DRC.

Inland waters in Central Africa support the highest freshwater biodiversity on the continent, with approximately 1,000 fish species, 400 aquatic mammalian species, 1,000 waterbirds and over 10,000 aquatic vascular plants (CARPE, 2001; AfDB, 2006). There are at least 73 Important Bird Areas in Central Africa region (CARPE, 2001). The geographic extent, dense hydrographic network, and diversity of river types and available habitats, are among the several existing several factors that contribute to the high richness of freshwater species in the Lower Guinea, and more noticeably, Congo provinces. A significant proportion of freshwater biodiversity is threatened due to loss of riparian habitats through deforestation, and the reduction of water quality through pollution (e.g., from mining activities, human settlement, and runoff of agricultural fertilisers), as well as increased sediment loads (caused by erosion of deforested and farmed land) (Brummett *et al.*, 2009).

Future dynamics: Projected increases in human settlement (see section on urbanisation above) and extractive industries (Chapters 4 & 5; SPM sections B & D) are likely to continue the trend of negative impacts on freshwater biodiversity. A particularly critical area in this regard, given projections of urbanisation and settlement growth, are the north shores of Lake Victoria (see section on projections of urbanisation). Complicating such future changes are the likely impacts of climate change on freshwater biodiversity in this region. Niang *et al.* (2014) cite significant projected impacts of climate change on freshwater ecosystems, with existing impacts already evident and likely to increase in severity in Lake Victoria and Lake Kivu (Niang *et al.*, 2014; Chapter 3, section 3.5.2.4), largely driven by increased water temperatures (a robust finding, since agreement amongst models regarding increased average, minimum and maximum temperatures is high – see, for example, Conway *et al.*, (2015) for Tanzania). Changes in thermal stratification in these lakes is also likely to continue under increased temperatures, with significant impacts on freshwater ecosystems, and likely impacts on fisheries in these lakes (complicated by continuing drivers of overfishing in certain areas, invasive species and pollution) (Niang *et al.*, 2014).

3.4.2.2.3 Shelf ecosystem

Status and trends: Collectively, these countries host approximately 4,214 km^2 of mangroves, with a few only being protected. The most important remaining blocks of habitat are found in the Niger River Delta in Nigeria, to the east of the mouth of the Cross River in Nigeria and Cameroon, around Doula in Cameroon, and the Muni Estuary and Como River in Gabon. Smaller fragments of shelf ecosystems are also found in Ghana, Conkouati lagoons of Congo, and in Angola. Five species of mangroves in three families are found in this region, including *Rhizophora racemose* (Least Concern)*, R. mangle, and R. harrisonii, Avicennia germinans* and *Laguncularia racemosa* (Least Concern), as well as an introduced species, *Nypa fruticans* (Least Concern) **(Table 3.9)**.

A unique feature of shelf ecosystems in Gabon is the fact that elephants, gorillas, chimpanzees, hippo, forest buffalo and Nile crocodile can often be observed on the beaches. These beaches are also among the world's most important for nesting marine turtles, particularly leatherbacks (Mayaux *et al.*, 2013). Urbanisation and pollution (contaminants) are the main threats.

Future dynamics: At the current rate, the aquatic units of analysis remain under threat of further decline because of increasing urbanisation, pollution and exploitation. Nevertheless, positive signals are noted with the development of integrated conservation project, such as Emerald Arc project that aims to integrate coastal ecosystems and protected areas in the sustainable development of the city of Libreville.

3.4.2.2.4 Open Ocean

Studies on marine species and their ecology in central Africa have been completely neglected. Whenever this information has been obtained, it has been limited to economically useful species (Gabche, 2003; Ogandagas,

Table 3 9 **African biogeographical regions: Atlantic mangrove (or western group (and Pacific or Eastern group). Source: Saenger *et al.* (1995); Cormier-Salem (1999); Ndour *et al.* (2001); Giri *et al.* (2008); Spalding *et al.* (2010); Hoppe-Speer *et al.* (2015).**

	Western group		Eastern group	
Coastal areas	**Tropical Atlantic** East of Atlantic Ocean: • West Africa; • Central Africa • Northern Africa (Mauritania)		**Pacific** West of Pacific Ocean/ Indian Ocean: • Eastern Africa and islands; • Southern Africa • Northern Africa (Sudan)	
Family	**Genus**	**Species**	**Genus**	**Species**
Avicenniaceae	***Avicennia***	*A. africana* *A. germinans* *A. nitida*	***Avicennia***	*A. alba* *A. marina* *A. officinalis*
Bombacaceae			***Lumnitzera***	*L. racemosa*
Combretaceae	***Laguncularia***	*L. racemosa*		
	Conocarpus*	*C. erectus*		
Lythrceae			***Pemphis***	*P. acidula*
Meliaceae			***Xylocarpus***	*X. obovatus* *X. granatum* *X. moluccensis*
Rhizophoraceae			***Bruguiera***	*B. gymnorrhiza*
			Ceriops	*C. tagal* *C. somalensis*
			Kandelia	*K. candel*
	Rhizophora	*R. harrisonii* *R. mangle* *R. racemosa*	***Rhizophora***	*R. apiculata* *R. mucronata* *R. stylosa*
Sonneratiaceae			***Sonneratia***	*S. alba*
Sterculiaceae			***Heritieria***	*H. littoralis*
	Total	**8**		**17**

2003). Marine resources include commercially valuable fish that are exploited at artisanal and industrial scales. The exploitable species of aquatic fauna within the marine and coastal ecosystems consist essentially of fishes, shrimps and molluscs. Currently the Carangidae, Carcharinidae, Clupeidae, Elopidae, Ephippidae, Haemulidae, Lutjanidae, Paralichthyidae, Polynemidae, Mugilidae, Sciaenidae families are overexploited (Ogandagas, 2003). An accelerated growth of coastal populations has led to crowded conditions where the poor depend on subsistence activities such as fishing, farming, sand and salt mining and production of charcoal (Sherman *et al*., 2008).

3.4.2.2.5 Deep-sea

The deep-sea biological communities in Central Africa are relatively unexplored with available records mainly from geological surveys for prospecting and drilling of hydrocarbons and from historical oceanographic cruises undertaking global navigations. In general, the structure, density and vertical distribution patterns of communities depend on the topographic features of the seabed and source of nutrients. The Congo deep-sea fan, for example, an area of 2,500 km^2 at 47,000 metres depth and 750–800 km offshore, has a unique habitat influenced by high inputs of organic carbon originating from the Congo River by turbidity currents, with high density assemblages of two large sized symbiotic Vesicomyidae bivalve species and microbial mats (Rabouille *et al.*, 2016). Although there are no true corals along the continental margin, there have been new observations of deep-water coral reefs *Lopheliapertusa* along the Angola margin that are generally associated with cold seep environments (Le Guillox *et al.*, 2009).

3.4.3 East Africa and adjacent islands

3.4.3.1 Terrestrial

3.4.3.1.1 Tropical and subtropical dry and humid forest

Status: The tropical and subtropical humid forests of East Africa and adjacent islands comprise lowland and montane forest habitats, which are found in fragmented patches due to human disturbance (lowland forests) or to natural isolation (mountain forests). The East African forests form a small proportion of the forests in Africa–for example representing only 4% of the African rainforests (Mayaux *et al.*, 2013). However the lowland and mountain forests of East Africa and adjacent islands are rich in biodiversity. The Malagasy eastern rainforests, for example, contain 159 species of mammals, 217 species of birds and 219 species of amphibians (Mayaux *et al.*, 2013) and hold 5% of the world's plant species (Brown *et al.*, 2004), 82% of which are endemic to Madagascar (Callamander *et al.*, 2011). High rates of species endemism are also found in the East African mountain forests in Tanzania and Kenya (Eastern Arc mountains) and Uganda, Rwanda, Burundi and DRC (Albertine Rift Mountains).

Most of the tropical dry forests in East Africa and adjacent islands are located in northern and western Madagascar (Crowley, 2004). They are found within a region that covers 31,970 km^2 of land (Madagascar, 2014), but most of the remaining forest is fragmented with patches up to 35 km^2 (WWF, 2017a). The dry forests of western Madagascar are some of the world's richest and most distinctive, with high local plant and animal endemism, which includes 101 mammal species, 154 reptile species, 73 bird species, 34 amphibian species and 198 plant species (IUCN, 2017). This region also contains important habitat for 131 of the 186 resident terrestrial bird species in Madagascar (Langrand, 1990). It is also the primary habitat for the island's largest predator, the fossa (*Cryptoprocta ferox*, Vulnerable), the endemic and Critically Endangered Madagascar side neck turtle (*Erymnochelys madagascariensis*), and one of the most Critically Endangered reptiles in the world, the ploughshare tortoise (*Astrochelys yniphora*).

Trends and future dynamics: Similar to other tropical regions, the extent of the lowland and mountain rainforests and dry forests in East Africa has been decreasing. For example, Malagasy eastern rainforests decreased by 1.69% annually from 1990–2000 and 1.08% from 2000–2010 (Mayaux *et al.*, 2013), and an estimated 97% of Malagasy dry western forests have been destroyed since human settlement (WWF, 2017c), with an annual deforestation rate of 0.75% from 1990–2000 (Gorenflo *et al.*, 2011).

In the eastern African coastal forests loss is primarily through conversion to farmland, mainly through shifting cultivations. Overall, coastal forest cover in Tanzania declined by over a third from 420,765 hectares in 1990 to 358,333 hectares in 2000 and to 273,709 hectares in 2007. The rate of deforestation has been lower within Tanzanian reserves: 0.2 and 0.4%/year during 1990–2000 and 2000–2007, respectively, compared to 1.3 and 0.6%/year outside reserves during the same periods (Godoy *et al., 2012; Burgess et al., 2017*). In the same forests, estimates by Burgess *et al.* (2010) of the total carbon emissions per annum from the Coastal forest areas of Tanzania were 631,933 tons of CO_2/year, for the period 1990–2000 and had declined to 198,154 tons of CO_2/year by the period 2000–2007. Elsewhere, monitoring data collected over a three year period from 2005–2008 in 67 permanent transects in Arabuko-Sokoke forest by Virani *et al.* (2010) showed a steady but not statistically significant decline in Sokoke Scops-Owl densities.

3.4.3.1.2 High mountain habitats

Status: East Africa and adjacent islands are home to the three highest mountains on the continent: Kilimanjaro (5,895 metres), Mount Kenya (5,119 metres) and the Rwenzori Mountains (5,109 metres) (Alweny *et al.*, 2014; UNEP, 2014). There are also extensive highland regions in Ethiopia. These mountains are the source of many of the major rivers in the region, such as the Nile, and are rich in biodiversity.

The mountain areas of the Eastern African region (and also into Arabia) have been grouped together in the 'Eastern Afromontane' hotspot by Conservation International (Mittermeier *et al.*, 2004). The flora of the Eastern Afromontane shows great continuity across the montane massifs, with its composition changing with increasing altitude. At the highest elevations, such as the Rwenzori Mountains, the Aberdares, Mt. Elgon, Mt. Kilimanjaro, Mt. Kenya, and the Bale and Simien Mountains in Ethiopia, Afro-alpine vegetation typically occurs above 3,400 metres. Afro-alpine vegetation is characterized by the presence of giant senecios (*Dendrosenecio* spp.), giant lobelias (*Lobelia* spp.), and *Helichrysum* scrub (McGinley, 2009). There are also about 13 endemic species of African primroses (*Streptocarpus* spp.) in the Eastern Arc Mountains, and 18 endemic species of *Impatiens* in the Albertine Rift (McGinley, 2009). The Eastern Afromontane hotspot is also home to nearly 500 mammal species, more than 100 of which are endemic to the region. Although several of Africa's larger flagship mammals, including the African bush elephant (*Loxodonta africana*, Vulnerable) and leopard (*Panthera pardus,* Vulnerable), are found in this hotspot, the majority of threatened species are primates and smaller mammals. The total birds number exceeds the 1,300 species initially reported by Mittermeier *et al.* (2004), and includes 157 endemics (Lincoln Fishpool, personal communication), 102 of which are restricted range species found within the eight endemic Bird Areas recognised by BirdLife International. New species continue to be discovered, particularly from the Eastern Arc Mountains of Tanzania (Bowie *et al.*, 2004, 2009). Nearly 350 reptile species are found in the Eastern Afromontane hotspot. More than 90 species are endemic, most of which are chameleons. The Eastern Afromontane hotspot is also home to more than 323 amphibian species, more than 100 of which are endemic.

There are three main areas of biological rich highland forest and moorland habitats in the region: The Ethiopian Highlands, the Albertine Rift and the Eastern Arc Mountains. These are presented in turn below.

The Ethiopian Highlands cover an area of 490,000 km^2 (Subhatu *et al.*, 2017) straddling Ethiopia and Eritrea, harbour an estimated 5,200 plant species, of which at least 200 are endemic. The genus *Senecio* is particularly diverse, with a dozen species found nowhere else. This area also has a monotypic endemic genus, *Nephrophyllum abyssinicum,* which is found on heavily grazed pastures, open ground, and rocky areas on steep slopes between 1,650 and 2,700 metres. Many species common in montane forest, such as trees of the genera *Podocarpus* and *Juniperus* have economic importance, while several crops including coffee (*Coffea arabica*, Least Concern) and tef (*Eragrostis tef*) from the Ethiopian Highlands have been domesticated (McGinley, 2009). A zone of bamboo is often found between 2,000 and 3,000 metres, above which there is often a *Hagenia* forest zone up to 3,600 metres.

More than 30 of the nearly 200 mammals found in the Ethiopian Highlands are found nowhere else, including a remarkable six endemic genera, four of which are monotypic: three rodents (*Megadendromus*, *Muriculus* (Least Concern) and *Nilopegamys* (Critically Endangered) and one primate, the gelada (*Theropithecus gelada*, Least Concern). The gelada is peculiar in that it is the only remaining primate to feed exclusively on plants–mostly grasses (Gippoliti *et al.*, 2008). The Ethiopian wolf (*Canis simensis*, Endangered) is an endemic species found in the Afro-alpine ecosystem of the Ethiopian Highlands; with around 440 individuals in seven small and isolated populations, this wolf is the rarest canid in the world; with around 440 individuals in seven small and isolated populations, this wolf is the rarest canid in the world (Sillero-Zubiri *et al.*, 1997).

About 680 species of birds are found in the Ethiopian Highlands, some 30 of which are endemic. Four endemic genera are found in this part of the hotspot, including three that are relatively widespread within it (*Cyanochen* (Vulnerable)*, Rougetius* (Near Threatened) and *Parophasma* (Least Concern)) and one that has a localized distribution in the south (*Zavattariornis*, Endangered). Six endemic genera of amphibians are found in the Ethiopian Highlands, four of which are monotypic (*Altiphrynoides*, *Spinophrynoides* (Critically Endangered), *Balebreviceps* (Critically Endangered) and *Ericabatrachus*, Critically Endangered), while the fifth, *Paracassina* (Vulnerable), is represented by two frog species world (Sillero-Zubiri *et al.*, 1997).

The Albertine Rift includes portions of Rwanda, Burundi, Uganda, Tanzania and the Democratic Republic of Congo and is formed along the Great Rift Valley, and contains considerable volcanism associated with the gradual splitting apart of Africa. The highlands have rich agricultural land, and as a result the region is a major exporter of tea and coffee. Biologically, it is famous for its outstanding species diversity and the large number of endemic species. The Albertine Rift is home to about 14% (about 5,800 species) of mainland Africa's plant species, with more than 550 endemic species, including three endemic genera: *Afroligusticum, Micractis* (Least Concern)*, Rhaesteria* (Sillero-Zubiri *et al.*, 1997).

Nearly 40% of continental Africa's mammals are found in the Albertine Rift; this comprises more than 400 species, of which 45 are endemic. Most of these endemic mammals are shrews and rodents, including two monotypic endemic genera: the Ruwenzori shrew (*Ruwenzorisorex suncoides*, Vulnerable) and Delany's swamp mouse (*Delanymys brooksi,* Vulnerable). New species continue to be found and described, particularly in isolated highlands such as Itombwe and Kabobo in DRC. The forests of the Albertine Rift are also home to at least 27 primate species, including Hoests monkey (*Cercopithecus lhoesti,* Vulnerable), the owl-faced monkey (*C. hamlyni,* Vulnerable), and the golden monkey (*C. mitis kandti,* Endangered). However, the most charismatic flagship species of the Albertine Rift, and indeed of the entire hotspot, are the great apes. The population of the well-known mountain gorilla (*Gorilla beringei*, Critically Endangered) is limited to about 480 individuals in Virunga volcanoes and 300 individuals in Bwindi Impenetrable National Park. Grauer's gorilla (*G. b. graueri*, Endangered), which is found in the lowlands, was estimated at a population of 16,900 in eastern DRC in 1996, but has since suffered major declines as a result of hunting, as well as habitat loss and diseases. There are also small populations of robust chimpanzee (*Pan troglodytes schweinfurthii*, Endangered) in many of the Albertine Rift forests including into western Tanzania. Other mammals include the Ruwenzori duiker (*Cephalophus rubidus*, Endangered), which is restricted to the Rwenzori Mountains, and the Ruwenzori otter shrew (*Micropotamogale ruwenzorii,* Least Concern), one of only three representatives of the family Tenrecidae on the African mainland (McGinley, 2009).

