CHAPTER 4

DIRECT AND INDIRECT DRIVERS OF CHANGE IN BIODIVERSITY AND NATURE'S CONTRIBUTIONS TO PEOPLE

Coordinating Lead Authors:

Luthando Dziba (South Africa), Wanja Nyingi (Kenya), Nicholas Oguge (Kenya)

Lead Authors:

Rodwell Chandipo (Zambia), Tidjani Adamou Didier (Niger), Edson Gandiwa (Zimbabwe), Samuel Kasiki (Kenya), Danielson Kisanga (Tanzania), Olaotswe Kgosikoma (Botswana), Odipo Osano (Kenya), Jacques Tassin (France), Souleymane Sanogo (Burkina Faso), Graham Von Maltitz (South Africa)

Fellow:

Houda Ghazi (Morocco)

Contributing Authors:

Sally Archibald (South Africa), James Gambiza (South Africa), Philip Ivey (South Africa) Patrice Bigombe Logo (Cameroon), Malebajoa Anicia Maoela (Lesotho), Thando Ndarana (South Africa), Mordecai Ogada (Kenya), Daniel Olago (Kenya), Sebataolo Rahlao (South Africa), Brian van Wilgen (South Africa)

Review Editors:

Opha Pauline Dube (Botswana), Guy Midgley (South Africa)

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CHAPTER 4

DIRECT AND INDIRECT DRIVERS OF CHANGE IN BIODIVERSITY AND NATURE'S CONTRIBUTIONS TO PEOPLE

EXECUTIVE SUMMARY

Africa's biodiversity and ecosystems are amongst the most vulnerable to climate change, with severe impacts already experienced on water availability and food production, thus affecting nature's contributions to people *(well established)*. This in turn is having a profound negative impact on Africa's ability to achieve sustainable development and will continue to do so unless mitigation measures are undertaken. Human-induced climate change is a major driver of biodiversity loss, changes in ecosystem structure and function and the ability of ecosystems to supply nature's contributions to people. Both the extent of climate change and the degree to which it impacts biodiversity and the supply nature's contributions to people are highly variable within and between Africa's subregions. In addition, temperatures in the continent are expected to rise faster than the global average with some areas warming at close to double the global mean. Future rainfall projections are less certain, although rainfall variability is projected to increase over most areas with most models suggesting fewer, but heavier rainfall and increased flooding events. Yet, many areas in Africa are predicted to become drier, despite the global increase in mean annual precipitation {4.2.2.1.2, 4.2.2.1.3}.

Africa's population is projected to grow from the current 1 billion to nearly 6 billion by 2100, putting severe pressure on the continent's biodiversity and the ability to provide nature's contribution to people. Africa is also one of the most rapidly urbanising continents, driving changes in biodiversity associated to land-use change due to increased demand for food, energy, water, infrastructure development and other services *(well established)*. Urban communities are producing large quantities of solid and other wastes that are leading to environmental pollution *(well established)*. Rapid population growth, urbanisation and the resultant demand for resources are driving land-use and land-cover change in Africa, leading to loss of the land's capacity to sustain biodiversity and provide nature's contributions to people *(well established)*. Conversion of forest and rangelands for agriculture, mining and urban development, among others, has led to habitat loss, degradation of catchment areas and soil erosion leading to loss of biodiversity and livelihoods. The fragmentation that results from various land-uses contributes to biodiversity loss because many wildlife species are migratory and conservation areas do not provide sufficient habitat and connectivity, especially for vulnerable species with narrow ecological niches *(well established)* {4.4.4}.

The spread of invasive alien species in terrestrial and aquatic ecosystems is rapidly increasing in Africa with impacts on native species, rural livelihoods and production systems *(established)*. These impacts affect major economic sectors including agriculture, forestry, tourism, fisheries and others. The introduction of most invasive alien species occurs for various reasons including enhanced supply of goods and services to people (e.g., timber, food, medicinal and manufacturing purposes), but the proliferation of invasive alien species into natural systems is rapid and complex. The management and control of invasive alien species in Africa remains a challenge. A few countries have quantified the extent and the impact of invasive alien species on biodiversity and nature's contributions to people. However, challenges remain with understanding rates of spread, complex interactions with disturbance regimes and natural climate variability. Climate change is set to exacerbate the impact of invasive alien species in many African ecosystems *(established, but incomplete)* {4.2.2.3}.

Overharvesting and poaching of vulnerable species (rhino and elephant poaching; lion hunting, abalone and other illegal fishing; illegal logging; charcoal production and bushmeat harvesting) is driven by commercialisation of biodiversity with national, urban and foreign markets imposing negative impacts on biodiversity and nature's contributions to people *(well established)*. The proliferation of unsustainable harvesting of wildlife is exacerbating the impacts of habitat loss. Rhino and elephant poaching for horn and ivory, respectively, have led to substantial decline in the populations of these keystone species in many subregions in Africa {4.2.2.2.3}. Global markets and demand for wildlife products as well as local pressure from privately owned commercial wildlife ranches have severely challenged national policies because of the prevailing poverty, illicit trade and the high value of these products in the global markets. Illicit trade in wildlife is many cases linked with international criminal gangs involved in the drug trade, human trafficking and terrorism *(well established)* {4.2.2.2}.

Soil, water and air pollution present major challenges and cause biodiversity and undermine nature's contributions to people and good quality of life in general. Pollution has led to degradation of ecosystem functions and services in Africa *(well established).* Population growth and urbanisation has created a greater demand for food production, energy and water but also increased the amount of wastes associated with provision of various services that rapidly growing urban populations demand. The expansion of agriculture, extractive (mining) and manufacturing industries, transport and building sectors and urban settlements is not congruent with existing effluent and waste-management strategies. A large number of chemicals and pollutants including prohibited Persistent Organic Pollutants such as Dichlorodiphenyltrichloroethane (DDT) continue to be marketed and used in the region with dire consequences for human health *(well established)* {4.2.2.4}.

Fires burn significant amounts of biomass across Africa every year, with more than half of global fires occurring in the continent of Africa. These is to a large extent being natural fires. However, the alteration of fire frequency and intensity impacts on biodiversity and nature's contributions to people *(well established).* Many landscapes of West, East and Southern Africa, especially in grasslands, fynbos and savannas, are fire-dependent ecosystems and burn frequently, especially during the dry season. Eliminating fire from these systems is detrimental to biodiversity. North Africa, and parts of east and southern Africa are semi-arid to arid and not prone to fire due to very low biomass to sustain fire. The equatorial region of Central Africa is too moist to support fires. Emissions from Africa's fires can be largely considered as climate-neutral as the burned biomass is replaced over the next few seasons. Climate change may, however change the nature of fires and the extent of areas burnt {4.2.1.2}.

Changes in land ownership and an increase in land acquisition (land grabs) to meet local, national and global food and renewable energy demand are driving changes in nature and nature's contributions to people. Land ownership is shifting from small-holder farmers to large-scale commercial farming and land-use (or the focus of production systems) is shifting from subsistence agriculture to supply a growing international biofuels industry, influenced by policies in rich nations *(established but incomplete)*. This is contributing to land conversion as critical ecosystems including wetlands, rangelands and forests are being converted into agricultural land for food or energy markets *(well established)*. There are also trade-offs in the use of land for the production and supply of food, water, energy and other land-uses such as mining and development of human settlements (food-water-energy nexus) *(well established)* {4.4.1}.