The Albertine Rift is also extremely rich in birds; more than 1,074 species in 368 genera have been recorded from the area. Of these, 43 are restricted-range species endemic to the rift area, and these include three monotypic endemic genera: *Pseudocalyptomena* (Vulnerable), *Graueria* (Least Concern), and *Hemitesia* (Least Concern). Both the African green broadbill *(Pseudocalyptomena graueri*, Vulnerable*)* and short-tailed warbler *(Hemitesia neumanni*, Least Concern*)* are more closely related to Asian species than they are to any birds in Africa, while the affinities of Grauer's Warbler *(Graueria vittata*, Least Concern*)* remain uncertain. A fourth species confined to the rift, the Congo bay-owl *(Phodilus prigoginei*, Endangered*)*, is one of only two species in the genus *Phodilus*.

Around 177 (14%) of Africa's reptile species live in the Albertine Rift, including about 18 endemic species. Five of these endemic species are chameleons, including the Rwenzori three-horned chameleon (*Chamaeleo johnstoni*, Least Concern). The very rare strange-horned chameleon (*Kinyongia xenorhina*, Near Threatened) is confined to the Rwenzori Mountains, where it has probably been over-collected for the wildlife trade (impacts not yet properly documented). The Albertine Rift contains 143 known species of amphibians, including 38 endemic species and three monotypic endemic genera: Parker's tree toad (*Laurentophryne parkeri*), the Itombwe golden frog (*Chrysobatrachus cupreonitens*, Endangered) and African painted frog (*Callixalus pictus*, Vulnerable).

The Eastern Arc Mountains and Southern Rift stretch from south-eastern Kenya to southern Tanzania and Malawi, with small outliers in eastern Zimbabwe and western Mozambique. The Eastern Arc Mountains have 3,473 species in 800 genera, of which at least 453 species and around 40 genera are believed to be endemic, including trees, shrubs and herbs. Endemism is lower in the Southern Rift, with perhaps only 100 endemic species. The Nyika Plateau supports nearly 215 orchid species, of which about four species are endemic. Many thousands of species of plants and animals are found in these forests and nowhere else on earth (EAMCEF, 2012), and these include at least 100 species of birds, mammals, amphibians and reptiles; at least 500 plants and huge numbers of smaller creatures including butterflies and millipedes.

The Eastern Arc Mountains hold 12 endemic mammal species (Rovero, 2015). Four species of primates are endemic to the Eastern Arc Mountains and Southern Rift: the kipunji monkey (*Rungwecebus kipunji* Critically Endangered), the sanje mangabey (*Cercocebus sanjei*, Endangered), the Udzungwa red colobus (*Procolobus gordonorum*, Endangered) and the mountain dwarf galago (*Galagoides orinus,* Near Threatened). Six shrew species are endemic to this part of the hotspot, including the desperate shrew (*Crocidura desperate*, Endangered), found only in the Udzungwa and Rungwe mountains, and Phillips' Congo shrew (*Congosorex phillipsorum,* Critically Endangered), known only from the highest altitude areas in the Udzungwa Mountains. Other notable mammals in the Eastern Arc include Abbott's duiker (*Cephalophus spadix*, Endangered) and the eastern tree hyrax (*Dendrohyrax validus*, Near Threatened). Several new mammal species have also been discovered in the past decade, including two possibly new species of dwarf galago (*Galagoides* spp.) in the Taita Hills and on Mount Rungwe, and the grey-faced elephant shrew (*Rhynchocyon udzungwensis*, Vulnerable) in the Udzungwa Mountains. The Eastern Arc has 21 endemic bird species and three endemic genera (*Xenoperdix* (Endangered), *Sceptomycter*, and *Modulatrix* (Vulnerable)) (Fuchs *et al.*, 2011).

Data compiled in 2010 show that 32 species of reptiles are endemic to the Eastern Arc Mountains, the majority of these being chameleons in the genera *Chamaeleo, Rhampholeon* and *Kinyonga* (MNRT, 2011). There are also endemic species of worm snakes (*typhlops*), geckos and colubrid snakes. The Southern Rift has fewer endemic species, but there are endemic chameleons on Mounts Mabu and Mulanje, including the Mulanje mountain chameleon (*Bradypodion mulanjense*) and the Malawi stumptail chameleon (*Rhampholeon platyceps*, Endangered). A new species of snake, *Atheris mabuensis,* is also known from Mount Mabu in Mozambique.

For the amphibians, there are more than 50 endemic species in the Eastern Arc Mountains, concentrated in the reed tree frogs (*Hyperolius*), forest tree frogs (*Leptopelis*), viviparous toads (*Nectophrynoides*), narrow-mouthed frogs (family Microhylidae) and caecilians. The Eastern Arc Mountains supports 50% of the members of the caecilian family, Scolecomorphidae, among which the genus *Scolecomorphus*, with three species, is endemic. The Eastern Arc Mountains and Southern Rift contain all species of the genus *Nectophrynoides*, which includes the majority of the world's viviparous (live-bearing) frogs. Seven new species of *Nectophrynoides* have been described since 2004 (Menegon *et al.*, 2004; Channing *et al.*, 2005; Menegon *et al.*, 2008). Another monotypic genus of toad, *Churamiti maridadi* (Critically Endangered), was discovered in the Ukaguru Mountains in 2002. In addition, three new species in the genus *Callulina* have recently been described (Loader *et al.*, 2010). Dozens of new species collected from the Eastern Arc Mountains remain to be described including more than 50 species of vertebrates, mainly amphibians and reptiles, but also some birds (Fjeldså *et al.*, 2010).

In addition to these three main massifs, a number of outlying mountains are part of this hotspot, including the Neogene volcanic of the Kenyan and Tanzanian Highlands (e.g., Mt Kilimanjaro, Mt Meru, Mt Kenya, Mt Elgon, Aberdares Range, and other peaks). Many of these massifs are volcanic in origin, and some are still active–especially in Virunga National Park (McGinley, 2009). Typically these newer mountains support much lower biodiversity values than the more ancient mountain blocks

Trends: There are relatively few studies of the trends in species in the mountains of Eastern Africa. In the Albertine Rift mountains and according to the IUCN Red List the mountain gorilla (*Gorilla beringei*, Critically Endangered) has suffered major declines as a result of hunting, habitat loss and degradation. Studies conducted by Borghesio *et al.* (2010) strongly suggest that a major population crash of the Critically Endangered Taita Apalis (*Apalis fuscigularis*, Critically Endangered) is underway. Compared with 2001, sighting rates in April-May 2009 had dropped by about 38%; repeated counts done in September–December 2009 and May–July 2010 showed even larger decreases, approaching 80%. This means that the global population of the species might now be only 60–130 individuals, almost all of which are located in a single forest, Ngangao, which is only about 120 hectares (BirdLife International, 2013).

In the Eastern Arc Mountains of Tanzania and Kenya, the forest has suffered an estimated 80% total loss in historical forest area and has lost 25% of forest area since 1955. Forest loss has not been even across all elevations. The upper montane zone (>1,800 metres) has lost 52% of its paleoecological forest area, 6% since 1955. Conversely, the submontane habitat (800–1,200 metres) has lost close to 93% of its paleoecological extent, 57% since 1955 (Newmark, 1998; Hall *et al.*, 2009). Losses were greatest, relative to original cover, in Taita Hills (98%), Ukaguru (90%), Mahenge (89%) and West Usambaras (84%). Only small declines are reported after 200 by Hall *et al.* (2009), mainly because all forest outside reserves has been cleared for farmland, leaving only the reserves and their habitats broadly intact.

3.4.3.1.3 Tropical and subtropical savannah and grasslands

Status: Savannas and grasslands dominate almost 75% of East Africa and adjacent islands (Reid *et al.*, 2005), covering an area of 527,000 km^2 (WWF, 2017b). They are highly diverse with regards to composition of plant species, with about 1,000 species of grass being endemic to the region (Boonman, 1993). The drier habitats are dominated by *Combretum-Acacia-Commiphora* bushlands and thickets (WWF, 2017b), and are found in the north of the eastern African region. The largest areas of savannah woodland in the central and southern parts of the region are termed the 'miombo' woodlands (Frost *et al.*, 1996; Timberlake *et al.*, 2011, 2014). 'Miombo' is the Swahili word for the tree genus Brachystegia. These woodlands are dominated by trees of the subfamily Caesalpinioideae, particularly miombo (*Brachystegia), Julbernardia* and *Isoberlinia*, and are mainly situated on the ancient African plateau at an elevation of 800 to 1,250 metres above sea level. Mean annual rainfall between 600 to 1,400 millimetres, occurring between the months of November and April, and temperatures in the warm sub-humid zone (24–27°C), characterize the climate (Frost *et al.*, 1996; Timberlake *et al.*, 2011; Timberlake *et al.*, 2014). The unimodal rainfall pattern with prolonged dry seasons, coupled with the well-developed grass layer, exacerbates the frequency of wide-spreading fires, which have both natural and anthropogenic causes. Fire and pastoralism are believed to have played integral roles in the structuring of the miombo ecoregion through the tens of thousands of years of anthropogenic presence in the area. The miombo contains some of the largest large mammal populations left in Africa, with large herbivores including elephant, rhino, buffalo and many species of antelope. Typically, these species need to undertake seasonal movements as the region has extended dry seasons and animals often need to move around to find food and water. There are also numerous species of endemic animal and plant species across the huge extent of the region, although the density of endemic species is low in this region as most species have large ranges.

Trends and future dynamics: Savannas are in a state of decline in most of East Africa and adjacent islands. Corridors for migratory animals have been reduced mostly through human settlement and farming. Populations of ungulates have declined at high rates where bush meat is a major source of protein. Black rhinoceroses have been decimated by trophy hunters and poachers for their horns. Plant species, such as the African Blackwood (*Dalbergia melanoxylon,* Lower Risk/near threatened), are threatened by overharvesting because of their commercial value in making carvings for tourists and furniture (WWF, 2017b).

3.4.3.1.4 Dryland and desert

Status: About 80% of the east African region's total area consists of sparse herbaceous/grassy steppe (e.g., *Acacia tortilis*) (Ludwig *et al.*, 2004), and the stands of mangroves (e.g., *Rhizophora mucronata*, Least Concern) in the southern part of the Red Sea Coastal desert, and spiny bush in the south and west of Madagascar Spiny Thickets (124,060 km^2) (Phillipson, 1996) Somali montane xeric woodlands (62,159 km^2 and the Somali and Eritrean coastal deserts (30,300 km^2) (WWF, 2017a). The xeric woodlands of Madagascar are critically endangered, the Somali desert ecosystems are vulnerable and the Somali xeric woodlands are also critically endangered. However, the Eritrean coastal desert is relatively stable (WWF, 2017a). The majority of these zones are recognised as important zones of endemism. For example, an estimated 825 to 950 plant species have been observed in Danakil depression and its surrounding, with 25 species endemic to this region and the adjacent equally dry parts of Ethiopia and Somalia (Friis *et al.*, 2001), and several hundred endemics to Somali Montane Xeric Woodlands (Friis, 1992; Thulin, 1994; WWF *et al*., 1994; Lovett *et al*., 1996). The highest percentage of plant endemism has been observed in Madagascar (Phillipson, 1996). Some of the endemic plants are extremely rare and have highly restricted ranges, such as *Aloe suzannae* (Liliaceae) and the palm, *Dypsis decaryi* (Vulnerable), as well as tiny *Euphorbia* herbs, *Pachypodium* spp., and *Hibiscus* shrubs.

The overall number of reptiles is relatively low, with strict endemics limited to roughly three species in Eritrean Coastal Desert (Ogaden burrowing asp (*Atractaspis leucomelas*), Ragazzi's cylindrical skink (*Chalcides ragazzii*), and Indian leaf-toed gecko (*Hemidactylus flaviviridis*)), and three other endemic reptiles in Somali Montane Xeric Woodlands (*Spalerosophis josephscorteccii* and *Leptotyphlops reticulatus*, and the lizard (*Pseuderemias savage*)) (Stattersfield *et al.*,1998). In all vertebrates levels of endemism are low, for example there only occurs only one Archer's lark (*Heteromirafra archeri*, Critically Endangered), a rodent, *Gerbillus acticola*, and two geckos, Arnold's leaf-toed gecko (*Hemidactylus arnoldi*) and a subspecies of the northern sand gecko (*Tropiocolotes tripolitanus somalicus*, Least Concern) in Ethiopian xeric grasslands and shrublands.

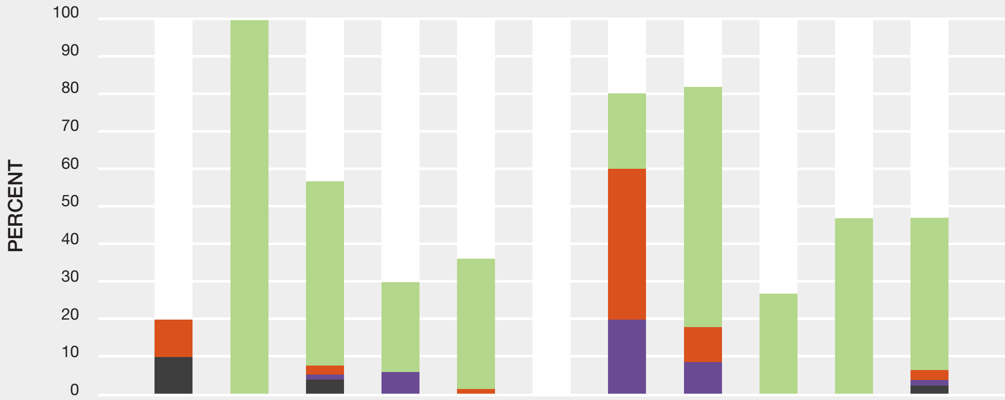
Among the mammals, desert ungulates are well presented. For example, Dorcas gazelle (*Gazella dorcas*, Vulnerable), Sömmerring's gazelle (*Gazella soemmerringii*, Vulnerable) and Salt's dikdik (*Madoqua saltiana*, Least Concern) are well known (Hilton-Taylor, 2000) in most part of desert, with the white-footed sportive lemur (*Lepilemur leucopus*, Endangered), Grandidier's mongoose (*Galidictis grandidieri*, Endangered), and grey mouse lemur (*Microcebus murinus*, Least Concern). With near-endemic mammals such as, the large-eared tenrec (*Geogale aurita*, Least Concern), and the lesser hedgehog tenrec (*Echinops telfairi*) only found in Madagascar (WWF, 2017a).

Trends and future dynamics: Drylands and deserts in East Africa and adjacent islands are largely intact but degraded by overgrazing and fuel collection, particularly near settlements. One of the major threats is over-exploitation of useful species e.g., *Hazomalania voyroni* (Least Concern) which has been over-harvested in Madagascar for construction wood although attempts are being made at replanting the species (Randrianasolo *et al.*, 1996). With current absence of protected areas, and weak environmental law enforcement, flora and fauna in these deserts is likely to be adversely affected.

3.4.3.1.5 Cultivated lands

Status and trends: Among the estimated 7,500 plant species in East African region (specifically in Kenya) are important wild species of vegetables, fruits, forage grasses, legumes, browse plants, cereals, pulses, oil crops, forest species, medicinal plants; which account for about 75% of agricultural production and over 75% of income generation (Salami *et al.*, 2010). No study exists on the level of genetic erosion of farmed species that has taken place in East Africa and adjacent islands (FAO, 2009a). However, it is believed in the last decade a lot of diversity has been lost due to both biotic and abiotic factors, despite the efforts being made in germplasm conservation. These factors include: aggressive promotion of exotic vegetables; changes in eating habits and over-exploitation; population pressure on land and changes in land (FAO, 2009a). Of the 291 known species of mammalian and avian breeds in East Africa, 12 are categorised as at risk. However, this is probably an underestimate of the actual situation, primarily due to a lack of information (FAO, 2007c; **Figure 3.11 & 3.12**).

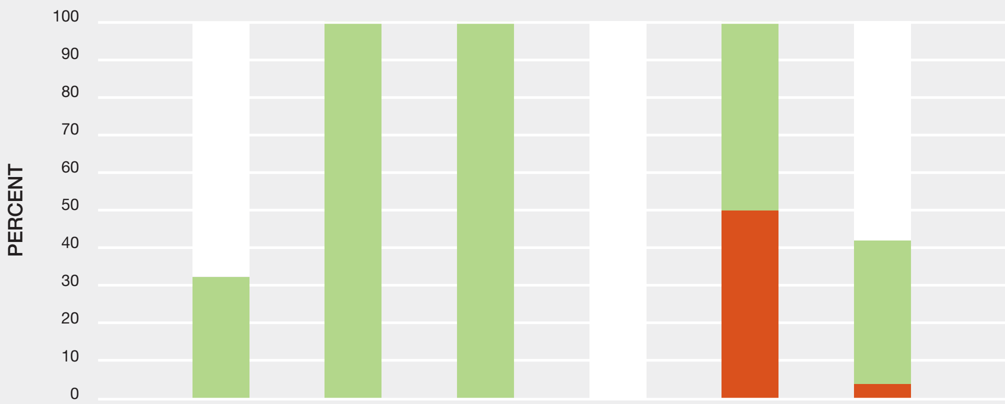
Figure 3 11 Risk status of livestock breeds recorded in East Africa* as of December 2005: absolute (table) and relative (chart) figures. Source: FAO (2007c).