Sustainable development thrives best in an environment of good governance, peace and security whereas armed conflict has substantial costs in human and material terms, hinders production, damages infrastructure, prevents the reliable delivery of social services to communities *(well established)*. Organised criminal networks carry out environmental crimes (poaching, illegal wildlife trade, illegal trade of timber and non-timber forest products) across borders and affect national economies, security and threaten sovereignty of some countries *(well established)*. Environmental crimes undermine the livelihoods of natural resource dependent communities, damage the health of the ecosystems they depend on, and restrict potential investment in development of affected areas. Terrorists and rebel groups participate in environmental crimes in order to fund their illegal activities *(well established)*. Insecurity leads to localized biodiversity loss, especially diversity of wild fauna and, undermines Africa's conservation legacy and livelihoods of resource-dependent communities *(well established)* {4.2.2.2.3, 4.4.1.2}.

Many communities in Africa are highly depended on natural resource-based livelihoods and are vulnerable to rapid societal changes in policies that affect their indigenous and local ways of livelihood *(well established).* Rapid changes (observable climate change, rapid urbanisation, rapid land transformation, changes in production systems) are strongly linked to the vulnerability of indigenous and local peoples and communities. There may be unintended consequences in that indigenous and local knowledge may be a barrier to exploring alternative development options. This is due to the fact that indigenous and local peoples do not easily adapt to rapid changes, such as those due to climate change, which necessitate changes in preferred crops because of changes in crop suitability maps. Indigenous and local knowledge works in small-scale agriculture setting but rapid changes to large-scale intensified agriculture may undermine indigenous and local knowledge methods *(established)* {4.4.4.1, 4.4.7}.

4.1 INTRODUCTION

This chapter deals with direct drivers (both natural and anthropogenic) and indirect drivers of change, as well as interactions between direct natural and anthropogenic drivers of change. Chapter 3 described the current status and trends of biodiversity and ecosystems (nature) and nature's contributions to people across the continent of Africa. The focus of this chapter is on key drivers that influence the status and trends of biodiversity, ecosystems and nature's contributions to people identified in Chapters 2 and 3, with a special focus on those that have the highest impact on the unique natural resources and nature's contributions to the people of Africa. Chapter 4 therefore follows up on the trends and value of nature's contributions to people dealt with in previous chapters, with more in-depth focus on drivers of change and their likely future dynamics. It is important to understand drivers of change, whether direct or indirect, in order to contribute to informed decision-making about managing the causes of negative changes in nature, nature's contributions to people and to good quality of life. Such information offers a range of scenarios and governance options for decision-makers, considered in Chapter 5 and Chapter 6, respectively. Both direct and indirect drivers of change constitute an essential part of the IPBES conceptual framework, and will be introduced in this section and elaborated on in sub-sections detailing the type of effects drivers have on nature, nature's contributions to people and to the quality of life of the peoples of the African continent (Díaz *et al.*, 2015; Figure 1.1 in Chapter 1).

Africa is endowed with abundant natural capital supporting livelihoods through a variety of nature's contributions to people (McNaughton *et al.*, 1988; McClanahan *et al.*, 1996; Tidjani *et al.*, 2009; Scholes *et al.*, 2011; Archibald *et al.*, 2013; Pascual *et al.*, 2017). These encompass a wide range of ecosystems ranging from deserts to tropical rainforests; Afro-alpine to marine habitats; rivers, wetlands, grassland and savanna ecosystems amongst others. Africa's rich biological and cultural diversity is an asset for the people of the continent. Interactions between diverse climates, vegetation types and topography create unique ecoregions and confer immense biological (floral, faunal and microorganism) diversity on the continent (Dixon *et al.*, 2003; Merbold *et al.*, 2009). Africa's biodiversity has underpinned its development for generations, as described in Chapter 1. Yet, the continent remains one of the poorest in the world. Instead of bringing prosperity, Africa's resources have been a source of many conflicts brought about by the scramble for her resources. Africa's biodiversity and ecosystems face a variety of threats (**Figures 4.22, 4.23, & 4.26** on Threats and Pressures).

Future trajectories for the continent suggest that Africa will continue to experience high population growth due to high fertility rates. Rapid urbanisation will also continue for the next half-century due to rural-urban migration (Young *et al.*, 2009; Freire *et al.*, 2014), with a projected 54% of Africa's population living in urban areas by 2030 (Hay *et al.*, 2005). These migrations are leading to massive and rapid infrastructure developments including roads, sewage, piped water and energy supply to support human settlements. Unlike indigenous and local or rural populations, which tend to be less dependent on centralized infrastructure, urban areas require planning and development of infrastructure and facilities to enable acceptable living conditions. Even though some threats and pressures from these are localized, others such as railways, motorways, overhead transmission lines and oil pipelines tend to operate at regional scales.

Direct drivers refer to those drivers, pressures and threats that have an explicit impact (negative or positive) on biodiversity, ecosystems and the nature's contributions to people and can either be natural or anthropogenic. The natural direct drivers discussed in this chapter include climatic factors, natural fires as a driver of ecosystem change, diseases and pests (zoonotic and human diseases) and natural disasters (tsunamis, volcanos, earthquakes). The anthropogenic direct drivers highlighted include land-use and land-cover change (deforestation and loss of rangeland), overexploitation (overgrazing, overharvesting, overfishing), invasive alien species, and pollution (soil, water, air). We have also considered positive drivers such as protected areas, the role of multilateral environmental agreements, and sustainable land management.

It is important to note that direct natural drivers of change are natural phenomena that occur without human intervention, although the impact or effect on people may be exacerbated by human activity as in the case of impacts of flooding on human settlements built in floodplains. Anthropogenic drivers, on the other hand, are purely an outcome of human activities, such as clearing of land for housing development or agriculture. Such human activities have a direct effect on biodiversity and ecosystems and therefore directly affect nature's contributions to people. The effect may be either positive or negative, depending on the benefit people seek to derive from nature. Generally, there are trade-offs that often result because the exploitation of one resource may improve quality of life for some people while diminishing nature's contributions and quality of life for others. The effects or general impact of these direct drivers of change can be identified, measured and monitored (Nelson *et al.*, 2005; Ash *et al.*, 2008; Díaz *et al.*, 2015). However, there are interactions between natural direct drivers and anthropogenic direct drivers that can be clearly linked to changes in biodiversity and nature's contributions to people. Climate change is an obvious example of this combined influence of both natural and anthropogenic drivers of change because although climate is a natural phenomenon, it is now widely accepted that increases in greenhouse gas emissions linked to both industrial and post-industrial era, has led to higher rates of global warming. This has huge consequences for both natural and social-ecological systems in Africa.