RISK STATUS	Ass	Buffalo	Cattle	Dromedary	Goat	Guinea Pig	Horse	Pig	Rabbit	Sheep	TOTAL
Extinct	1	0	4	0	0	0	0	0	0	0	5
Critical	0	0	1	1	0	0	1	1	0	0	4
Endangered	1	0	2	0	1	0	2	1	0	0	7
Not at risk	0	1	47	4	19	0	1	7	3	25	107
Unknown	8	0	41	12	35	2	1	2	8	28	137
TOTAL	**10**	**1**	**95**	**17**	**55**	**2**	**5**	**11**	**11**	**53**	**260**

* Breeds that are also recorded in countries outside Africa are excluded from the analysis.

Figure 3 12 Risk status of avian domestic breeds recorded in East Africa* up to December 2005: absolute (table) and relative (chart) figures. Source: FAO (2007c).



RISK STATUS	Chicken	Duck	Goose	Guinea fowl	Turkey	TOTAL
Endangered	0	0	2	0	1	7
Not at risk	8	1	2	4	1	12
Unknown	17	0	0	1	0	18
TOTAL	**25**	**1**	**2**	**1**	**2**	**31**

* Breeds that are also recorded in countries outside Africa are excluded from the analysis.

Future dynamics: Similar to other subregions, the plant genetic diversity used in agriculture–crops and livestock breeds is predicted to erode further is no interventions are taken.

3.4.3.2 Aquatic (Freshwater, Marine and Coastal)

3.4.3.2.1 Wetlands and mangroves

Status: Wetlands and mangroves in East Africa and adjacent islands account for 80% of the total wetland area (Kalinga *et al.*, 1998; Spalding *et al.*, 2010). The largest mangrove areas are in one of global biodiversity hotspot-Madagascar (2,991 km^2) and Mozambique (2,909 km^2) (Chapman *et al.*, 2001; Samoilys *et al.*, 2015). However, the Rufiji Delta contains the largest continuous block of estuarine mangrove forest in East Africa and adjacent islands. The major wetlands in East Africa and adjacent islands include the major lakes Tanganyika, Nyasa, Turkana and Victoria; the small lakes Rukwa, Manyara, Eyasi, Natron, Kitangiri, Burigi, Ikimba (Samoilys *et al.*, 2015). Lake Turkana has more than 350 species of aquatic and terrestrial birds, and is also an important flyway for migrant birds, including more than 100,000 little stint (*Calidris minuta*, Least Concern) (Bennun *et al*., 1999). Central Island has a breeding population of African skimmers (*Rynchops flavirostris*, Near Threatened). Mangroves in East Africa are a home of 10 species, the most common species being *Avicennia marina* (Least Concern), *Rhizophora mucronata* (Least Concern), and *Ceriops tagal* (Least Concern). The only endemic mangrove is *C. somaliensis*, found only in Somalia. Salt *Avicennia* and *Sonneratia* leaves from mangroves are important sources of food feed for the Zebu cattle (Cormier-Salem, 2007).

Mangroves forests and wetlands provide fertile land for agriculture which contributes to the livelihood of rural communities. They are key breeding sites for marine fisheries. Concerns have been raised over the increasing erosion of wetlands and mangrove forest fauna and flora due to water and soil pollution (Beuel *et al.*, 2016). For instance, recent studies have revealed severe degradation of crabs and molluscs due to polluted waters and soils of the wetlands and mangrove forest. Since 2011, non-governmental organisations have been involved in projects in Madagascar to assess the feasibility of using payments for blue carbon as a long-term financial mechanism for community-based mangrove management (Leach *et al.*, 2013; Cormier-Salem *et al.*, 2016).

Trends and future dynamics: Mangroves in the Kilifi area in Kenya only make up a small proportion of the total area, but have seen the highest rate of loss estimated at 18% between 1985 and 2010 (Kirui *et al.*, 2013). In Madagascar, the loss of mangroves was found to be 7% of mangrove forests from 1975 to 2005 (Giri *et al*., 2008). Mangroves are particularly overexploited in the areas surrounding major cities on the East African coast, such as Mombasa, Dar-es-Salaam and Maputo, becoming heavily degraded or destroyed by multiple pressures on resources and pollution. Domestic wastewater has for instance detectable effects on crabs and molluscs, suggesting their usefulness as bioindicators of its effects in mangroves. They are also threatened by erosion caused by tree-cutting in the highlands, and by land grabbing. Due scarcity of wood from other hinterland sources, direct harvesting of the mangrove trees is occurring. Demographic trends suggest this situation could change in the future (Spalding *et al.*, 1997).

With current: lack of protected areas in desert areas; lack of enforcement; expansion of the Rift valley in Ethiopia; overgrazing, and increasing permanent settlements, some species endemic to wetlands and mangrove forest in East Africa are likely to face extinction. A further potential threat is continued climate change.

3.4.3.2.2 Inland surface waters and water bodies/freshwater

Status: There are 12 main river basins that flow into Western Indian Ocean (WIO) of which 6 are in Kenya, Tanzania and Mozambique (UNEP, 2009). These rivers support extensive mangrove forests often associated with seagrass beds (Samoilys *et al.*, 2015), and provide important bursary grounds and breeding areas for numerous commercially important fishery species such as tuna and mackerel (e.g., *Scomberomorus commerson*, Near Threatened). Eastern Africa, an area rich in freshwater species and very high levels of endemism, has just fewer than 26% of species assessed as regionally threatened (Darwall *et al.*, 2005). They host several commercially important fish species such as Nile Perch (*Lates niloticus*) and tilapia (*Oreochromis niloticus*, *O. leucosticus* and *Tilapia zillii* (Least Concern)) (Bwathondi, 1990). Many migratory bird populations rely on these river deltas as well as on wetlands and mangrove forests as a winter stopover (Samoilys *et al.*, 2015). An estimated 40,000 water birds comprising 62 species inhabit the Rufiji Delta (Spalding *et al.*, 2010).

Trends and future dynamics: The major rivers in East Africa have been dammed to varying extents for hydropower, water supply or irrigation. This has to a certain extent together with mangrove harvesting and removal affected the diversity of flora and fauna in inland waters adversely. In addition to dams construction, alien invasive species, desertification, agricultural encroachment, overexploitation and pollution are some of the leading causes of freshwater species decline and ecosystem degradation (Revenga *et al.*, 2003). Even though some of these areas are protected, management of these sites do not effectively combat these threats. A particular concern is the potential impact of water resource development such as construction of dams for water supply, irrigation and hydro-electricity on freshwater biodiversity. To help ensure the conservation of these water bodies, biodiversity information should be integrated with environmental and development planning and identification of Key Biodiversity Areas for inland waters of Eastern Africa.

3.4.3.2.3 Shelf ecosystem

Status: The shelf ecosystems of East Africa and adjacent islands commonly known as the Eastern African Marine Ecoregion (EAME) harbour a characteristic set of species, habitat, dynamics and environmental conditions (Wells *et al.*, 2007). Since the first marine protected areas were established in the 1960s and 1970s, 8.7% of the continental shelf in Kenya, 8.1% in Tanzania and 4.0% in Mozambique has been designated (Wells *et al.*, 2007). The coast consists of lagoons, coastal lakes, mangrove forests, inshore reefs and other habitat types (Wells *et al.*, 2007). EAME support an incredibly rich species composition, exceeding 11,000 species of plants and animals (e.g., *Dugong dugon*, Vulnerable) (WWF, 2017a). In a rare occurrence, 10 dugongs were sighted in the seagrass beds next to the Rufiji Delta (Sea Sense, 2011). The region has a highly diverse fish fauna (over 1,500 species of fish are recorded). One of the most notable fish in the region is the coelacanth (*Latimeria chalumnae*, Critically Endangered) (Wells *et al.*, 2007).

There are also significant populations of corals (200 species), seagrass (12 species), marine algae (1,500 species), several hundred sponge species, molluscs (3,000 species), crabs (450 species), with about 10-15% of species considered to be endemic to the region. Certain parts of the shore areas provide feeding and breeding areas for a high diversity of resident and migratory birds and marine turtles such as the olive ridley (*Lepidochelys olivacea*, Vulnerable), green turtle (*Chelonia mydas*, Endangered) and hawksbill (*Eretmochelys imbricate*) (Wells *et al.*, 2007), all of which are CITES listed. The open waters are important for many species of pelagic fish including the Black marlin whose distribution is restricted to Eastern Africa and Australia and many increasingly endangered elasmobranchs such as the Whale shark, Great White shark, sawfish and manta ray.

Trends and future dynamics: Increasing demands for marine resources have resulted in significant ecological changes in many parts of EAME, largely due to destructive fishing, notable blast fishing and water pollution (Cinner *et al.*, 2015). Continuation of some of these activities coupled with temperature-induced coral bleaching (Veron *et al.*, 2009) is likely to result in complete loss of biological diversity of EAME. Of particular concern if the loss of coralline algae, which is essential for cementing coral rubble into solid reef–a critical habitat for many organisms (Veron *et al.*, 2009). Therefore proper management of Shelf ecosystem if of immerse importance for improving the chances of achieving social-ecological sustainability (see Cinner *et al*., 2015).

3.4.3.2.4 Open Ocean

Status and trends: Coastal fish diversity is relatively high in East Africa and adjacent islands, with approximately 1,000 species identified and 142 endemics (Briggs *et al.*, 2012). Marine crustacean biodiversity is poorly documented, however, 165 species of shrimp have been identified in Seychelles, many of which are endemic. There are also a number of regionally endemic crustacean species associated with coral habitats (Briggs *et al.*, 2012). Marine catches are around 550,000 tons in 2014 for overall catches compared to less than 1 million tons for continental catches (especially from Lake Victoria). Major species are small pelagic, caught almost everywhere along the coast and demersal fish, essentially caught by artisanal fishermen. Most of the coastal stocks are fully exploited or overexploited (FAO, 2016).

3.4.3.2.5 Deep sea

Status: The fauna inhabiting seamounts found in West Indian Ocean is poorly known (Rogers, 2012). More studies have been undertaken on Walter's Shoal (submerged mountains off coast of Madagascar) due to its proximity to the land (Rogers, 2012). Species found at shallow waters of Walter's Shoal include *Comanthus wahlbergi tenuibrachia* (Collette *et al.*, 1991) and several crustaceans including an endemic species of aphid shrimp (*Alpheus waltervadi*) and endemic isopod (*Jaeropsis waltervadi*). Whilst little is known about the diversity of deep seas in Indian Ocean, recent studies have discovered an endemic species of rock lobster (*Palinurus barbarae*) (Groeneveld *et al.*, 2006), and West Indian Ocean coelacanth *Latimeria chalumnae* (Critically Endangered) (Nulens *et al.*, 2011). Deeper depths (~400 metres) of Walter's Shoal hosts over 50 species of fishes, which several are endemic (Shotton, 2006). Water birds are very rare and scarce (Shotton, 2006). The most commonly found bird species around areas of deep-water fishing are white-chinned petrels (*Procellaria aequinoctialis*, Vulnerable), cape petrels (*Daption capense*, Least Concern), and sooty shearwaters (*Puffinus griseus*, Near Threatened) (Shotton, 2006).

Trends and future dynamics: The fisheries of the Indian Ocean are subject to multiple stressors including: fishing, ocean acidification, changing sea temperatures, salinity and dissolved oxygen. Therefore, there is an urgent need for enforcement of (a) the Southwest Indian Ocean Fisheries Commission, which was opened in 2004 to promote sustainable utilization of marine living resources, and (b) the South Indian Ocean Fisheries Agreement (Rogers, 2012).

3.4.4 West Africa

3.4.4.1 Terrestrial

3.4.4.1.1 Tropical and subtropical dry and humid forest

Status: West African rainforests (12,002 million hectares) account for about 6% of African rainforests (Mayaux *et al.*, 2013; **Figure 3.13**). The Guinean forests of West Africa are recognised as a biodiversity hotspot with high levels of biodiversity (e.g., primate diversity) and endemism. Mammal diversity is exceptional. For example, an estimated 390 terrestrial mammal species (16% threatened) are found in Guinea forests, representing over one-quarter of roughly 1,100 total African mammal fauna that are native to continental Africa represented (CEPF, 2015). More than 60 mammals are endemic to these forests (e.g., two rarest antelopes in the world: the Endangered Jentink's duiker and the Vulnerable zebra duiker) (CEPF, 2015). West African rainforests are home to 917 species of birds (5% are threatened), of which 48 are endemic and more than 9,000 vascular plant species, of which around 20% are thought to be endemic (Brooks *et al.*, 2000; Mittermeier *et al.*, 2004). The diversity of amphibians (29% are threatened) and reptiles (10% are threatened) species is poorly documented, although it is suggested that more than 200 species of amphibians and reptiles recorded (Bakarr *et al.*, 2004; Norris *et al.*, 2010; Mallon *et al.*, 2015) and more likely to be discovered in future. The total carbon stock in West African rainforests is estimated at 5.8 GT, corresponding to 11.6% of the total carbon storage in Africa (Mayaux *et al.*, 2013).

The dry forest areas in West Africa are located in the Cape Verde Islands, with an extent of approximately 4,661 km^2 (WWF, 2017d). Four species of land-birds are endemic to these islands (Bourne, 1955; Stattersfield *et al.*, 1998), and 12 of the 15 species of lizards on Cape Verde are endemic (Stuart *et al.*, 1990). These regions support breeding populations of three bird species, Fea's petrel (*Pterodroma feae*, Near Threatened), magnificent frigate bird (*Fregata magnificens*, Least Concern) and red-tailed tropicbird (*Phaethon rubricauda*, Least Concern) (BirdLife International, 2000; WWF, 2017d).

Trends: The region lost 80% of its original forest cover by 1980s affecting not only the habitats of animals (e.g., great apes (MacKinnon *et al.*, 2015)), but also the rainfall. During the last decades precipitation has diminished (Campbell, 1996; Campbell *et al.*, 2000). Annual deforestation rate in West African rainforests for the period of 2000–2010 is estimated to be 0.35% (Mayaux *et al.*, 2013; **Figure 3.14**). The native vegetation in the dry forest of the Cape Verde Islands has been declining and is now severely fragmented (WWF, 2017d).

In recent years, harvesting of amphibians, vultures and iconic species in West Africa for international trade, food, medicine and cultural purposes has intensified markedly

Figure 3 13 **Spatial distribution of the rainforests in West Africa. Source: Mayaux *et al.* (2013).**

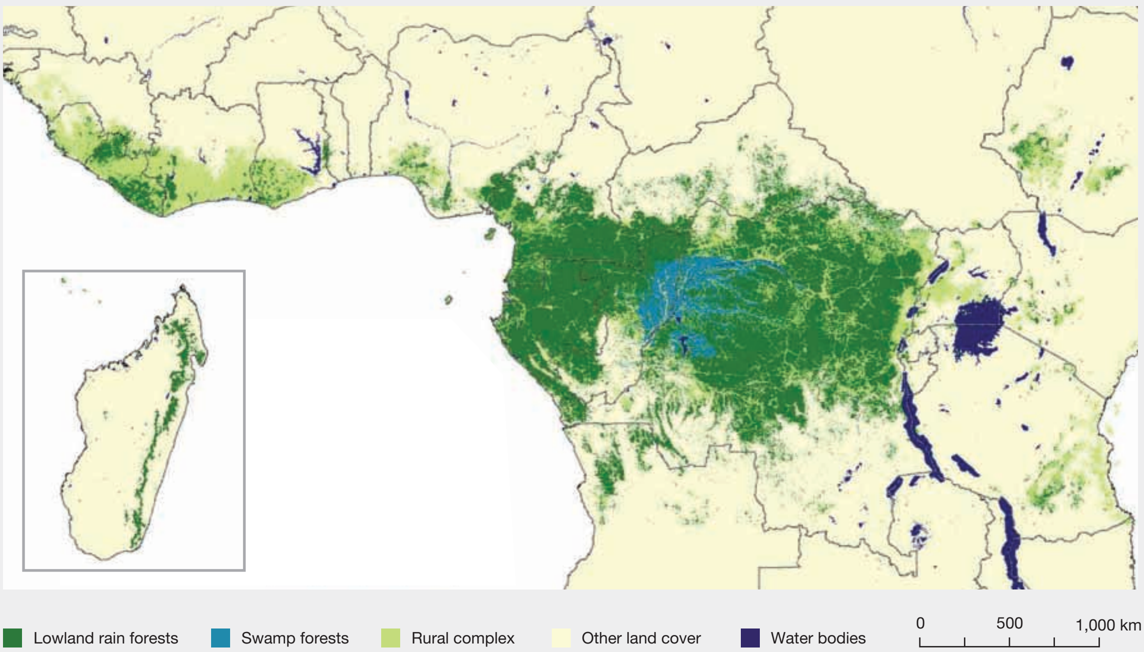
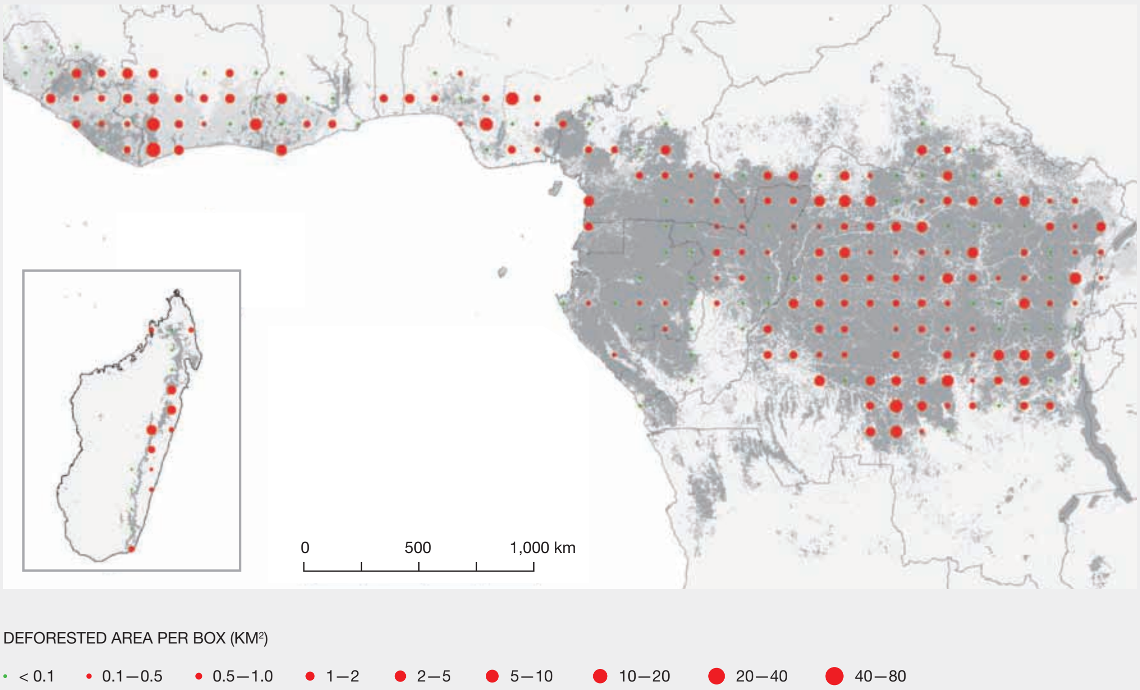