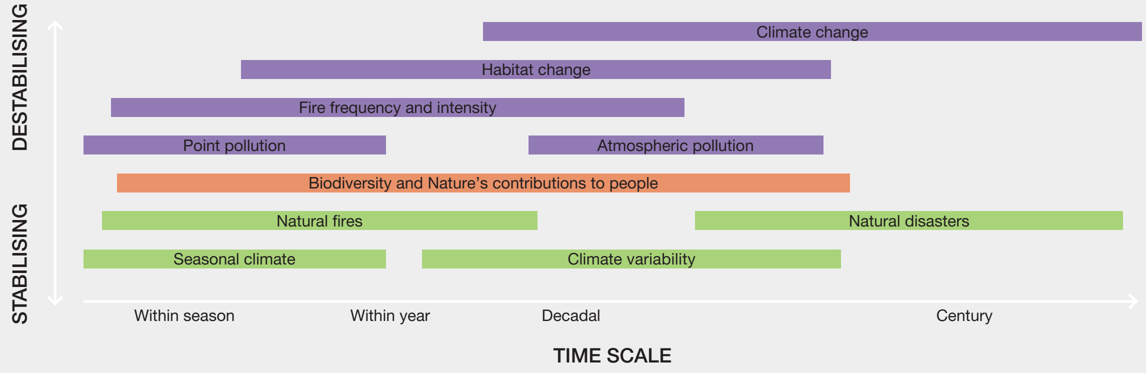
Indirect drivers of change, on the other hand, are drivers that cause alteration of the rate at which direct drivers impact biodiversity and nature's contributions to people (Nelson *et al.*, 2005). The decisions made by society, whether influenced by leaders in the public or private sector, and the influence of those decisions on human behaviour has major consequences for nature and nature's contributions to people. There are many examples where decision-making has led to poor outcomes for nature and nature's contributions to people, leading to declines in the quality of life of the people. The consequences are usually severe for vulnerable communities, particularly rural populations and the poor, who depend directly on nature's contributions to people for essentials such as food, timber and water. In this chapter we discuss many drivers of change, but we also address in particular those drivers that may result in positive changes in nature and nature's contributions to people. Here, we consider the following drivers: changes in economic and environmental policies, economic systems, population growth, migration and urbanisation, technology developments and application, insecurity and corruption, and cultural practices and spirituality.

This chapter takes into consideration that the effects of the different drivers of change vary across Africa's subregions. Care has thus been taken to ensure that cases of unique subregional or ecosystem (terrestrial, freshwater and coastal/marine) differences among the drivers have been taken into account. This chapter, therefore, provides a critical analysis of how various direct and indirect drivers of change currently influence change in nature and nature's contributions to people, and ultimately human well-being or the quality of life for the people of Africa. Such an analysis is aided by the use of case studies and infographics. An attempt has been made to link content presented in this chapter to other IPBES thematic assessments (such as those on scenarios and modelling and land degradation), which are also pertinent to the continent of Africa.

4.2 DIRECT DRIVERS OF BIODIVERSITY CHANGE AND FLOW OF ECOSYSTEM SERVICES

Direct drivers of biodiversity change and ecosystem service flows can be discussed as natural occurrences or anthropogenic ones, taking into consideration that frequent interactions occur between the drivers. All natural systems have a degree of resilience to change – of particular concern is when the drivers of change are of sufficient severity to exceed thresholds leading to a permanent change in the systems dynamics, or in the case of biodiversity to the local or global extinction of species (Holling, 1973; Folke *et al.*, 2010). Direct drivers have an explicit effect on ecosystem dynamics and processes and are known to cause direct physical change that may be identified and monitored (Nelson *et al.*, 2005; Ash *et al.*, 2008). In African ecosystems there are natural disturbances such as drought or fire which occur in most ecosystems, but with location-specific return intervals and severity. These are important for maintaining the integrity and resilience of the ecosystems over the long-term, but can negatively impact on flows of nature's contributions to people over the short-term. Superimposed on these natural disturbances are a host of anthropogenic drivers of change that can have devastating impacts on the natural environment either on their own or through interactions with the natural disturbances. For instance humans can change the frequency or seasonal timing of fire and climate change can alter the frequency and intensity of droughts **(Figure 4.1)**. In the section below, natural and anthropogenic direct drivers are discussed.

Figure 4 1 **The time periods over which different types of disturbances either help stabilise and build resilience in natural biodiversity and the nature's contributions to people that it provides, or leads to change in the biodiversity and nature's contributions to people.**



4.2.1 Natural direct drivers

African biodiversity and ecosystems have evolved under the influence of a number of natural disturbance regimes, and when viewed over sufficient time and space, are to a large extent resilient to natural drivers of change. In fact, many disturbances such as fire, are important for maintaining biodiversity. However, at a local level or short time span, natural drivers can have profound impacts on biodiversity and the flow of nature's contributions to people. As will be discussed later, the interplay between natural and anthropogenic drivers can enhance these impacts.

The long-term natural drivers of change are now known to be paced by orbital forcing, and display dominant periodicities at 100,000, 41,000 and 23,000 years, which are related to the earth's eccentricity, tilt and precession, respectively. They subtly modulate the incoming radiation from the sun at the surface of the earth, but their effects are amplified by earth-intrinsic factors such as the volume and extent of sea and land ice, vegetation and soil cover, ocean and atmospheric circulation, and variations in cloud cover and type, to an extent where the resultant climatic and environmental changes are large enough to be etched visibly on the geological record (O'Hare *et al.*, 2005). Studies of long-term changes in vegetation indicate that there is a close and dynamical relationship between such changes and variations in temperature, precipitation and atmospheric CO_2 concentrations (Olago, 2001), and the present day distribution of vegetation in Africa largely reflects the continent's precipitation patterns. Large ecosystems may buffer climate signals of small amplitude, but vegetation response time to climate change is slow (Ssemmanda *et al.*, 2002; Marchant *et al.*, 2004).

4.2.1.1 Natural climate variability and weather patterns

African biodiversity has evolved in an environment with a naturally high level of climate variability, and, as such biodiversity and ecosystem services are adapted to, and dependent on climatic zones and their associated variability (Dixon *et al.*, 2003; Merbold *et al.*, 2009). Africa's biodiversity is a consequence of past climatic regimes (Letten *et al.*, 2013). The vast savannas, grasslands and deserts have strong seasonality of rainfall. In the northern and southern tips of the continent, there is a Mediterranean climate with hot and dry summers and characterized by winter rainfall. The tropical rainforests of Central Africa and the southern coast of Southern Africa tend to have all year rainfall. Rainfall patterns through much of the continent are linked to cyclic fluctuations in sea surface temperature, with the El Niño Southern Oscillation causing cycles of wet and dry years in eastern and southern Africa **(Figures 4.2, 4.3, and 4.4)**. The coefficient of variance of rainfall is negatively correlated with rainfall and the arid areas are therefore the most prone to intense droughts (Tyson, 1986; Plisnier *et al.*, 2000; Davey *et al.*, 2014). Given that arid areas are already at the margins of agricultural productivity, these droughts can have severe human consequence. Droughts are part of the natural cycle and current biodiversity patterns are adapted to them. However, human pressure caused by increased reliance on the natural environment during periods of drought can lead to degradation of these ecosystems (Behnke *et al.*, 2016).