Figure 3 14 **Net deforestation between 1990 and 2000. The circle size is proportional to the surface affected by deforestation in each sample of 100 km². Source: Mayaux *et al.* (2013).**



(Mohneke *et al.*, 2009, 2010; Onadeko *et al.*, 2011; Botha *et al.*, 2012). Of 49 important amphibian species, 92% are for the pet trade (Carr *et al.*, 2014). A total of 450,000–2,738,610 frogs are harvested annually in West Africa (Mohneke *et al.*, 2011). Not only amphibians are severely declining, so are the populations of *Panthera leo*. In 2002 the population of *Panthera leo* was estimated to be 1,230 (Chardonnet, 2004), 835 in 2004 (Bauer *et al.*, 2004) and 406 in 2014 (Henschel *et al.*, 2014). Recent surveys also suggest that the African elephant, and African wild dogs have disappeared from much of their formers range in West Africa, with small and isolated population of lion only found in three protected areas (Chase *et al.*, 2011). More than 90% of elephant population in West Africa has been lost in the 20th century (MacKinnon *et al.*, 2015). The remaining isolated and small populations consist of little more than 100 elephants (MacKinnon *et al.*, 2015). Severe declines of large birds have also been reported in West Africa (Thiollay, 2001; Rondeau *et al.*, 2004; Thiollay, 2006a, b, & c), with collapse of raptor populations in protected areas (Thiollay, 2007).

Future dynamics: With projected climate change (Belle *et al.*, 2016), ongoing overhunting and conversion of forest to agriculture (FAO, 2015b); forest species (in particular mammals, amphibians, reptiles, and birds) and their services are expected to be negatively impacted in West Africa. For example, 91% of the amphibian, 40% of bird, and 50% of mammal species are projected to be found in areas of lower climate suitability by the 2070–2099 time period (Belle *et al.*, 2016). It is therefore crucial to consider conservation of this taxonomic groups, specifically for those species that have been assessed globally as threatened (Belle *et al.*, 2016).

3.4.4.1.2 High mountain habitats

Status: The Guinean Montane Forest ecoregion consists of scattered mountains and high plateau areas. Parts of the ecoregion are found in four West African countries, from Guinea in the west to Côte d'Ivoire in the east (Morton, 1986). Bintumani Peak on Loma Mountain (1,947 metres) in Sierra Leone is the highest peak in Africa west of Mount Cameroon (Cole, 1968). Tingi Hills, and Sankabiaiwa, also in Sierra Leone, both attain a height of 1860 metres. Other notable mountains in this ecoregion are Mount Nimba (1,752 metres) (Curry-Lindahl, 1966), the Simandou Massif in Guinea (1,650 metres), the Ziama Massif (1,387 metres) in Guinea, Mount Dutova in Liberia, and the Man Massif and Mont Peko in Côte d'Ivoire. Average rainfall is between 1,600–2,400 millimetres/year (Morton, 1986), and most major rivers in West Africa have their origins within the peaks of the Guinean Montane Forest ecoregion. For example, the most westerly tributary of the Niger River originates in the Loma Mountains of Sierra Leone, while the Senegal and Gambia Rivers originate in the Fouta Djallon of Guinea. The Sewa River in Sierra Leone has many of its tributaries arising from the Loma Mountains and Tingi Hills, making it the most important watershed in the country. There is considerable variation in the rainfall on different sides of the mountains. Temperatures are also quite extreme on these mountain slopes, with maximum temperatures ranging between 24ºC and 33ºC while minimum temperatures can fall below 10ºC. White (1983) classified the forests here as part of an Afromontane archipelago-like regional centre of endemism. Lowland forest, part of the greater Guinea-Congolian forest complex, occurs on the lower reaches of the mountains closer to the coast. On northern slopes, forest-savanna mosaic becomes montane forest with increasing elevation and precipitation. At mid-altitudes (above 1,000 metres), the forest is often shrouded in clouds, resulting in verdant growth of epiphytes. With increasing altitude on the highest mountains, forests give way to grassland intermixed with bamboo, wetlands and gallery forests. The dominant flora of the grassland includes the genera *Anadelphia, Loudetia*, and *Tristachya* (Morton, 1986). Grassland also occurs on the ridges and peaks of Mount Nimba and is generally dominated by Andropogon and Loudettia, while the sedge, *Hypolytrum cacuminum* (Endangered) occurs on some wetter slopes (Morton, 1986).

According to Cole (1968), 4 plant communities have been recognised on these massifs, including closed forests and Guinea savanna (460–915 metres), sub-montane shrub savanna (915–1,700 metres), montane grassland (prairie d'altitude) (1,700 metres) and sub-montane gallery forests (1,700 metres). At higher altitudes, the shrub layer of the sub-montane shrub savanna of the Loma Mountains and Tingi Hills is comprised of *Syzygium* spp., *Kotschya ochreata* var *ochreata*, *Monechma depauperatum*, *Dissotis elliotii*, *Dissotis fructicosa* and the tree ferns, *Cyathea manniana* and *Cyathea dregei*. Tree ferns are noted as common in the gallery forest (Cole, 1968; Morton, 1986).

The diversity and endemism on Mount Nimba is well documented, with over 2,000 species of vascular plants recorded (WWF *et al*., 1994). Biodiversity studies of the Loma Mountains have produced considerable information about the flora, with records for 1,576 species distributed in 757 genera and 135 families (WWF *et al*., 1994). Nine species are endemic to Loma mountains, and include *Afrotrilepis jaegeri*, *Digitaria phaeotricha* var. patens, *Dissotis sessilis*, *Gladiolus leonensis*, *Ledermanniella jaegeri*, *Loudetia jaegeriana*, *Loxodera strigosa*, *Schizachyrium minutum* (*S. brevifolium*) and *Scleria monticola* (Jaeger, 1983). The four endemic plant families found in tropical Africa are also represented in the Loma Mountains by *Triphyophyllum peltatum* (Dioncophyllaceae), *Octoknema borealis* (Octoknemataceae), *Bersama abyssinica* (Melianthaceae), and *Napoleona leonensis* and *Napoleona vogelii* (Lecythidaceae). For the entire Guinean Montane Forest (including the following mountains: Fouta Djalon, Loma, Tingi, Nimba and Man), 35 endemic plants including 11 palaeo-endemics have been recorded (Schnell, 1952; Cole, 1967; Morton, 1972; Cole, 1974; Jaeger *et al*., 1975). The 11 palaeo-endemics are *Borreria macrantha*, *Cyanotis lourensis*, *Droogmansia scaettaiana* (Near Threatened), *Eriosema parviflorum*, *Eugenia pobeguinii*, *Hypolytrum cacuminum* (Endangered), *Kotschya lutea*, *Mesanthemum aurantum*, *Rhytachne glabra* (Vulnerable), *Vernonia nimbaensis* and *Xyris festucifolia* (Cole, 1974). A total of 101 species in the Orchidaceae have been recorded for Mount Nimba, including one endemic species *Rhipidoglossum paucifolium* (Johansson, 1974). Phorophytes like *Heritiera utilis* (Vulnerable), *Lophira alata* (Vulnerable) and *Parinari excelsa* (Least Concern) were also reported to carry an abundance of epiphytes. There are Mount Nimba otter shrew (*Micropotamogale lamottei*, Near Threatened) (Hilton-Taylor, 2000), two species of white-toothed shrew (*Crocidura obscurior,* Least Concern and *C. nimbae,* Near Threatened) and a species of leaf-nosed bat (*Hipposideros marisae,* Vulnerable). A number of other rare forest mammals may also occur marginally in the mountains of this ecoregion, including Johnson's genet (*Genetta johnstoni*, Near Threatened) and a murid rat (*Praomys rostratus*, Least Concern). The western chimpanzee (*Pan troglodytes* verus, Endangered) also occurs in this ecoregion, with high densities reported from Mt Loma. The largest predator in the ecoregion is the leopard (*Panthera pardus*, Vulnerable). The avifauna of Mount Nimba has been well described and includes the near-endemic Sierra Leone prinia, the grey-winged robin-chat (*Cossypha polioptera*, Least Concern) and lemon dove (*Columba larvata*, Least Concern), and Sharp's apalis (*Apalis sharpii*, Least Concern) (Colston *et al.*, 1986; Gatter, 1997). The presence of the rare yellow-headed rock fowl (*Picathartes gymnocephalus*, Vulnerable) has also been confirmed in the Loma Mountains (Thompson, 1993). The ecoregion is also of importance for endemic amphibians. More than 10 species are believed to be strictly endemic (WWF *et al*., 1994), including *Nimbaphrynoides occidentalis* (Critically Endangered), an endemic toad occurring in savannas on Mount Nimba (Curry-Lindahl, 1966). Several new species of insects in the family Coleoptera have been reported for both the Loma and the Nimba Mountains (Villiers, 1965). For the Loma Mountains, these include *Promecolanguria lomensis*, *Barbaropus bintumanensis* and *Barbaropus explanatus*. The species recorded on Mount Nimba include *Promecolanguria dimidiata*, *Promecolanguria pseudosulcicollis*, *Promecolanguria mimbana*, *Promecolanguria armata* and *Barbaropus nigritus*.

Trends: The Upper Guinea Forest receives less annual rainfall and has higher rainfall seasonality than pan-tropical rainforests, which are characterized by annual rainfall greater than 1,500 millimetres with little-to-no dry season (Peel *et al.*, 2007; Malhi *et al.*, 2009). Since the 1970s, a drying trend has been observed, and these changes have been primarily associated with shifts in a natural low-frequency mode (65–80 years) of sea surface temperature (Hulme *et al.*, 2001). Rapid population growth has exacerbated regional development pressures, including timber harvesting and demand for agricultural land (Knauer *et al.*, 2014). Vegetation analysis indicated that declines in woody coverage were the predominant trends across the Upper Guinea Forest region of West Africa, even in the drier Guinean Forest Savanna Mosaic and West Sudanian Savanna ecoregions that were also characterized by widespread trends of increasing greenness as measured by environmental vegetation index (Liu *et al.*, 2017). Such a decline in woody vegetation was also captured between 1990 and 2000 along the West African forest-savanna transition zone (Bodart *et al.*, 2013). Recent landscape-level studies of land cover and land-use change in the forested zone of southwestern Ghana have also documented declining trends in woody vegetation cover, with the largest decreases occurring near the forest-savanna boundary (Alo *et al.*, 2008; Dwomoh *et al.*, 2017). Despite the widespread decline of woody vegetation in many of the drier parts of West Africa, remotely-sensed greenness metrics also indicated a prevalence of greening, consistent with re-greening trends found in many other studies of West Africa (Herrmann *et al.*, 2005; Brandt *et al.*, 2015; Kaptué *et al.*, 2015).

3.4.4.1.3 Savannah and grassland

Status: The savannahs and grasslands of West Africa are rich in biodiversity. The West African savannah occupies about 60% of the surface of tropical Africa, with its appearance and degradation status largely determined by human activities (Laube, 2007). The grass component of the northern dunes is dominated by *Cenchrus biflorus*, *Aristida mutabilis* and *Schoenfeldia gracilis*. Grasslands like *Echinochloa stagnina*, *Oryza barthii* (Least Concern) and *Vossia cuspidata* provide excellent grazing when the floods have receded. These areas were historically rich in wildlife including megafauna such as elephant, giraffes, lions, cheetahs and many ungulates. However, today the faunal diversity of the savannahs and grasslands are restricted to isolated pockets of protected areas that are facing large pressures from encroaching human populations.

Trend: The Sahelian grazing lands have suffered much damage in the past 50 years, through an increasing human population, excessive advance of cropping into very marginal areas and serious deforestation, mainly for firewood, all exacerbated by recurrent droughts. *Andropogon gayanus* is becoming scarce because of clearing and in cultivated areas has been replaced by vast areas of poor, unpalatable grasses. The 2017 IUCN Red List Animals listed Scimitar-horned Oryx (*Oryx dammah*, Extinct in the Wild) as extinct in Burkina Faso, Mali, and Niger. The 2004 IUCN Red List Animals listed *Gazelle dorcas* in Mauritania as Endangered, Mali as Probably Endangered, Niger Probably Vulnerable or Endangered, Senegal as Extinction in the wild Burkina Faso as Probably Endangered and Nigeria as Possibly Extinct.

3.4.4.1.4 Dryland and desert

Status and trends: Western African countries with substantial covers of aridity zones include; Chad, Mali, Mauritania and Niger. Countries with some semi-arid and dry sub-humid arid cover include Benin, Gambia, Ghana, Nigeria and Senegal. In West Africa only Gambia had a net forest cover gain of 1.0% during the decade. (Bellefontaine *et al.*, 2000; FAO, 2001b). Rainfall decreases from south to north, so the vegetation belts run east-west. The average Sahelian rainfall is of 250–500 millimetres with dry season of nine to eleven months. According to Wickens (1997), the 150 millimetres isohyet corresponds to the southern limit of the Saharan species *Cornulaca monacantha, Panicum turgidum* and *Stipagrostis pungens* and to the northern limits of such Sahelian shrubs as *Boscia senegalensis* and *Commiphora africana* and the grass *Cenchrus biflorus* in the northern Sahel. The Sahel's southern limit adjoins the deciduous woodlands of the Sudanian domain at between 450 and 500 millimetres/year of precipitation. *Acacia* spp. dominate the thin scrub along with *Balanites aegyptiaca*; laterite outcrops and cuirasses are colonized by *Combretum nigricans*, *Guiera senegalensis*, *Lannea acida* and *Sclerocarya birrea*. The Saharan cheetah (northwest African cheetah) lives in Niger, Mali, Benin, and Burkina Faso. There are also small desert crocodiles at Mauritania. *Oryx dammah* (Extinct in the Wild) are constituted by the Sahelian populations found in Niger and in Mali (Grettenberger *et al.*, 1990). During the 1970's, the Oryx seems to have been reduced to small groups (Dragesco-Joffé, 1993) living on the desert edges of Niger between Agadez and the Termit (Grettenberger *et al.*, 1990). The Scimitar-horned Oryx is extinct in the wild and has been reintroduced in large fences within a protected area in Senegal (CEPF, 2015). The species was present in the area from the Louga region in the west to the Bakel region in the east (White, 1983; Sournia *et al.*, 1990). The Scimitar horned Oryx is now in the south-Sahelian deciduous shrub zone in Burkina Faso (White, 1983) and in the south-Sahelian deciduous shrub belt in Nigeria (White, 1983; Anadu *et al.*, 1990).