The Sahelian drought and resultant degradation of the 1970s to 1990s was initially referred to as desertification (Behnke *et al.*, 2016). At the time this was attributed to increasing population and poor land management, which clearly placed increased pressures on the system. New and

Figure 4 2 **Long-term precipitation trend and anomaly (1930–2014) in the Horn of Africa. Source: Ghebrezgabher *et al.* (2016).**

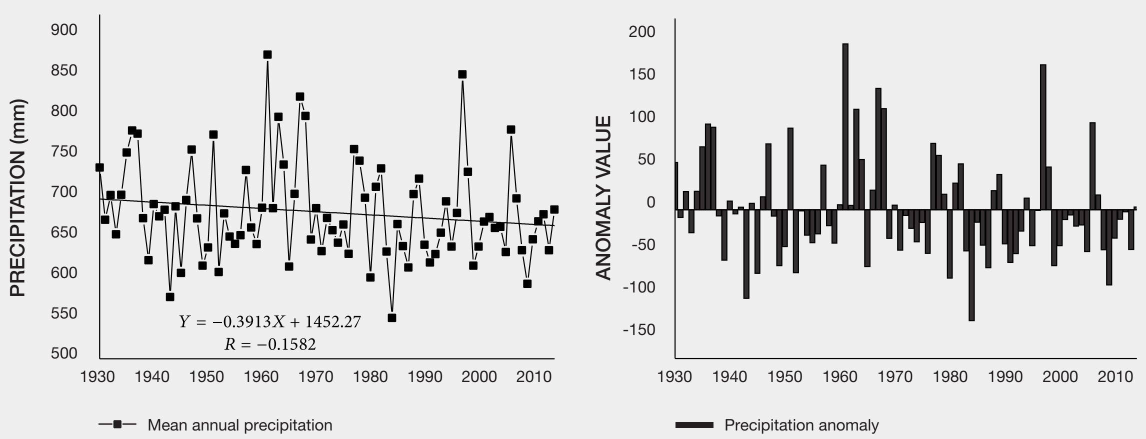


Figure 4 2

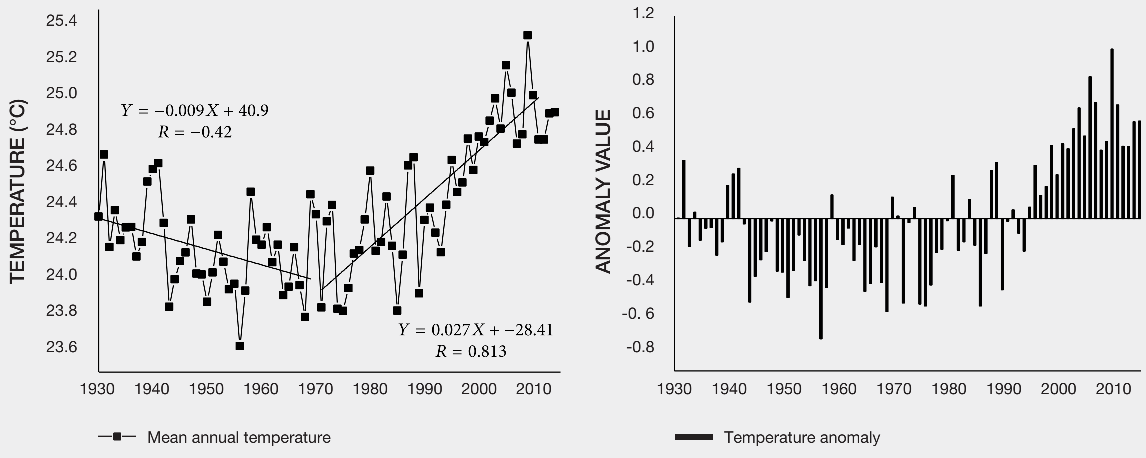


Figure 4 3 **Annual rainfall variability over the Semi-arid regions of Southern Africa. Source: New (2015).**

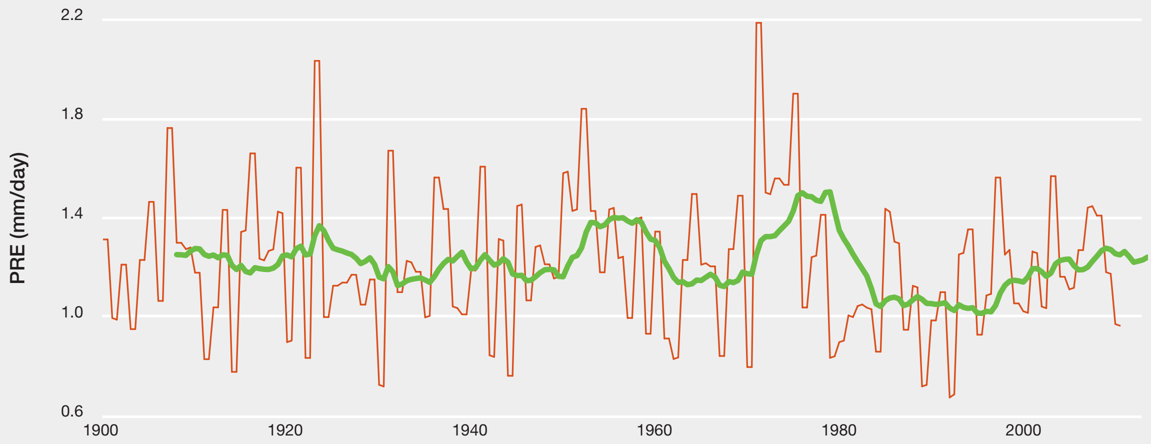
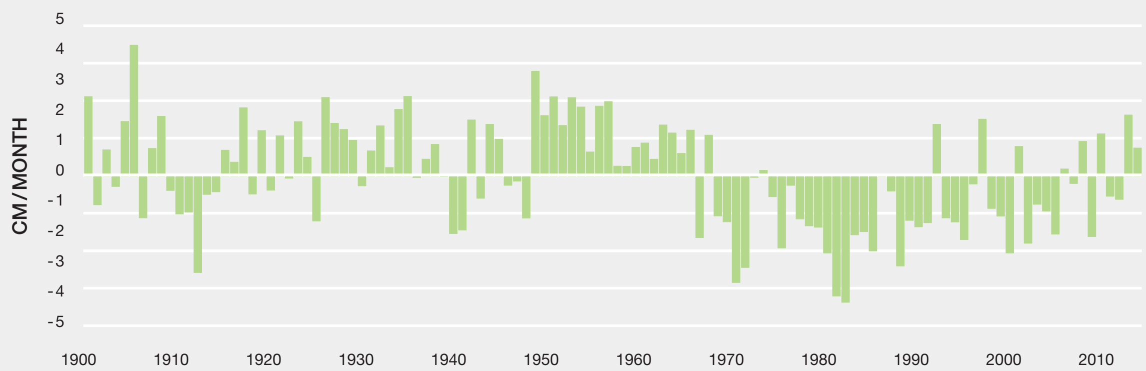


Figure 4 4 **Sahel rainfall from 1900 to 2016 averaged over June, July, August, September, and October. A prolonged wet period from 1915 to 1970 was followed by a dry period from 1970 to 2016. The region appears to again be entering a wet period. Source: https://doi.org/10.6069/H5MW2F2Q.**



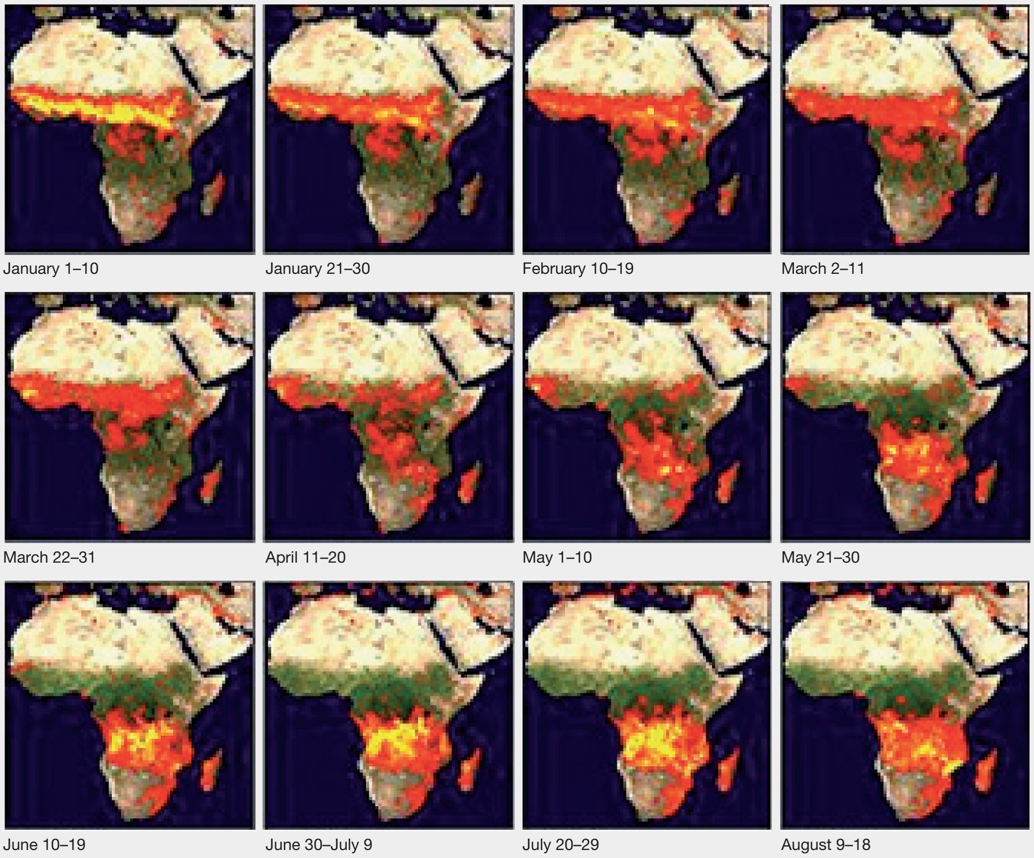
extensive evidence shows that this degradation coincided with a prolonged dry period, the causes of which are still poorly understood but may be related to global sulfate pollution in the northern hemisphere (Hwang *et al.*, 2013) or Interdecadal Pacific Oscillations (Villamayor *et al.*, 2015; **Figure 4.4**). More recent increases in rainfall are largely responsible for the greening of the area as detected from satellite imagery (UNEP, 2012). Long-term climatic fluctuations rather than human-induced desertification, therefore, seem to be the primary cause of the Sahelian degradation of the 1970s and 1990s (Behnke *et al.*, 2016).

4.2.1.2 Fire as driver of ecosystem change

In Africa, both natural fires and human-ignited fires play an important role in shaping the structure and composition of various ecosystems, except where biomass is too low to carry a fire or where the area is too wet to burn. Fire is also seen as a management tool for manipulating vegetation for various management objectives such as influencing the distribution of animals, setting fire belts and for burning moribund vegetation. Certain vegetation types such as the grasslands, savanna and fynbos are dependent on fire for their optimal ecological function. In these vegetation types suppression of fire has major negative consequences for biodiversity with gradual negative impacts on ecosystem services. Globally, fire activity peaks at intermediate productivity, and this is also apparent in Africa: in arid ecosystems there is seldom sufficient fuel for fires, and in wet, more productive systems there is plenty of fuel, but it is usually too wet to be easily flammable **(Figure 4.5)**. Because systems with a lot of fire have a biota that has evolved with these fire regimes, the relationships between biodiversity and fire are not simple.

It has been suggested that it is the variability in fire events (different fire sizes, fire intensities, fire return times) that is key for maintaining high biodiversity (Martin *et al.*, 1992), and there is evidence in Africa that bird and mammal species richness responds positively to "pyrodiversity" (Hempson

Figure 4 5 **The fire season appears as a distinct wave as it spreads through Africa. It peaks in January in West Africa (the northern hemisphere dry season), and in southern Africa in August (southern hemisphere dry season). Source: NASA MODIS Active Fire product.**



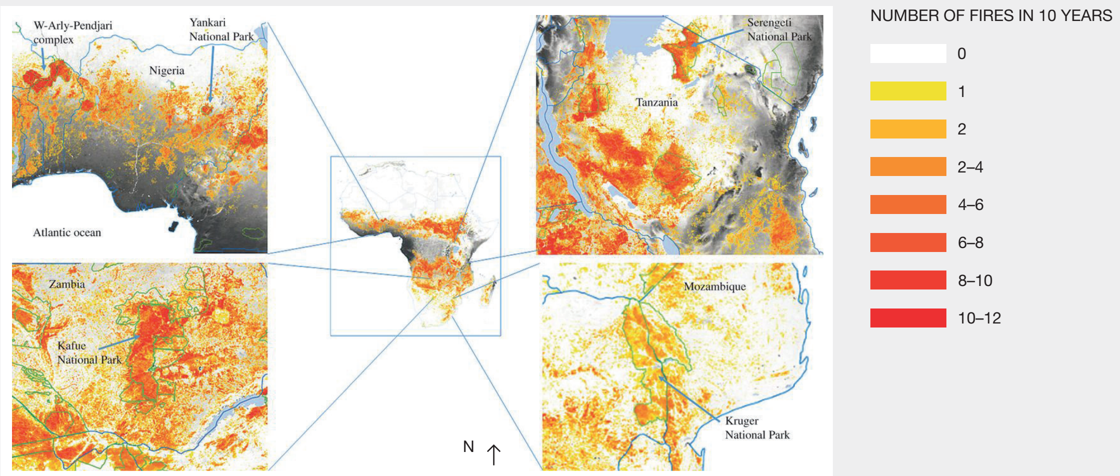
et al., 2017) – especiallyespecially in wet ecosystems where fire can dramatically influence habitat structure (altering the size and cover of trees and the amount of grass), and where variability in fire can result in a variety of habitats. More targeted use of fire has also been suggested for preventing particular undesirable landscape change/biodiversity loss. Fire can be a management tool, coupled with browsing, to maintain open grassy ecosystems and prevent increases in woody vegetation in grasslands (Trollope *et al.*, 1989) in these instances, targeted intense and/or frequent fires are necessary. In contrast, burning cooler, less frequent fires in Miombo woodlands can preserve woodland resources and increase ecosystem services (Ryan *et al.*, 2016).

Both human activities and changing climates are likely to impact fire, with associated impacts on biodiversity and ecosystem services (Andela *et al.*, 2014). Because fire peaks at intermediate productivities we expect different responses to climate change in arid and mesic systems: high-temperature environments will make the wet end of the continuum more likely to burn, but could also further reduce fuel loads in arid systems, and result in less fire in these regions. Moreover, increased woody cover can suppress fire. In general increased human populations leads to more frequent, but smaller fires than in natural systems (Archibald *et al.*, 2013), with far less area burned as croplands and rangelands expand (Andela *et al.*, 2014). It has been shown in Africa and elsewhere that people can buffer ecosystems from climate-induced extreme fire events, because they burn over a wider range of weather conditions, and because their land-use activities break up the fuel landscape. These activities can over-ride climate drivers of large fires. Unexpected fire may have short-term but devastating effects on forage resources and dry winter crops, affecting the livelihoods of local communities. Accumulated biomass due to fire suppression has never seldom been a problem in Africa, except in the fynbos biome.