3.4.4.1.5 Cultivated lands

Status and trends: West Africa is composed of an array of diverse ecosystems and an equally high number of food production systems (Cotillon, 2017). West African agriculture contains a rich variety of economically important resources. These resources include (i) cash crops like cotton, coffee, cacao, groundnut, palm, and cashew, millet, sorghum, maize, paddy rice, and (ii) animals like cows, sheep, pigs, and poultry. In West Africa, a total of 266 crop wild relatives have been identified and among the 20 of 266 appeared to be species demanding highest priority for conservation (Idohou *et al.*, 2013). The number of the income crops that have declined or disappeared in Western Africa is striking. Of the 530 known species of mammalian and avian breeds in North and West Africa, 18 are categorised as at risk. However, this is probably an underestimate of the actual situation, primarily due to a lack of information (FAO, 2007b; **Figure 3.15 & 3.16**).

There have been three main causes of these major crop declines; pests and disease pressures (Chapter 4, section 4.2.1.3; Table 4.2), changes in market or consumption preferences, and least significant, fertility decline or land shortage (Goldman, 1995). The same problems also face livestock populations, particularly the indigenous Zebu cattle breeds in Nigeria, which are reported to have been badly affected by corridor disease (a tick-borne disease) during the last ten years (FAO, 2007b). Other driving forces of livestock diversity erosion include climate change, drought, quantitative and qualitative changes in demand for livestock products and services (FAO, 2007b).

More than anywhere else, West Africa is a home to a diversity of agro-ecosystems **(Figure 3.17)**. These ecosystems create a strong production base for a range of crops and encourage complementarity between major production areas. The forest areas with the sub-tropical climate are excellent for production of roots (cassava) and tubers (yams) making West Africa one of the world's major repositories of these crops (Reynolds *et al.*, 2015).

Future dynamics: In the absence of high-level farmer and institutional response, most of these income crops are likely to decline due to drought, given that irrigation is financially out of reach for the vast majority of producers (e.g., Schroth *et al.*, 2016).

Figure 3 17 **Major production systems in West Africa. Source: Blein *et al.* (2008).**

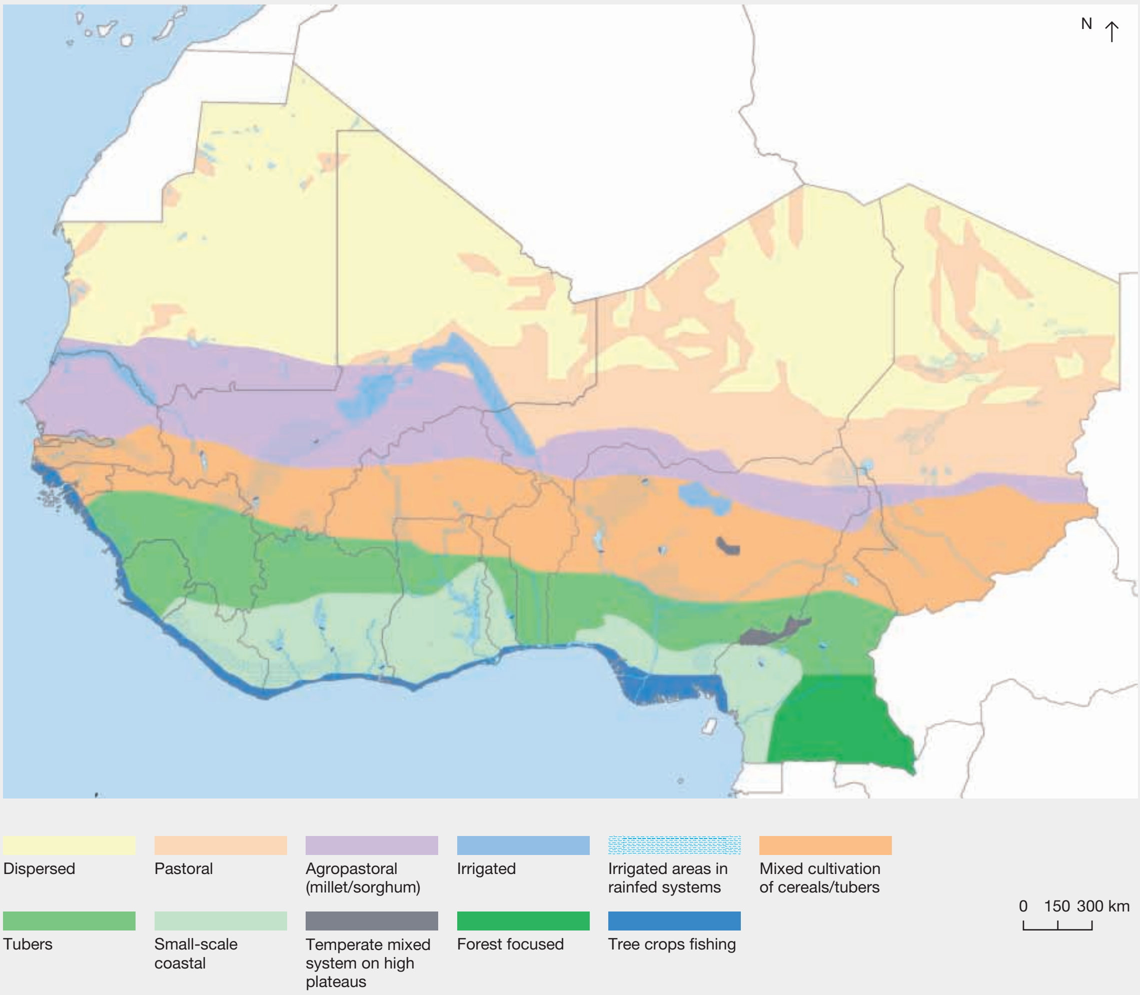
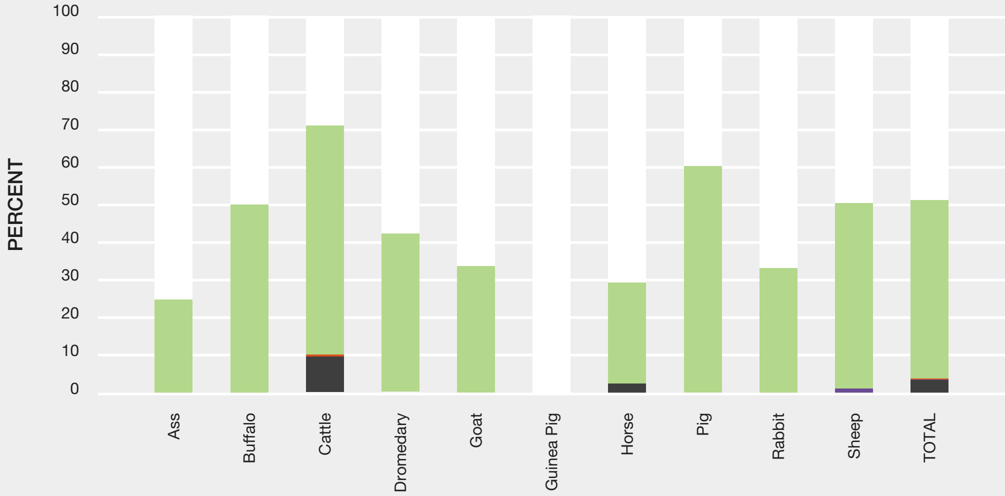


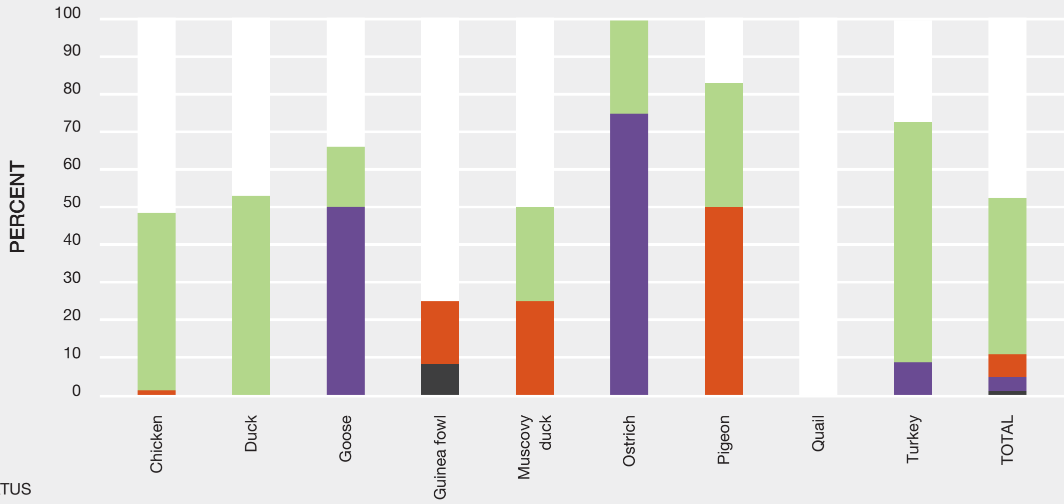
Figure 3 15 The risk status of livestock breeds recorded in North and West Africa* as of December 2005: absolute (table) and relative (chart) figures. Source: FAO (2007b).



RISK STATUS	Ass	Buffalo	Cattle	Dromedary	Goat	Guinea Pig	Horse	Pig	Rabbit	Sheep	TOTAL
Extinct	0	0	11	0	0	0	1	0	0	0	**12**
Critical	0	0	0	0	0	0	0	0	0	1	**1**
Endangered	0	0	1	0	1	0	0	0	0	0	**1**
Not at risk	3	1	70	12	16	0	10	20	4	40	**176**
Unknown	9	1	33	16	31	2	26	13	8	40	**179**
TOTAL	**12**	**2**	**115**	**28**	**47**	**2**	**37**	**33**	**12**	**81**	**369**

* Breeds that are also recorded in countries outside Africa are excluded from the analysis.

Figure 3 16 Risk status of avian domestic breeds recorded in North and West Africa* as of December 2005: absolute (table) and relative (chart) figures. Source: FAO (2007b).



RISK STATUS	Chicken	Duck	Goose	Guinea fowl	Muscovy duck	Ostrich	Pigeon	Quail	Turkey	TOTAL
Extinct	0	0	0	2	0	0	0	0	0	**2**
Critical	0	0	3	0	0	3	0	0	1	**7**
Endangered	1	0	0	4	1	0	3	0	0	**9**
Not at risk	40	7	1	8	1	1	2	0	7	**67**
Unknown	43	6	2	18	2	0	1	1	3	**76**
TOTAL	**84**	**13**	**6**	**22**	**4**	**4**	**6**	**1**	**11**	**161**

* Breeds that are also recorded in countries outside Africa are excluded from the analysis.

3.4.4.2 Aquatic (Freshwater, Marine and Coastal)

3.4.4.2.1 Wetlands

Status and trends: Outstanding wetlands that harbour very high numbers of migratory and wintering waterfowl are found in West Africa. They include the Inner Niger Delta in Mali, Lake Chad and Hadejia-Nguru wetlands in Nigeria (CEPF, 2015). In Niger alone, wetlands are estimated to hold 1.2 million waterbirds (Brouwer *et al.*, 2001), whereas the Senegal River Delta is home to over 3 million wintering shorebirds, at least 108 bird species of nesting piscivorous birds and is one of the 3 transfrontier Biosphere Reserves of Africa (Bouamrane *et al.*, 2016). Of the 46 Critical sites identified in West Africa, 10 sites holds highest number of migratory waterfowl (e.g., *Arcocephalus paludicola*) (CEPF, 2015).

Threats to West Africa's mangroves and wetlands, and their associated biodiversity and ecosystem services are linked to a growing population, industrial and agricultural development and a changing climate (Hamerlynck *et al.*, 2003; Sy *et al.*, 2015). Coleman *et al.* (2008) showed that between 1987 and 2002, in an area of 1,110 km^2 of the lower Niger delta, approximately 88 km^2 of wetlands had been converted to open water or converted to agricultural activities. Current levels of water extraction have also impacted wetlands, as exemplified by Lake Chad, which has shrunk from a surface area of 25,000 km^2 in the early 1960s to around 1,350 km^2 in 2001 (Smith *et al.*, 2009). According to Thieme *et al.* (2005) 12 of 17 freshwater ecoregions are either listed as Critical or Endangered and the region contains over a third of all the ecoregions in Africa listed as Critical.

Future dynamics: In West Africa, mangroves are found discontinuously from Senegal to the Niger Delta, however, these mangroves are in moderate decline, with an estimated average decline of 25% between 1980 and 2006, then recovering in a few countries in the last decade. The decline is due to cutting of the trees for fuelwood and poles for housing construction; urbanisation and industrialisation; the use of poison and dynamite for fishing, canalisation, discharge of sewage and other pollutants, siltation, sand mining, erosion, construction of embankments; and in some areas, from the damming of the Volta River. Apart from declining mangrove ecosystems in West Africa, a study by Belle *et al.* (2016) revealed that in term of proportions, by 2040–2069, 80% of the assessed will be vulnerable to climate change. Of the 202 species identified as climate change vulnerable by 2040–2069, 62 are globally threatened.

3.4.4.2.2 Inland surface waters and water bodies/freshwater

Status and trends: The inland waters of West Africa supports a high diversity of aquatic species with high levels of endemism (Smith *et al.*, 2009). High endemism of the species is due to the various different habitat types from the dry Sahel in the north, moving south through grassland and into tropical moist forests near the coast. Covering the northern part of the region in Niger, Mali, Mauritania and Chad is the Sahel, a dry region, characterized by scattered oases, semi-permanent pools and temporary rivers, which receives on average just 30-50 millimetres of rain/year (Thieme *et al.*, 2005). These freshwater bodies are of economic importance to both locals and nations in the region. The value of fisheries production for the major river systems in western Africa is estimated to be over $200 million/year (FAO, 2009b).

Inland waters of the Upper Guinean Forests support approximately 1,281 species of fishes, of which 38% are considered endemic (Paugy *et al.*, 2003), 155 species are globally threatened (Smith *et al.*, 2009). Threats to these species are mainly anthropogenic and as human populations increase throughout the region, the pressures on these inland waters and its biodiversity is going to rise as well. The immediate priorities for conservation actions to be taken are fully comprehensive Environmental Impact Assessments, designation of areas with high levels of biodiversity as Protected Areas and filling the information gap (large number of species fall into the data deficient category of the Red List).

3.4.4.2.3 Shelf-ecosystem

Status and trends: The narrow coast (generally less than 100 km on average) is home to approximately 148 species of seabirds and marine seabirds (CEPF, 2015). Biodiversity is related to the type of coastal habitat rocky beaches occur on less than 3% of the coastline, sandy beaches (16%), headlands and coves (14%), areas associated with estuaries, river mouths and lagoons (19%), and mangroves (48%) (Diop *et al.*, 2014). Sea-grass beds are not well developed in the region and there are no true reefs due to intrusion of cool waters of the Benguela and Canary currents and high turbidity of the waters. All countries in the region are signatories to the Ramsar Convention, with 37 designated sites within the coastal marine zone. The beaches are especially important for five of the seven species of marine turtles that are globally threatened.

The coastal ecosystems support highly diverse faunal and floral communities, including fish and invertebrate fauna, many of which are important commercial species. In West Africa, mangroves are found discontinuously from Senegal to the Niger Delta. Six species of trees are found **(Table 3.6)**. Mangroves, estimated at 13,898 km^2 (Tang *et al.*, 2014), provide many important ecological functions. They support the subregion's fisheries which contribute $400 million annually to the total economy and can sequester up to 1,000 tons of carbon, three times more than tropical rainforests (Rotich *et al.*, 2016). The largest areas are in

Guinea-Bissau and Nigeria, representing 2.5% and 4.7% of the global total areas of mangroves globally, respectively (Giri *et al.* 2011). Trends from 1975 to 2013 however show a decline of 4.8% in mangrove area (984 km^2) due to overexploitation and changing land-use. Increasing pollution from agricultural, industrial, domestic activities, petroleum exploitation and exploration, have negative implications on the species composition and ecological balance in these ecosystems (Church *et al.*, 2010).

Coastal ecosystems are internationally important for migratory waterfowl (Senegal Delta, coastal lagoons of Ghana), and for manatee (Niger Delta) and for shellfish and juveniles fish. The Niger Delta provides spawning/ nursery areas for the fisheries in the Gulf of Guinea. A high diversity is found in the pelagic fish community, with 48 species in 38 families (Ajao, 1993). Pelagic families and species associated with them include Clupeidae (*Ethmalosa fimbriata*, Least Concern)*, Pellonula leonensis* (Least Concern)*, Ilisha africana* (Least Concern)*, Sardinella maderensis* (Vulnerable)*, Belonnidae, Ablennes hians* (Least Concern)*, Strongulura senegalensis*), Megalopidae (*Tarpon atlanticus*), Hemiramphidae (*Hyporhamphus Picarti*, Least Concern), Elopidae (*Elops lacerta,* Least Concern)*, E. senegalensis*), and Albulidae (*Albula vulpes,* Near Threatened) (Isebor *et al.*, 1993; Shumway, 1999). West African manatee (*Trichechus senegalensis*, Vulnerable) (Hughes *et al.*, 1992), the soft-skinned turtle (*Trionyx triunguis,* Vulnerable), and in the Niger Delta, isolated populations of pygmy hippopotamus (*Hexaprotodon liberiensis heslopi*, Vulnerable) are the most remarkable fauna. Besides, five species of marine turtle, leatherback (*Dermochelys coricea*, Endangered), loggerhead (*Caretta caretta*, Endangered), olive ridley (*Lepidochelys olivacea*, Vulnerable), hawksbill (*Eretomychelys imbricata*, Critically Endangered), and green turtles (*Chelonia mydas*, Endangered).

The Upper-Guinea Coast, from Saloum Delta in Senegal to Sierra Leone, contain the most-inhabited (human density up to 40–80 houses/km^2) and best-developed mangroves in West Africa (8,507 km^2) (Ruë, 2002). Oysters found in this region include species s such as C*rassostera gazar*, and cockle species like: *Anadara senilis, Galatea paradoxa*, *Murex hoplites, Murex cornutus, Orbicularia orbiculat, Pugilina morio, Cymbium* spp.*, Cultellus tenuis* (Cormier-Salem, 1999). Same as Mangroves found in other parts of Africa are threatened by drought, rural exodus and the coastal erosion, being translated by the salinization and the acidification of muddy soils. More than 25% of the mangrove trees have been lost (Conchedda *et al.*, 2011; Temudo, 2012; Carney *et al.*, 2014; Zwarts, 2014; Cormier-Salem *et al.*, 2016; Temudo *et al*., 2017). In 2015, mangrove forests occupied 349,555 hectares of the territory of Guinea-Bissau which corresponds to an annual change rate of 1.54% (Temudo *et al*., 2017).

Future dynamics: Development partners have supported mangrove conservation efforts at different scales, notably the West Africa Marine and Coastal Conservation Platform for Mauritania, Senegal, the Gambia, Guinea-Bissau, Guinea, Sierra Leone and Cape Verde. It is the most important example of coordinated mangrove conservation partnership and led to the adoption by the six countries of a Mangrove Charter and subsequent national action plans.

3.4.4.2.4 Open Ocean

Status and trends: Off the coast is the Guinea Current Large Marine Ecosystem (GCLME) with distinctive bathymetry, hydrography, chemistry and tropho-dynamics that make it one of the top five most productive large marine ecosystems in the world in terms of biomass yields. Periodical upwelling of deeper nutrient-rich cold water to the surface (mainly July to September each year) contributes to the high average primary productivity of 392 grams of Carbon/ m^2/year that causes a high biological activity and increased fish spawning. Marine biodiversity has been estimated at 1,811 species (Polidoro *et al.*, 2017). A value of €872 million has been estimated for selected regulation services such as water treatment, carbon sequestration and coastal protection (Interwies, 2010; Interwies *et al.*, 2013). The fishery resources, estimated at about 239 fish species (Ukwe *et al.*, 2006), is made up of locally resident stock as well as transboundary straddling and migratory stocks. Exploited species include small pelagic fishes, large migratory pelagic fishes such as tuna and billfishes, crustaceans, molluscs and demersal fish. Total reported landings (composed of mixed species due to poor categorisation of species at landings) have generally increased, from approximately 567,000 tons in the 1950s to a peak of 4.8 million tons in 2000, after which it declined to less than 4.4 million tons in 2010 and 2014 (Belhabib *et al.*, 2015; FAO, 2016). Small pelagics constitute almost 50% of landings and demersal resources in most areas are considered to be either fully fished or overfished (FAO, 2016).

Fisheries and overharvesting are the biggest threat to marine resources, affecting 87% (109 of 125 species) of threatened species, followed by habitat loss and coastal development affecting 55% of threatened species (69 of 125) (Polidoro *et al.*, 2017). Combination of habitat loss and overharvesting, in addition to natural environmental variations, is leading to significant changes in species composition over time, with the size spectrum of fish becoming smaller. With climate variations, annual landed value is estimated to decrease by 21% with an annual loss of $311 million for the entire economy of the region by 2050s (Badjeck *et al.*, 2010). The region is operating below its optimum level of ocean health and falls in the highest risk group, scoring a low 58 out of 100 on its ocean health index, compared to other large marine ecosystems (Kershaw *et al.*, 2016). The marine trophic index has also declined since the mid-1970s although there has been 18.57% increase in the coverage of marine protected areas between 1983 and 2014, from 829 km² to 16,216 km², respectively (Robin *et al.*, 2015).

3.4.4.2.5 Deep sea

In general, information about the deep sea megafauna is limited, although the echinoid *Phormosoma placenta* is known as a common and abundant species in the subregion (Jones *et al.*, 2013). More than 650 deep-water and near-shore species of marine bony fish have been recorded in West Africa (CEPF, 2015). Of the 87 species of sharks and rays assessed, 54% are found to be threatened (CEPF, 2015).

3.4.5 Southern Africa

3.4.5.1 Terrestrial

3.4.5.1.1 Tropical and subtropical dry and humid forest

Status: The tropical dry forests of Southern Africa are located in Zambia, encompassing approximately 38,073 km² of dry evergreen forest (WWF, 2017b). These forests represent a transition from Guineo-Congolian rainforest to Zambezian woodlands and are species-rich, but contain few endemics such as *Crypotsepalum exfoliatum pseudotaxus*, known locally as "mavunda" (WWF, 2017b). These forests in Zambia are a home to 17 species of amphibians, 175 species of birds, 89 species of mammals, 9 species of reptiles and 30 species of plants (IUCN, 2017). In South Africa, forest covers only about 17,600 km² **(Table 3.10)**, though there are patches of forest located within the savannah biome **(Table 3.11)**.

Trends: About 40% of Zambian primary forest has been lost particularly in the northern region (Zambia, 2015). This trend is evident in the rapid depletion of Zambia's natural forests with the deforestation rate currently estimated between 250,000–300,000 hectares/year. According to Chidumayo (2013), Zambia has lost a significant portion of its forest cover since 1990 to 2012 with impacts on wood biomass **(Figure 3.18)** an important contribution of nature to people. Indeed forest degradation was estimated to cause aboveground wood biomass loss of 0.3 tons/hectare/year on the least impacted site to 4.0 tons/hectare/year on the most impacted site. The biodiversity of the Southern African dry forests in Zambia is slightly declining, with 2.85% of bird species, 5.61% of mammal species and 6.66% of plant species threatened to extinction (IUCN, 2017).

Table 3 10 **The average fraction of the 'natural populations of plant and vertebrate groups estimated to remain in the major biomes of South Africa. Source: van Jaarsveld *et al.* (2005).**

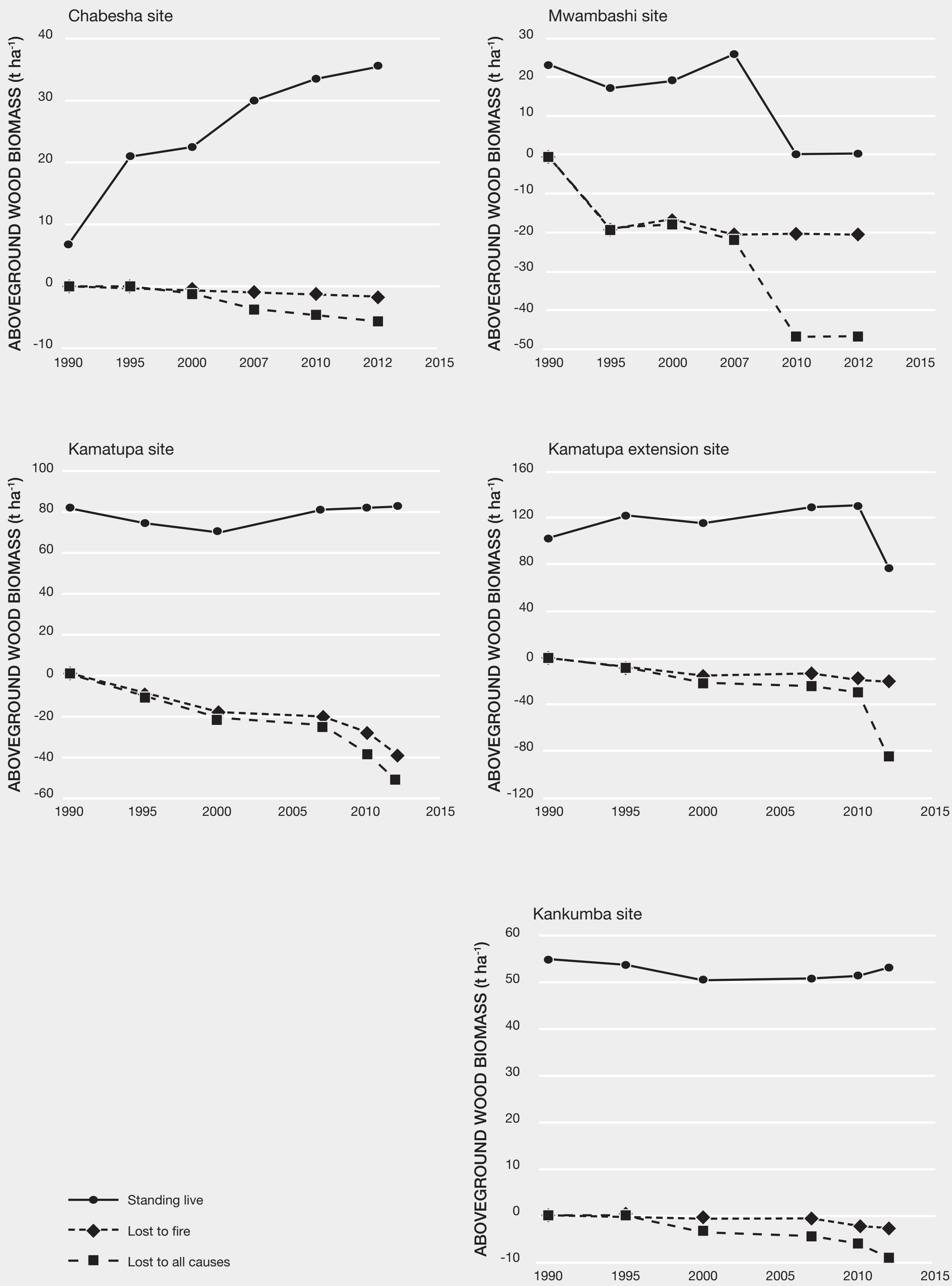
	Area (km²)	Plants	Mammals	Birds	Reptiles	Amphibia	All taxa
Forest	176,893	0.75	0.75	0.92	0.86	0.85	0.78
Savana	2,329,550	0.86	0.73	0.96	0.89	0.96	0.87
Grassland	408,874	0.72	0.55	0.90	0.76	0.81	0.74
Shrubland	750,217	0.86	0.72	1.06	0.93	1.27	0.89
Fynbos	78,533	0.75	0.78	0.91	0.77	0.79	0.76
Wetland	95,166	0.91	0.83	0.94	0.92	0.95	0.91
All biomes	3,839,233	0.82	0.71	0.96	0.88	0.95	0.84

Table 3 11 **Biodiversity status in the three major Gariep biomes. Source: van Jaarsveld *et al.* (2005).**

Biome	Area (km²)	Species richness[1]	Endemic spp.[2]	Endangered spp.[3]	Protected area[4] (%)	Transformed area[5] (%)
Grasslands	215,508	1,377	144	112	2.7	28.8
Savannah	190,646	1,424	106	102	10.6	6.7
Nama Karoo	237,147	979	99	73	1.3	1.5

1: Species data for birds, butterflies, mammals, reptiles and scarabs from SA-ISIS (https://www.csir.co.za).
2: Endemic to South Africa.
3: Endangered if listed in the Red Data Books for birds and mammals. Other taxa assessed by expert opinion.
4: Based on data from Department of Water Affairs and Forestry (DWAF), Pretoria, South Africa.
5: Based on National Land-Cover Database (Thompson 1996).

Figure 3 18 **Zambia: Trends in aboveground wood biomass in Zambia where the largest portion of forest exist in Southern Africa. Source: Chidumayo (2013).**



A decline in forest area has also been seen in South Africa which consist of Afrotemperate forests that are mainly found in the southern Cape region and other areas where there are ravines protected from fire. For example, since 1944, when there were 7,143 hectares of indigenous forest in the Karkloof-Balgowan region, there has been a 5.7% decline in forest area to 6,739 hectares in 1996 (Lawes *et al.*, 2004).

Future dynamics: The Zambezian dryland forests of Angola and Zambia appear not be threatened in the near to medium term due to the small human population, poor agricultural potential and lack of water (WWF, 2017b). However, in South Africa, there has been a decrease in the area of natural forest between 1990 and 2015. According to Biggs *et al.* (2008), the observed erosion of forest in South Africa is due to land conversion for cultivation and is predicted to suffer the most dramatic loss in future.

3.4.5.1.2 High mountain habitats and Grassland

Status: The two major mountain formations in Southern Africa are the Southern African Great Escarpment, and the Cape Fold Mountains. These mountains provide a range of ecosystem services including water catchments, food production (both grazing and crops), forestry plantations or mining and tourism (Blignaut *et al.*, 2010).

The Southern African Great Escarpment extends in a 5,000 km horse-shoe formation from the border between Mozambique and Zimbabwe in the north-east, through South Africa and Lesotho to Namibia and Angola in the northwest. The Great Escarpment provides most of the freshwater in Southern Africa and is home to an estimated 8,574 plant species, of which 17% are endemic (Clark *et al.*, 2011). Vegetation types vary with altitude and rainfall, ranging from tropical evergreen and semi-deciduous rainforest in northern Angola, through to Afromontane forest-grassland mosaics and miombo woodland, through to Highveld shrublands, Nama-Karoo semi-desert, and fynbos (Clark *et al.*, 2011). There are also many endemic fauna in the montane areas of Southern Africa and include mammals such as the oribi, reptiles such as the cream-spotted mountain snake (*Montaspis gilvomaculata*), cottrell's mountain lizard (*Tropidosaura cottrelli*, Near Threatened) and essex's mountain lizard (*T. essexi*, Least Concern). It also includes amphibians such as the Maluti river frog (*Amieta umbraculata*) and the Phofung river frog (*A. vertebralis*) (Perera *et al.*, 2011). Lesotho's Sehlabathebe national park also harbours the Maloti minnow (*Pseudobarbus quathlambae*, Endangered), a critically endangered fish species only found in this park. Range-restricted birds include the Drakensburg Rock-jumper, Drakensburg Siskin as well as a breeding stronghold for Cape and Bearded vulture (Perera *et al.*, 2011).

Data availability and conservation capacity varies along the escarpment, the most data deficient area being Angola and the best studied being the east (South Africa, Lesotho and Swaziland). The Great Escarpment Biodiversity Programme is a multi-disciplinary collaboration that aims to collect biogeographical data of relevance to conservation policy and predicting future responses of montane ecosystems. There are several transfrontier conservation initiatives, including the Richtersveld transfrontier national park between Namibia and South Africa, the Maloti–Drakensberg Transfrontier Park between South Africa and Lesotho, and the Chimanimani transfrontier conservation area between Zimbabwe and Mozambique.

The highest mountain ranges of the Great Escarpment are the Drakensberg (altitude 2,000–3,000 metres). The Drakensberg are characterized by high altitude grasslands with over 2,500 species of higher plants. The Maloti-Drakensberg Park which is a transboundary site is composed of the uKhahlamba Drakensberg national park in South Africa and the Sehlabathebe national park in Lesotho. Maloti national park in South Africa was designated specifically to protect water catchments (Egoh *et al.*, 2012).

Vegetation of the Cape Fold belt is primarily fynbos, a species-rich, fire-prone shrubland that is unique to Southern Africa. Afrotemperate forests co-exist alongside fynbos, in wetter areas that are protected from fire. The Cape Fold Belt is an important part of the Cape Floristic Region, one of 25 global biodiversity hotspots (Mittermeier *et al.*, 1998). It is the smallest and richest internationally recognised floral kingdom containing more than 9,000 plant species, of which 68% are endemic (Myers *et al.*, 2000; Rejmánek, 2001; Manning *et al.*, 2012). It is a global conservation priority because of species richness, endemism, and rates of transformation; about 30.3% of its primary vegetation has already been lost.

Trends: Land outside of protected areas is threatened existing and emerging invasive alien species (especially Australian Acacias), including pollution /mining impact, and habitat loss, the compounding effects of climate change as well as by growing numbers of high density rural settlements, particularly in the KwaZulu-Natal Drakensberg foothills (Blignaut *et al.*, 2010, Clark *et al.*, 2011, Egoh *et al.*, 2011; Turpie, 2016).

Future dynamics: Projected increases in temperatures, decreases in precipitation and longer dry seasons are likely to become important drivers of change in Southern African mountain systems. Direct impacts include physiological stress, mortality and range shifts in species, and altered composition and function at ecosystem levels. Resulting changes in fire regimes are likely to have important indirect impacts on the region's biodiversity. Climate change also presents an important threat to water and food security in Southern Africa. An estimated 97% of Cape Town's water originates from surface water from mountain catchment areas (Lonsdale *et al.*, 2009). At the time of writing, Cape Town's dammed water reserves were at 24% despite severe water restrictions (City of Cape Town, 2017). Ingoing immigration and population growth in the region is likely to exacerbate water shortages in the future.