Fires burn significant amounts of biomass across Africa every year, with more than half of global fires burn on the continent of Africa (van der Werf *et al.*, 2010; Scholes *et al.*, 2011; Archibald *et al.*, 2013). Yet, the distribution of fire across the continent is not homogenous. North Africa, which tends to be semi-arid to arid (mostly covered by the Sahara desert), is not prone to fire due to very low biomass to sustain fire. Desert zones within Northern and western Africa are not affected by bush-fires because of poor vegetation cover. On the other hand, grazing lands in semiarid zones growing on sandy soils are highly subjected to bush-fires accidentally provoked by human at the beginning of dry seasons. Their impacts are harmful to the environment through the reduction of forage availability as well as decrease of biodiversity, and at social level through the degradation of food security for livestock and poverty increase in communities (Abdou, 2012). In Niger, between 1990 and 2000, 861 cases of bush-fires were reported with effect on more than 2,119,604 hectares (Ichoua, 2001).

Parts of East Africa and adjacent islands, especially in the Horn of Africa, as well as South-Western parts of Southern Africa are also less prone to fires due to lack of vegetation to support fires. The vegetation is too sparse and shrubby and fire plays a very insignificant role in management of these landscapes (Archibald *et al.*, 2013; **Figure 4.6**). The equatorial region of Central Africa is also not prone to fire despite large amounts of biomass. This is mainly due to wet

Figure 4 6 **Frequency of fire in Africa for the period 2000 to 2010. Dividing the number of times a pixel was detected as having burned into 10 gives the approximate fire return time, in years. Source: Archibald (2016).**



conditions that prevail in this region throughout the year. In contrast, many parts of West Africa, East Africa and adjacent islands, and Southern Africa, especially in grasslands and savannas, are prone to burning especially during the early dry season when the grass is dry and other conditions for fire (whether natural or human-ignited) prevail. These include high temperatures and humidity and relatively high speeds of dry winds that cause rapid spread of fires. Sahelian savannas, grasslands and some shrubland ecosystems, many of them being fire driven ecosystems, tend to burn more frequently and with greater intensity during the dry season. These fires, many of them ignited by humans, have great impacts on biodiversity and ecosystem services.

4.2.1.3 Diseases and Pests (zoonotic diseases, human diseases)

Diseases and pests impact the ecosystem health and integrity of the African terrestrial, aquatic and agroecosystems in ways ranging from economics (loss of output, income and investments) to ecological (e.g., loss of populations and species diversity) **(Table 4.1)**. These impacts are greatly influenced by human encroachment of wildlife habitats, agricultural intensification, and urbanisation (Daszak *et al.*, 2000) as well as changes in global weather patterns (Hernández-Delgado, 2015). Loss of biodiversity commonly leads to increased occurrence of emerging infectious diseases including zoonotic diseases (Keesing *et al.*, 2010) thus compromising key nature's contributions to people offered by biodiversity. Historically, the African continent has been afflicted by a number of notable emerging infectious diseases which are newly discovered diseases, diseases that have changed pathogenesis, diseases with increased geographic or host range (Anderson *et al.*, 2004). Among the plants, cassava mosaic virus (East African cassava mosaic virus-Uganda 3Svr (whitefly-transmitted begomovirus) and the fungal Karnal Burnt (*Tillentia indica*), are known to have seriously affected cassava in East Africa and wheat in South Africa, respectively (Anderson *et al.*, 2004; **Box 4.1**). Both domestic animals and wildlife have also been affected by the emerging infectious diseases. Notably rinderpest, rabies, trypanosomiasis, canine distemper, and anthrax which are domestic animal diseases and have been known to be transferred to wildlife due anthropogenic factors, with devastating consequences.

The canine distemper infected 85% of the lion population in Serengeti and eliminated one third of the population (Cleaveland *et al.*, 2000; Guiserix *et al.*, 2007) while Ebola

Table 4 1 **Economic impacts of pest diseases in Africa.**

	Pest/disease	Damage caused	Estimated losses from outbreaks or control	Country/region	Source
Pests	African armyworm	Feeds on all types of cereal crops (e.g., corn, rice, wheat, millet and sorghum)	Cost of control: $10–$16/hectare Potential damage: $11–$15/hectare	All African countries	Wild, 2017
	Tsetse fly	Feeds on the blood of vertebrate animals	Each year in Africa the tsetse fly causes more than $4 billion in agriculture income losses, kills three million livestock and infects up to 75,000 people with trypanosomiasis, according to the United Nations	Sub-Saharan Africa	Shaw, 2009
	Insect and mite pests	Significant yield losses of agricultural crops	The economic crop losses caused by introduced arthropods in South Africa alone are estimated to be $1 billion/year	All African countries	Pimentel *et al.*, 2000
Diseases	Brucellosis	Serious alien livestock disease	Estimates are that brucellosis alone is causing losses amounting to $100 million/year	Sub-Saharan countries	Ducrotoy *et al.*, 2015
	Anthrax	Threat to both domestic and wild animals. It is only disease that must kill its host to propagate itself in the environment	In Namibia, millions of dollars (~ $27 million) are spent annually on surveillance in both wildlife and domestic animals	Currently occurs throughout Africa	Magwedere *et al.*, 2012
	Rinderpest		The total cost of the Pan African Rinderpest Campaign programme was estimated to be €51.6 million	Sub-Saharan Africa	Tambi *et al.*, 1999
	Wheat rusts	A fungal disease that affects wheat, barley and rye stems, leaves and grains	Annual losses of as much as $3 billion in Africa are possible due to wheat rust	East Africa, North Africa	Chaves *et al.*, 2013
	Bacterial wilt	Causes fruit to ripen prematurely, which can wipe out up to 90% of a crop	Due to bacterial wilt, Uganda loses $299.6 million worth of bananas annually	Eastern Congo, Ethiopia, western Kenya, Rwanda, northern Tanzania and Uganda	Yuliar *et al.*, 2015
	Foot and mouth disease	Livestock	Foot and mouth disease outbreaks in Africa causes losses of $1–5 billion/year	Africa	Knight-Jones *et al.*, 2013

Box 4 1 Cassava mosaic and brown streak virus disease: A threat to food security in Africa.

In about 15 African countries, over 4 million people live within areas of high cassava production. Often these are among the most remote and poorest rural areas. Cassava production continues to be threatened by the spread of cassava diseases with immediate and far-reaching impacts on food supply in the affected countries (commonly referred to CaCESA: Cassava diseases in central, eastern and southern Africa). These diseases cause losses estimated at $1,200 annually (Thresh *et al.*, 1997).

The two major viral diseases, spread by a whitefly vector (*Bemisia tabaci*) and the movement of planting materials, now pose a severe threat to cassava culture in many regions.

According to researchers at the National Agricultural Research Organisation, cassava brown streak disease is a devastating disease that causes loss of cassava root (tuber) production and quality. It can render susceptible varieties unusable if cassava roots are left in the ground for over nine months.