3.4.5.1.3 Savannah and grassland

Status: The savannas and grasslands represent the largest area in Southern Africa occupying 54% of its territory (Cowling *et al.*, 1997) covering about 139,000 km^2. It contains within it vegetation types such as Miombo, Mopane, Zambezian and Kalahari Acacia-Baikiaea Woodlands as well as the Kalahari Xeric Savanna (Cowling *et al.*, 1997). Many of these savanna vegetation types are utilized for grazing by livestock animals or wildlife. The subregion boasts an average of 57 mammalian species and 136 breeding bird species per 10,000 km^2 (UNEP *et al*., 2002). Southern Africa's rich biodiversity plays an important role in ensuring long-term food security and provision of basic materials to people especially rural people who make up approximately 60% of the total population in most countries in the region (World Bank, 2016). Also, about 10% of Southern African plants (roughly 3,000 species) are used medicinally, and about 350 species are widely utilized (van Wyk *et al.*, 1997). Much of the savanna is under protection with the existence of large game Parks such as Kruger National Park in South Africa and Hwange in Zimbabwe and many private game reserves, safaris and conservancies (SANBI, 2017) complemented by the existence of Transfrontier Conservation Areas such as Great Limpopo. This also provides important economic benefits from tourism and big game hunting.

Trends: The savanna terrestrial unit of analysis itself is under pressures such as expansion of agriculture and plantation forestry, poaching, spread of invasive alien species, human settlements, mining activities, and other commercial or subsistence activities, both inside and outside of protected areas (UNEP *et al*., 2002). Poaching continues to be a problem and 1004 rhinos were killed by poachers in South Africa in 2013 alone (RSA, 2014). Threatened vegetation types within Savannah include Tzaneen Sour Bushveld and Lebombo Summit Sourveld (Mucina *et al.*, 2006). Individual species are also threatened and declining in numbers and diversity (UNEP *et al*., 2002). Threatened vegetation types within the Grassland Biome include the Northern Escarpment and the Woodbush Granite Grassland (Mucina *et al.*, 2006). High altitude grasslands are threatened by agriculture, mining and commercial forestry, as well as inappropriate fire management, overstocking and soil erosion (Blignaut *et al.*, 2010; Clark *et al.*, 2011, Egoh *et al.*, 2011), and a growing numbers of high density rural settlements, particularly in the KwaZulu-Natal Drakensberg foothills.

Future dynamics: At current rates of urbanisation coupled with climate change, the savanna terrestrial unit and the individual species within it are likely to continue declining if no concerted efforts are made at policy level to reverse this trend. Currently, there is an emerging trend for increasing woody vegetation with the possibility of biome switches between savanna and forest vegetation types driven by CO_2 enrichment (Higgins *et al.*, 2012).

3.4.5.1.4 Dryland and desert

Status: In Southern Africa, dryland and desert are diverse and are represented by various ecosystems such as the Succulent Karoo, Namib Desert, Nama Karoo and the Kalahari Desert and xeric savanna (WWF, 2017a). The Succulent Karoo stretches from the western coast of Namibia to South Africa (Jürgens *et al.*, 1999), covering an area of approximately 102,000 km^2 (WWF, 2017a). In terms of species diversity, the Succulent Karoo boasts about 5000 higher plant species of which 40% are endemic and has the highest succulent diversity in the world with about 1,000 species (435 species of miniature succulents and 630 species of geophytes) (WWF, 2017a). Also, about 67 genera and 1,940 species of both flora and fauna are endemic to this region which is made up of 4 centres of endemism (Hilton-Taylor, 1994). For these reasons, the Succulent Karoo qualifies as a global biodiversity hotspot (CEPF, 2016). Less than 3% of the succulent Karoo is protected in statutory reserves (WWF, 2017a) but two new developments are positive signs for the future of the Succulent Karoo. These include the creation of the Namaqua national park which is set to expand westwards to encompass Sandveld habitats on the coastal plain. Also, public awareness of the value of the region is growing through the Succulent Karoo Ecosystem Programme which among other actions is leading to increased efforts of landowners in the region to adopt biodiversity-friendly land-use patterns (Loon, personal communication).

The Namib Desert is the world's oldest and has been arid for 55 million years (Barnard *et al.*, 1998). It is home to many endemic species adapted to the hyper-arid conditions, and coastal fog. The desert hosts 70 reptile species, of which 20 are endemic, and the popular gymnosperm plant, *Welwitschia mirabilis,* the Namibian wolf snake (*Lychophidion namibianum*) and amphibian Damaraland pygmy toad (*Poyntonophrynus damaranus*) are also endemic here. Most of the Namib Desert is protected in conservation areas (Maggs *et al.*, 1998). The Nama Karoo is confined to the Northern, Western and Eastern Cape Provinces of South Africa (WWF, 2017a) and has low species diversity and endemism (WWF, 2017a). Vegetation here is dominated by members of the Asteraceae, Poaceae, Aizoaceae, Crassulaceae and Fabaceae (Palmer *et al.*, 1997; Mucina *et al.*, 2006). Very little of the Nama Karoo is protected (Barnard *et al.*, 1998).

Transnational, is the Kalahari xeric savanna which stretches from north-western South Africa through southern Botswana to south-eastern Namibia (WWF, 2017a). The Kalahari Desert is considered to have the lowest species diversity and animal endemism in southern Africa (van Rooyen, 1999). The Kalahari Desert is relatively well conserved with protected areas such as Kgalagadi Transfrontier Park which cover more than 34,000 km^2.

Trends and future dynamics: All ecosystems in this terrestrial unit are facing decline due to anthropogenic disturbances such as overgrazing, mining, illegal harvesting of succulents, disruptive off-roading activities by tourists, unregulated water extraction affecting water table, veterinary fences hindering ungulate migration, human-wildlife conflicts and alien invasive species (Albertson, 1998; Lovegrove, 1993; WWF, 2017a). Charismatic species with declining populations include halfmen (*Pachypodium namaquanum*, Lower Risk/near threatened), quiver trees (*Aloe dichotoma*) and *Aloe ramossisima* (WWF, 2017a). The African wild dog is most severely threatened especially in the Nama Karoo (Hilton-Taylor, 2000). The drylands and desert in Southern Arica will continue to decline unless activities such as mining are halted and more protected areas are established.

3.4.5.1.5 Urban/Semi-urban

Status and trends: Urbanisation is increasing rapidly in most parts of Southern African particularly South Africa and Zambia, where more than 50% of the population already live in urban areas (Mwendera, 2010). In South Africa, urbanisation is most rapid in Johannesburg or the wider Gauteng province area. By 2014, the Johannesburg area is in the 5–10 million category (although some debates regarding numbers have been engaged in, as well as consideration of the greater municipality area). By 2014, Luanda also fell within the 5–10 million size category. By 2030, the World Urbanisation Prospects 2014 analysis predicts the Gauteng area as a 10 million or more megacity, although no hotspots of 100% probable expansion to urban areas are found in the Seto *et al.* (2012) analysis.

Future dynamics: About 59% of the population of Southern Africa lives in urban areas, and is predicted to increase to 78% by 2050 (UN-habitat, 2010).

3.4.5.1.6 Cultivated lands

Status and trends: The agrobiodiversity in Southern Africa, as in other parts of Africa and globally, is of great importance at both small scale and large commercial farmers through its provision of ecosystem services (FAO, 2007a). The cultivated lands in Southern Africa represents 40–60% of the land cover, with 53 known green vegetables/crops, of which 27 are underutilized and 26 are major commercial crops (Mabhaudhi *et al.*, 2016). An example of major commercial crops would be maize–a major source of livestock feed, and export crops in some countries (van Wyk *et al.*, 2000). Southern Africa is also endowed with a great variety of indigenous/traditional fruits commonly known as crop wild relatives, and non-domesticated animals. About 1,593 taxa (species, subspecies and varieties) of crop wild relative species are known in Southern Africa, 258 of these have been selected as focal species based on their conservation status, level of endemism, current economic value, their use as food and their breeding potential (Mogale *et al.*, 2017). Among the 404 known mammalian and avian breeds in Southern Africa, 44 are categorised as at risk (FAO, 2007a; **Figure 3.18 & 3.20**). However, this is probably an underestimate of the actual situation, primarily because of a lack of information (FAO, 2007a).

Southern Africa is a home to several distinct farming regions and farming activities range from intensive crop production, to cattle ranching in the bushveld and sheep farming in the more arid regions (Auricht *et al.*, 2014). These farming systems have become inadequate to cope with population growth explosions and lack investment in African farming systems that are experienced in the region (FAO, 2007a).

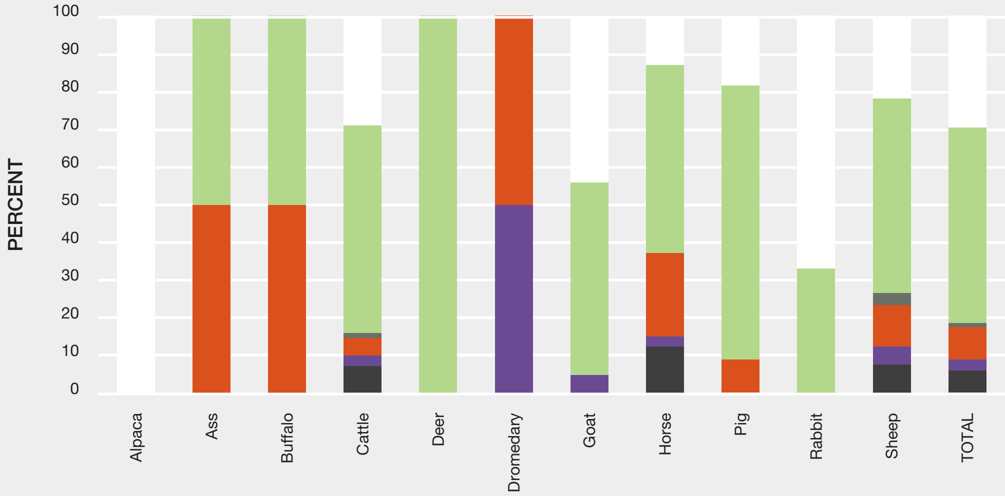
Future dynamics: Interesting changes in food consumption and production due to population growth have been evident since the 1970s in Southern Africa in particular South Africa (WWF, 2017e). The average production of maize for instance in South Africa has remained constant over time since 1970s (WWF, 2017e). This is a concern, as consumption has increased with the growing population and maize production may soon not meet local demand, affecting both local and regional supply. Apart from population growth, water scarcity and climate change is compelling farmers to the move toward genetically modified crops in South Africa. This shift in itself will not only impact biodiversity in cultivated lands but it presents Southern Africa with a possibility of being isolated from lucrative export markets (WWF, 2017e).

3.4.5.2 Aquatic (Freshwater, Coastal and Marine)

3.4.5.2.1 Freshwater

Status: Southern Africa's wetlands are among the most diverse, both physically and biologically of any in the world (Taylor *et al.*, 1995; Darwall *et al.*, 2009). A systematic assessment of river biodiversity revealed

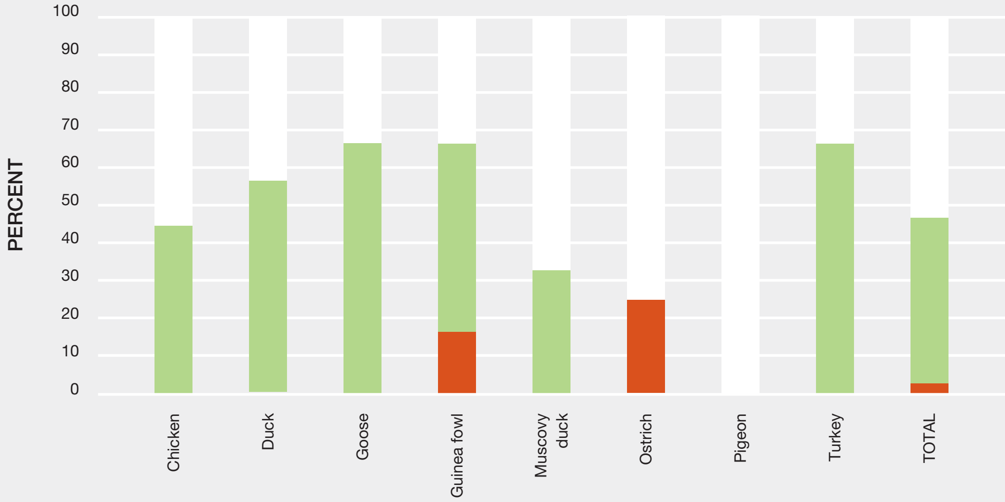
Figure 3 19 **Risk status of livestock breeds recorded in Southern Africa* as of December 2005: absolute (table) and relative (chart) figures. Source: FAO (2007a).**



RISK STATUS	Alpaca	Ass	Buffalo	Cattle	Deer	Dromedary	Goat	Horse	Pig	Rabbit	Sheep	TOTAL
Extinct	0	0	0	9	0	0	0	5	0	0	5	**19**
Critical	0	0	0	3	0	1	2	0	0	0	3	**10**
Endangered	0	1	1	6	0	1	0	9	3	0	7	**28**
Endangered maintained	0	0	0	2	0	0	0	0	0	0	2	**4**
Not at risk	0	1	1	71	1	0	22	20	18	4	34	**172**
Unknown	1	0	0	37	0	0	19	5	13	8	14	**97**
TOTAL	**1**	**2**	**2**	**128**	**1**	**2**	**43**	**34**	**34**	**12**	**65**	**330**

* Breeds that are also recorded in countries outside Africa are excluded from the analysis.

Figure 3 20 **Risk status of avian domestic breeds recorded in the Southern Africa* as of December 2005: absolute (table) and relative (chart) figures. Source: FAO (2007a).**



RISK STATUS	Chicken	Duck	Goose	Guinea fowl	Muscovy duck	Ostrich	Pigeon	Turkey	TOTAL
Endangered	0	0	0	1	0	1	0	0	**2**
Not at risk	21	4	2	3	1	0	0	2	**33**
Unknown	26	3	1	2	2	3	1	1	**39**
TOTAL	**47**	**7**	**3**	**6**	**3**	**4**	**1**	**3**	**74**

* Breeds that are also recorded in countries outside Africa are excluded from the analysis.

that 84% of river ecosystems are threatened, including 54% critically endangered (Nel *et al.*, 2007). Of the 1,279 freshwater species assessed at the regional scale, just over 7% are regionally threatened (Darwall *et al.*, 2009).

Trends: Freshwater ecosystems and species are threatened by habitat loss and degradation, including groundwater extraction and dam construction, pollution (e.g., from mining waster, and over-harvesting, and alien invasive species (Darwall *et al.*, 2009; Darwall *et al.*, 2011). Invasive alien species include deliberately introduced exotic fish (e.g., *Micropterus dolomieu*, Least Concern, *Oncorhynchus mykiss* and *Salmo trutta,* Least Concern, and species of the cichlid genus *Oreochromis*) and invasive plants such as the water hyacinth, and black wattle which invades riparian corridors. Increasing development pressure is expected to lead to deterioration in the status of southern Africa's freshwater biodiversity. Water transfer schemes are also a threat to lake ecosystems, as they allow mixing of previously separated populations of fish, with the potential for competition, predation and hybridization (Darwall *et al.*, 2011).

Future dynamics: Climate change and climate variability, especially increased frequency of drought are likely to further impact freshwater systems that are already stressed by multiple factors.

3.4.5.2.2 Shelf-ecosystem

Status: The coastal areas extend along the 10,000 km of coastline from Angola on the Atlantic Ocean side to Tanzania on the Indian Ocean side. Near-shore ecosystems of Southern Africa include cold temperate (Atlantic), warm temperate, and sub-tropical (Indian Ocean), which experience different stressors and have varied responses to climate change. Fisheries on the cold temperate west coast of southern Africa are fed by the nutrient-rich waters of the Benguela upwelling system. Anchovy and sardine are the dominant species in pelagic fisheries. Excessive fishing pressure led to the collapse of Namibian and South African sardine, beginning in the 1960s. The demersal fish community has also changed, with a decline in slower-growing long-lived species. West coast rock lobster populations have also declined dramatically due to a combination of overfishing and low oxygen water, and the species is now severely overfished (DAFF, 2014). The demise of prey populations has impacted on livelihoods, and also on predators such as sea otters, penguins, gannets and cormorants. Nevertheless, the west coast Benguela marine ecosystem is still productive, and there is no evidence that any species have been lost. Tourism is also an important source of gross domestic product and livelihoods, as are oil, natural gas and diamonds.

There is a rich coastal and marine biodiversity associated with the fringing and patch coral reefs and mangrove forests in Tanzania and Mozambique (UNEP, 2005a). Large stands of mangroves are found at the mouths of the Zambezi, Save, Pungue, and Limpopo rivers along the coastline of Mozambique. The dominant trees are *Rhizophora racemosa* (Least Concern), *R. mangle* (Least Concern), *R. harrisonii* and, *Avicennia Africana*. In Angola, mangrove communities occur at the mouths of the Cuvo, Longa, Cuanza, Dande, and M'Bridge Rivers (Huntley *et al.*, 1994), though they are not as extensive as the vast mangrove swamps at the mouth of the Zaire River. In South Africa, the distribution of mangrove forests (temperate and subtropical) is patchy and the drivers of the mangrove's distribution are still poorly understood. A changing climate that results in increased temperature may favour the expansion southward of mangrove forest in South Africa's estuaries (Hoppe-Speer *et al.*, 2013; Kairo *et al.*, 2016). In the Eastern Cape, mangroves are located in one of the most southerly mangrove distributions in the world (Hoppe-Speer *et al.*, 2013). Along the east coast of South Africa, 6 species in Kosi Bay (*Avicennia marina* (Least Concern)*, Bruguiera gymnorrhiza, Rhizophora mucronata* (Least Concern)*, Ceriops tagal* (Least Concern)*, Lumnitzera racemosa* (Least Concern) and *Xylocarpus granatum* (Least Concern) and 3 in Nahoon (*Avicennia marina*, Least Concern*, Bruguiera gymnorrhiza* and *Rhizophora mucronata*, Least Concern) are found.

Mangroves are traditionally used for charcoal, firewood, building material for housing, fences and fish traps, but also for medicine (notably in Mozambique). Mangroves have also been considered efficient systems for the removal of nutrients and other pollutants (Lewis *et al.*, 2013). In response to drought and non-tidal conditions (as a result of mouth closure in St Lucia Estuary, South Africa), Hoppe-Speer *et al.* (2013) showed that mangrove species have difficulties in surviving such harsh conditions. Mozambique, the Foundation for the Conservation of Biodiversity is promoting mangrove conservation. In South Africa, Kosi, St. Lucia, Mfolozi and Mhlathuze Estuaries account for about 75% of mangroves and except Mfozoli that are protected.

Coral communities occur in shallow waters of Mozambique, Tanzania, and on the Maputoland Reef in KwaZulu-Natal, South Africa (Obura *et al.*, 2004). All five species of marine turtles occurring in South African waters are listed on the IUCN Red List as either 'vulnerable' or 'endangered', as well as the blue whale (*Balaenopteramusculus intermediais*, Endangered). Four other marine mammals occurring in South African waters are considered to be 'vulnerable' namely, Indian Ocean bottlenosed dolphin (*Tursiops aduncus*), Indian Ocean humpback dolphin (*Sousa plumbea*, Endangered), sperm whale (*Physetter microcephalus*) and Bryde's whale (*Balaenoptera brydei*) (Atkinson *et al.*, 2005).

3.4.5.2.3 Open Ocean

Status: Offshore areas are important habitat for many threatened seabirds, turtles and deep water fish, but most offshore habitats remain unprotected and poorly studied (Sink *et al.*, 2011). Offshore to the limit of the exclusive economic zone on the Atlantic side, the seas are influenced by the cold, northward-flowing Benguela current large marine ecosystem, with highly productive upwelling supporting industrial-scale fisheries. The east coast, under the influence of the East African Coast Current flows northward along the coast of Tanzania and southward towards Mozambique while the Agulhas Currents, is sub-tropical in South Africa (UNEP, 2005b). These waters are moderately productive with an average of 150–300 grams of carbon per square metre/year with considerable spatial variability in the productivity. Ecosystem goods and services have been estimated between $54.3 and $269 billion/year (Costanza *et al.*, 2014).

The marine resources of Southern Africa are rich and diverse, with commercial and recreational fisher catch at over 250 marine species (Mann, 2000). High catches have significantly decreased between 1965 and 1989, with stable total production capture of 1.4 million tons/year in the last decade, which mainly come from the exclusive economic zones of Angola, Namibia and South Africa (FAO, 2016). The Southeast Atlantic has shown a decreasing trend in catches since the early 1970s, from a total production of 3.3 million tons to 1.3 million tons in 2013. Horse mackerel and hake represent the most important species in terms of landings, with 25 and 22%, respectively. Stocks of both deep-water hake off South Africa and shallow-water Cape hake off Namibia have recovered to biologically sustainable levels as a consequence of good recruitment and strict management measures introduced since 2006. Southern African pilchard and anchovy stocks have improved and were categorised as fully fished in 2013. Whitehead's round herring is not fully fished. However, the condition of Cunene horse mackerel remained overfished in 2013. The condition of the perlemoen/abalone stock, targeted heavily by illegal fishing, has deteriorated and remains overfished.

Trends and future dynamics: Marine and coastal ecosystems face a similar range of threats as terrestrial systems, including overharvesting, climate change, pollution and invasive species. According to Sink *et al.* (2011), fisheries remain the biggest threat in South African coastal systems, while invasive species and climate change are emerging as threats to these systems. As climate warms, temperate communities are declining and tropical communities are increasing as these communities expand into areas formerly dominated by warm temperate species. On the eastern coast, (Lloyd *et al.*, 2012) recorded a decline in temperate species and an increase in tropical species, associated with warming sea temperatures. On the shallow Aghulas bank, several species of endemic seabreams and sciaenid's have been severely over-exploited, whereas warm water corals have been well protected. At the same time, cold water kelps and associated fauna are also penetrating the warm temperate zone (Bolton *et al.*, 2012). Habitat loss will lead to declines in marine species on which many coastal communities depend for food and employment.

3.4.5.2.4 Deep sea

Status and trends: Offshore areas are important habitat for many threatened seabirds, turtles and deep water fish, but most offshore habitats remain unprotected and poorly studied (Sink *et al.*, 2011). Seamounts and other complex, raised seabed features in the open ocean are often hotspots of biological diversity and production. Some attract concentrations of commercially-important pelagic fish, such as tuna, and concentrations of animals such as cetaceans, seabirds, sharks and pinnipeds. Seamounts also host deep-water fish species, such as orange or alfonsino that are highly attractive to commercial operator. The unsustainable nature of deep-sea fisheries and their impacts on seabed life raised concerns amongst the international community. One approach, adopted by the deep-sea fishing industry in some regions was to voluntarily close areas of the deep sea to trawling where they suspected there were concentrations of vulnerable marine ecosystems as a result of high levels of by-catch of corals and other habitat-forming species. Another approach was to try and estimate the distribution of vulnerable marine ecosystems like cold-water coral reefs through habitat suitability modelling and then to feed this information into spatial management of deep-sea fisheries to prevent impacts. Artisanal fisheries in the Indian Ocean are critical for the livelihoods and food security of the populations of coastal States in the region, particularly island nations such as the Seychelles. The offshore fisheries of the western Indian Ocean are rich but countries within the region have been unable to develop the infrastructure to exploit these fisheries. As a result they have allowed the distant-water fishing fleets of developed countries to access fish resources through multilateral or bilateral agreements. Currently (as of July 2010), there is little or no information available for the assessment of the impacts of deep-sea fishing in high-seas areas of the Indian Ocean on populations of target or bycatch species.

Future dynamics: A systematic approach to conservation planning and management has been applied in some terrestrial and coastal areas to maintain ecosystem health and guide sustainable use, but governance of high seas areas is currently weak (Ban *et al.*, 2014). The recent Phakisa initiative aims to establish 22 offshore Marine Protected Areas in the South African Economic Exclusion Zone.

3.5 IMPACT OF BIODIVERSITY CHANGES ON NATURE'S CONTRIBUTION TO PEOPLE

The contribution of nature to people is mostly recognised through different aspects of biodiversity, ecosystem processes and ecosystem functions that deliver services which are harnessed by humans for their well-being **(Figure 3.21)**. Scientists and policymakers throughout the world recognise that the delivery of most ecosystem services is underpinned by biodiversity and ecological functions (MA, 2005; Díaz *et al.*, 2006; Egoh *et al.*, 2009; Maes *et al.*, 2012; Balvanera *et al.*, 2014; Harrison *et al.*, 2014; **Figure 3.21**). The link between biodiversity and ecosystems services can be traced from individual species or a group of species to ecological processes and ecosystem functions (Díaz *et al.*, 2007; Luck *et al.*, 2009; Maes *et al.*, 2016). The relationship between biodiversity and ecosystem services is indeed complex with some services delivered by single species while others are delivered by either a combination of species, functional traits or habitat types **(Figure 3.22)**.

In most cases, species abundance and richness are particularly important for provisioning services such as timber production, fish production and medical plants, while habitat extent and functional diversity or traits are important for regulatory services such as water purification and regulation (Harrison *et al.*, 2014; **Figure 3.22**). Although this link needs to be proven in different continents, the relationship is mostly the same for most services but the underlying biodiversity may be different.

Since the relationship between biodiversity and ecosystem services is mostly positive, decline in individual species that play a central role in the ecosystem may have serious consequences for ecological processes that underpin nature's contribution to human well-being (Schwartz *et al.*, 2000). Also, habitat degradation impacts both species and ecological functions. For example, losses in forest cover can result in loss of timber species as well as loss in litter cover, which is important for water infiltration. However, the most important biodiversity attribute that impacts ecosystem services is functional diversity as it mainly impacts on the underlying processes (Díaz *et al.*, 2006; Flynn, 2009; Harrison *et al.*, 2014). Areas identified as hotspots for biodiversity have also been shown to overlap with areas important for the provision of ecosystem services, with degradation in such areas, resulting in negative impacts in multiple ecosystem services (Naidoo *et al.*, 2008; Anderson *et al.*, 2009; Egoh *et al.*, 2009). Indeed, the complete impacts of biodiversity on ecosystem services are nonlinear and complex and yet fully understood (Costanza *et al.*, 2007).

The governance of nature also occurs at multiple scales which does not necessarily align with the beneficiaries and depends on several factors including the value of nature.

Figure 3 21 **Links between nature and people. Source: Maes *et al.* (2016).**

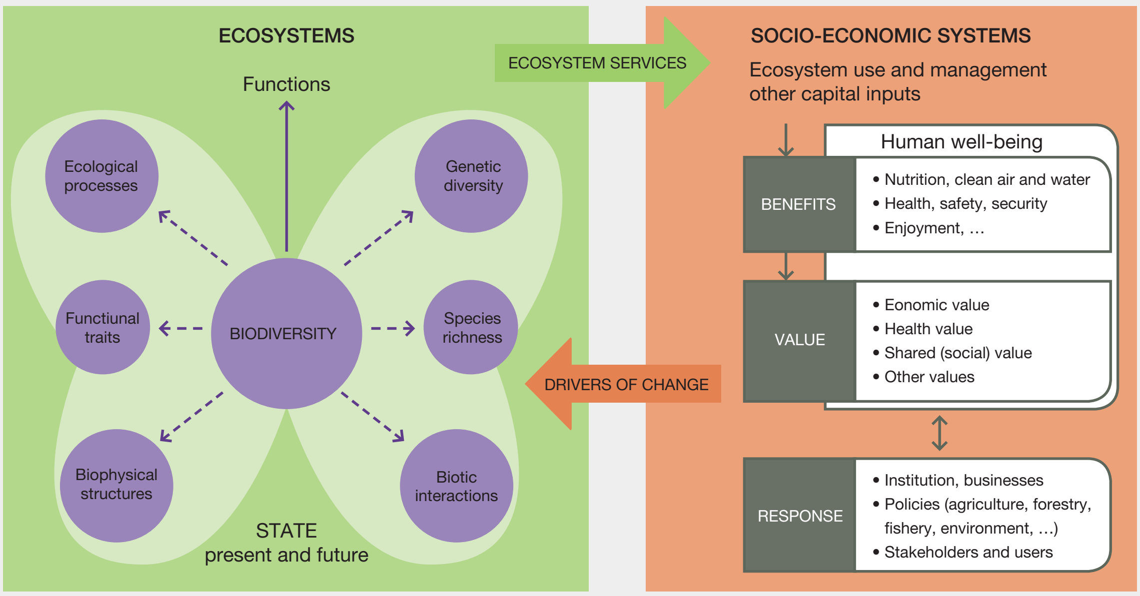


Figure 3 22 **Summary of positive and negative relationship between biodiversity and nature's contribution to people:**

↑ = strong positive relationship; ↑ = moderate positive relationship; ↓ = moderate negative relationship.
Source: Bugter *et al.* (2015).

	SPECIES ABUNDANCE	SPECIES RICHNESS	SPECIES DIVERSITY	SPECIES SIZE/WEIGHT	MORTALITY RATE	FUNCTIONAL RICHNESS	BEHAVIOURAL TRAITS (POLLINATION)	BEHAVIOURAL TRAITS (BIOCONTROL)	COMMUNITY/HABITAT AREA	COMMUNITY/HABITAT STRUCTURE	PRIMARY PRODUCTION	ABOVEGROUND BIOMASS	BELOWGROUND BIOMASS	STEM DENSITY	COMMUNITY/HABITAT AGE	LITTER/CROP RESIDUE QUALITY
PROVISIONING SERVICES																
Timber production	↑	**↑**↓														
Freshwater fishing	↑	↑		↑	↓						**↑**					
Freshwater provision									↑↓					↓	↓	
REGULATING SERVICES																
Water purification		↑							**↑**							
Water flow regulation									**↑**	↑					↑	
Mass flow regulation		↑							↑	↑		↑	↑			
Atmospheric regulation		↑	↑	↑	↓					↑		↑	↑		↑	↑
Pest regulation	↑	↑			↑			↑	↑	↑						↑
Pollination	↑↓	**↑**				↑										
CULTURAL SERVICES																
Recreation (species)	↑↓	↑	↑	↑												
Landscape aesthetics									↑	**↑**						

However nature is governed, unsustainable use of nature due to gaps in governance will threaten the livelihood of the very same people who benefit from it. Therefore most of the key drivers affecting nature's contributions to humans are also those associated with the use of nature by humans through ecosystem services. For example, humans use grazing land for meat production but overgrazing is a serious threat to the continuous delivery of the services (Anderson *et al*., 2007). Other examples include overharvesting, overfishing and water extraction which are all listed as drivers hampering nature's contributions to people. The benefits of nature can only be achieved if use is sustainable through good governance across all scales.

3.6 DATA GAPS

Research on nature's contribution to humans on regulatory and non-material contribution is largely lacking in most parts of Africa. Moreover most of the work in nature's contribution to people in regulating climate, water, soils and other regulatory services in mostly biased towards Southern Africa while material contributions such as non-forest timber products are biased towards areas with forest.

3.7 CONCLUSIONS AND RECOMMENDATIONS

Africa is very rich in biodiversity and is the last place on Earth with a largely number intact assemblage of mammalian megafauna. The continent has significant regional, subregional and national variations in biodiversity that reflect climatic and physical differences, as well as its long and varied history of human interactions with the environment. Africa's natural richness coupled with the wealth of indigenous and local knowledge on the continent, is central to, and constitutes a strategic asset for, the pursuit of sustainable development. Africa has diverse forests, woodlands, savannas, grasslands, arid zones, deserts, wetlands, inland surface waters and freshwater bodies like rivers, lakes and estuaries and the continent is surrounded by six large marine ecosystems. Most, if not all, terrestrial ecosystems in Africa have already experienced major biodiversity losses in the past 30 years, which has negative impacts on nature's contribution to people. Unfortunately, unless major policy interventions are implemented, the prospect is that this trend will continue in the future. Africa's highly diverse terrestrial ecosystems are threatened by the land-use change (land conversion to agriculture, deforestation, habitat fragmentation) and climate change.

Freshwater biodiversity in Africa is under severe pressure with the majority of threatened species are found in areas with high levels of development and demand on water resources, mainly along the Mediterranean and Atlantic coasts of Morocco, Algeria and Tunisia, in Upper and Lower Guinea, southern and eastern South Africa and in the Great lakes in eastern Africa. Much of Africa's marine and coastal biodiversity is also threatened. The wide continental shelf along the northwest coast of Africa, mangrove forests of West and East Africa and adjacent islands, provide diverse habitats that support high levels of biodiversity of fish and invertebrate species. The Red Sea has a high degree of endemism and is an important repository of marine biodiversity. With overexploitation, habitat degradation and loss, acidification, pollution from land-based sources, invasive alien species and sea level rise, highly valuable ecosystem services are being threatened. Current losses of genetic biodiversity due to climate changes and unsustainable resource exploitation in Africa are restricting future management and development options and threaten the livelihoods of many African communities.

However, Healthy ecosystems can reduce socioeconomic vulnerability by supporting well-being. Healthy ecosystems are conserved social-ecological systems and a number of them are managed by local and indigenous communities. Africa has a vast amount of undocumented ILK that would enhance our understanding of biodiversity and ecosystems status and trends. ILK of the status and trends of biodiversity may be especially critical in the African region because of the relative dearth of scientific cultural diversity studies relative to other regions. The environmental knowledge held by indigenous people can lead to the discovery of new species and populations and can enhance our understanding of status and trends of species and ecosystems, particularly those that contribute to human livelihoods and well-being. The role of protected areas and new conservation strategies and tools such as the Management Effectiveness Tracking Tool are increasingly useful in managing current unprecedented rates of biodiversity loss. The extent of protected areas in Africa has almost doubled in the last decades; protected areas now cover 14% of Africa's terrestrial area and 2.5% marine. Effectiveness of protected areas is poor in many areas due to a combination of factors, such as: climate change, overexploitation (over-hunting, logging, livestock herding), civil conflicts, and encroachment from local populations to sustain their livelihoods, and inadequate park design and administration.

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The regional assessment report on BIODIVERSITY AND ECOSYSTEM SERVICES FOR AFRICA

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UNESCO United Nations Educational, Scientific and Cultural Organization

Food and Agriculture Organization of the United Nations

UNDP Empowered lives. Resilient nations.