Given the severity of the current cassava disease outbreaks and the threat they pose to the food security of millions of people in Africa, several international organisations and partnerships are working to restore cassava production systems, particularly among the Great Lakes countries of East Africa. FAO, with the European Union support, is active in the multiplication and distribution of clean (disease-free) re-planting materials.

killed 5,000 of the endangered and charismatic gorillas, and other non-human primates coinciding with a human outbreak of the Zairean strain of the virus (Bermejo *et al.*, 2006; Le Gouar *et al.*, 2009). The occurrence of and control measures instituted against trypanosomiasis in large parts of Africa impacts on biodiversity and restricts economic development (PATTEC, 2006). The disease caused by varied species of a protozoan, *Trypanosoma* spp, is transmitted by tsetse fly (*Glossina* spp), to humans, livestock and wildlife and occurs in more than 30 sub-Saharan African countries (Wamwiri *et al.*, 2016). The disease causes severe health burden among infected humans, limits productivity of livestock, leads to overstocking of livestock in disease-free zones and poses serious conflict on the choice of appropriate policy measures for its control (FAO, 2008; Selby *et al.*, 2013). For example, bush clearing is a strategy to control the vector of Trypanosomiasis (Rutto *et al.*, 2013) but also leads to destruction of wildlife habitat and environmental degradation. Tsetse and trypanosomiasis infestations have negative impact on wildlife health too, and can be a threat to the survival of some endangered species such as the rhino (Kenya Wildlife Service, 2012) while rinderpest can cause high deaths in the buffaloes, giraffes, and wildebeests. Foot-and-mouth disease is one of the major diseases affecting numerous species of cloven-hoofed wildlife and livestock, including buffalo, impala, cattle, sheep, goats and pigs. Understanding the epidemiology of Foot-and-mouth disease, including roles played by different hosts, is essential for improving disease control. The African buffalo (*Syncerus caffer*) is a reservoir for the Southern African Territories serotypes of Foot-and-mouth disease virus (Wekesa *et al.*, 2015). Foot-and-mouth disease has severely negative economic impacts because imports of meat and animals from affected countries are banned by disease-free countries to control the spread of Foot-and-mouth disease. Among amphibians, the panzoonotic Chytrid fungus (*Batrachochytrium dendrobatidis*) is widespread in Africa except in the West of Dahomey (Penner *et al.*, 2013). It causes hyperplasia and hyperkeratosis disrupting critical functions of the infected amphibian's skin and leading to cardiac arrest (Voyles *et al.*, 2011).

A number of vectors (pests) play key roles in transmission of diseases between the domestic animals, wildlife and the humans. Disease vectors include insects, such as mosquitoes, ticks, and arachnids. As mentioned in Chapter 1 and 2, the rise of such diseases results from closer relationships among wildlife, domestic animals, and people, allowing more contact with diseased animals, organisms that carry and transmit a disease from one animal to another, and people. The rift valley fever, a haemorrhagic febrile viral zoonotic disease transmitted by Aedes, Culex and Anopheles mosquitoes is associated with abortion and perinatal death in the affected livestock and ruminant wildlife, and fatal haemorrhagic fever syndrome in humans (Evans *et al.*, 2008; Chevalier *et al.*, 2010; Boshra *et al.*, 2011). Outbreaks of rift valley fever coincide with conducive weather (wet) for breeding of the vector mosquitoes, mostly the Aedes and Culex, especially in the general low rainfall areas (Evans *et al.*, 2008). Severe outbreaks of the disease and fatalities in humans have been confined to northern and Africa (North and sub-Saharan Africa) so far, but potential for spread to southern Europe exists (Chevalier *et al.*, 2010).

4.2.1.4 Natural hazards and disasters

Natural hazards are potentially damaging physical events, phenomena or human activities that may cause injury or loss of life, damage to property, social and economic disruption or environmental degradation. They result from natural processes of the earth, including floods, landslides, droughts, volcanic eruptions, earthquakes, tsunamis, cyclones and other geological processes (ICSU, 2005). Disasters are a function of vulnerability to the impacts of these processes and occur from a combination of hazards, conditions of vulnerability and insufficient measures to reduce negative consequences. They are serious disruptions of the functioning of communities and cause widespread human, material, economic or environmental losses.

The economic damage of natural disasters in Africa between 1974 and 2003 is estimated at $35,144 million with majority of the effects occurring in eastern and northern Africa (Guha-Spair *et al*., 2016; **Table 4.2; Box 4.2**). Some of the most devastating disasters recent decades include droughts in the Sahel (1972–1973), Ethiopia (1983–1985), East (2011) and southern (2014-–2015) Africa; floods in Central (2002), North (2009 and 2010) and Southern (2010–2011) Africa; and the volcanic eruption of Nabro (2011). The frequency of disasters is increasing on the continent with data demonstrating

Table 4 2 **Number of natural disasters in different subregions of Africa from1974 to 2003. (Notes: Ndr = Number of disasters reported; na = no data available)**

Category	Type of natural disaster	Subregion	1974–1978	1979–1983	1984–1988	1989-1993	1994–1998	1999–2003	1974–2003
Geophysical	Volcanic	Eastern	3	ndr	ndr	1	ndr	ndr	4
		Middle	1	ndr	2	ndr	ndr	3	6
		Northern	ndr	ndr	ndr	ndr	ndr	ndr	ndr
		Southern	ndr	ndr	ndr	ndr	ndr	ndr	ndr
		Western	ndr	ndr	ndr	ndr	1	ndr	1
		Total	**4**	**ndr**	**2**	**1**	**1**	**3**	**11**
	Earthquakes and tsunami	Eastern	ndr	ndr	1	3	1	4	9
		Middle	ndr	ndr	ndr	1	ndr	ndr	1
		Northern	ndr	2	3	5	2	4	16
		Southern	ndr	1	2	ndr	ndr	ndr	3
		Western	ndr	1	0	ndr	ndr	ndr	1
		Total	**ndr**	**4**	**6**	**9**	**3**	**8**	**30**
Climatological	Drought	Eastern	8	18	19	18	16	49	128
		Middle	6	8	7	4	2	4	31
		Northern	1	7	4	3	5	8	28
		Southern	ndr	8	8	12	7	10	45
		Western	27	30	22	7	5	10	101
		Total	**42**	**71**	**60**	**44**	**35**	**81**	**333**
Hydrological	Flood	Eastern	16	9	11	19	34	73	162
		Middle	ndr	ndr	4	5	10	28	47
		Northern	6	10	5	7	16	30	74
		Southern	3	1	5	2	7	13	31
		Western	3	4	14	7	24	46	98
		Total	**28**	**24**	**39**	**40**	**91**	**190**	**412**
Meteorological	Windstorm	Eastern	10	10	12	8	12	24	76
		Middle	1	1	1	ndr	ndr	3	6
		Northern	ndr	1	2	ndr	2	4	9
		Southern	1	1	3	3	4	10	22
		Western	2	1	3	2	1	10	19
		Total	**14**	**14**	**21**	**13**	**19**	**51**	**132**
Natural disasters with economic damages		Eastern	13	9	8	7	13	8	58
		Middle	2	1	2	0	1	2	8
		Northern	2	3	2	4	6	9	26
		Southern	1	1	5	1	2	6	16
		Western	21	5	6	1	3	7	43
		Total	**39**	**19**	**23**	**13**	**25**	**32**	**151**

Box 4 2 A treatise of natural disasters in Africa.

In 2015, Africa suffered from 62 natural disasters compared to 2005–2014 annual average which was 68 (Guha-Spair *et al.*, 2016). This affected 30.9 million people. Approximately 28 million were affected by climatological disasters. Hydrological disasters accounted for impacts on 2.8 million people who were largely victims from flooding in Somalia (900,000 people), Malawi (639,000 people) and Madagascar (174,000 people). The economic estimate of the disasters were made for only 11 events, highest being drought in South Africa ($1billion), floods in Malawi ($400 million) and a storm in Egypt ($100 million).

that the East African region is under the greatest threat from natural disasters (Lukamba, 2010). This region has experienced the highest recorded number of disaster events over the past 30 years, followed by the West African region. Northern Africa is placed third followed by the Southern Africa **(Table 4.2)**, whereas the least disaster-prone region is central Africa (Lukamba, 2010). Eastern Africa recorded more than 67% of victims killed or affected between 1974 and 2003, and Northern Africa experienced 53% of the economic damages for the same period. The most frequent disaster recorded during the 30 years (from 1974 to 2003) was hydrometeorological, followed by floods **(Table 4.2)**.

Long-term effects of natural disasters on wildlife are usually assumed to be small. These may, however, amplify through interactions with other drivers leading to enhanced invasions by promoting the transport of propagules into new regions, decreasing the resistance of native communities to establishment of invasive non-native species, or by putting existing non-native species at a competitive advantage (Diez *et al.*, 2012). For instance, volcanic lava flows have been shown to facilitate tree invasion in the Reunion Island by enhancing the spread of Casuarina (*Casuarina equisetifolia*) by 20-fold (110–2,373 hectares) over a 40 year (1972–2012) period (Potgieter *et al.*, 2014). It is widely acknowledged that those who are most vulnerable to natural disasters and climate change are those who typically live in poor quality housing in low-income informal settlements that lack provision for basic infrastructure and services (Adelekan *et al.*, 2015).

4.2.2 Anthropogenic direct drivers

Anthropogenic direct drivers comprise human induced drivers whose impact can be directly observed and monitored.

4.2.2.1 Land-use and land-cover change

Land conversion from natural vegetation to farmlands, grazing lands, infrastructure, human settlements and urban centres contributes significantly towards loss of biodiversity and ecosystem functionality (Biggs *et al.*, 2008; Maitima *et al.*, 2009). In Africa, a large proportion of livelihoods depend on natural resources including minerals, agriculture, fisheries, and forestry. Agricultural expansion and mining are the dominant drivers of biodiversity loss (Biggs *et al.*, 2008), particularly due to conversion of natural habitat to cultivation land or as a result of open cast mining activities. There has been an expansion of cash crops, much of this as large-scale cropland cultivation that has been termed the Green Revolution. Land-use change is worsened by the growing land grab phenomenon where foreign investors are allocated large pieces of land for agriculture, especially crop production (Cotula *et al.*, 2009; Byerlee *et al.*, 2013), with great impact on indigenous and local populations, natural resources, local knowledge and quality of life in general (Cotula *et al.*, 2016).

Habitat fragmentation compounds the impacts of habitat loss, preventing migration and creating island biogeography effects where small fragmented habitats hold less biodiversity than larger habitats. Evidence shows that tropical forest fragments suffer twice the total number of extinctions than unfragmented forests (Brooks *et al.*, 1999). Habitat conversion may also result in loss of ecologically critical areas such as suitable breeding grounds (e.g., wetlands for birds) or seasonal grazing areas, where impacts on biodiversity may be far higher than the proportion of land lost. Small-scale farming is increasingly being driven by population growth in most areas of Africa. As population density increases, there is a move from shifting agriculture to intensification of permanent agricultural fields. The total area cultivated is strongly associated with loss in indigenous plant abundance (Biggs *et al.*, 2008) and indirectly results in loss of mammal and bird species. In Uganda and Tanzania, mammal species richness has been reported highest in grazing lands and lowest in cultivated areas (Msuha *et al.*, 2012; Kiffner *et al.*, 2014), partly due to complete destruction of habitat in cultivated lands. This suggests that continued expansion of lands under cultivation will lead to shrinking of wildlife habitat and further threaten mammalian communities. Loss of space for wildlife due to increased areas of cultivation and grazing lead to human-wildlife conflicts. There is need for policy intervention to ensure balance between livelihoods of farmers and pastoralists and wildlife in these mixed-use landscapes.

Another effect of fragmentation of landscapes is the disruption of migration and movement of wildlife species (Kiffner *et al.*, 2014). In addition, conservation areas have been reported to augment fragmentation and do not provide sufficient wildlife habitat. For example, the development of veterinary cordon fences in Botswana and Namibia to control diseases and comply with international sanitary and phytosanitary standards for meat exports has led to decline in wildebeest and other wildlife due to fragmentation of their habitat. Hence, there is a need to have corridors to ensure functional connectivity between wildlife populations and other organisms across fragmented landscapes. Africa has tended to engage in agricultural expansion as opposed to the global norm of agricultural intensification (Reardon *et al.*, 2001). Whereas the area of land under agriculture has actually decreased globally due to improved yields, in Africa there is still rapid agricultural expansion (Reardon *et al.*, 2001). This is mostly linked to small-scale agriculture production on near subsistence type farms. Low soil fertility, and low use of artificial fertilizers means that disproportionally large areas of agriculture are needed to produce relatively small (in global terms) quantities of agricultural production (Wood *et al.*, 2004; Brink *et al.*, 2009; von Maltitz *et al.*, 2012).

Unsustainable harvesting is leading to extensive loss of African forests, with high deforestation rates being reported for many African countries. Households derive income from the informal production of woodfuel ($3,705 million at 2011 prices), charcoal ($10,585 million at 2011 prices) and forest products used for house construction ($112 million at 2011 prices) (FAO, 2015). Indications are that the rate of deforestation is slowing in most countries (de Wasseige *et al.*, 2013; FAO, 2015), but Africa is still globally one of the areas with the highest rates of forest loss. The consequence on biodiversity particularly loss of vulnerable species with narrow ecological niche is a major concern, as natural habitats are completely lost.

Infrastructure development, including urban sprawl and mining, is resulting in habitat loss and land conversion **(Box 4.3)**. Most African cities are expanding at a rapid rate, way in excess of national population expansion rates (Young *et al.*, 2009; Freire *et al.*, 2014). This is driven by increased rural-urban migration. In addition to habitat loss from this urban expansion, there is a secondary impact driven by the need to fuel and feed this growing urban population. For instance, both Dar es Salaam and Maputo have a far-reaching footprint in terms of deforestation (to provide the urban charcoal needs) that extends over 300 km along main arterial routes out of the city (Tadross *et al.*, 2012).

4.2.2.2 Deforestation

Deforestation is a global problem. Statistical data showing the long-term trends for Africa **(Box 4.4)**. Deforestation in Africa has mostly been caused by demand for wood and non-wood products for commercial purposes associated with trade and development, or subsistence of communities around forests. Generally, there has been a tendency towards lose than gain of forest areas in Africa, with most losses occurring in areas with medium to high tree densities **(Figure 4.7)**. Africa lost the highest percentage of tropical forests compared to other continents during the 1980s,

Box 4 3 Impact of mining on protected areas in Africa.

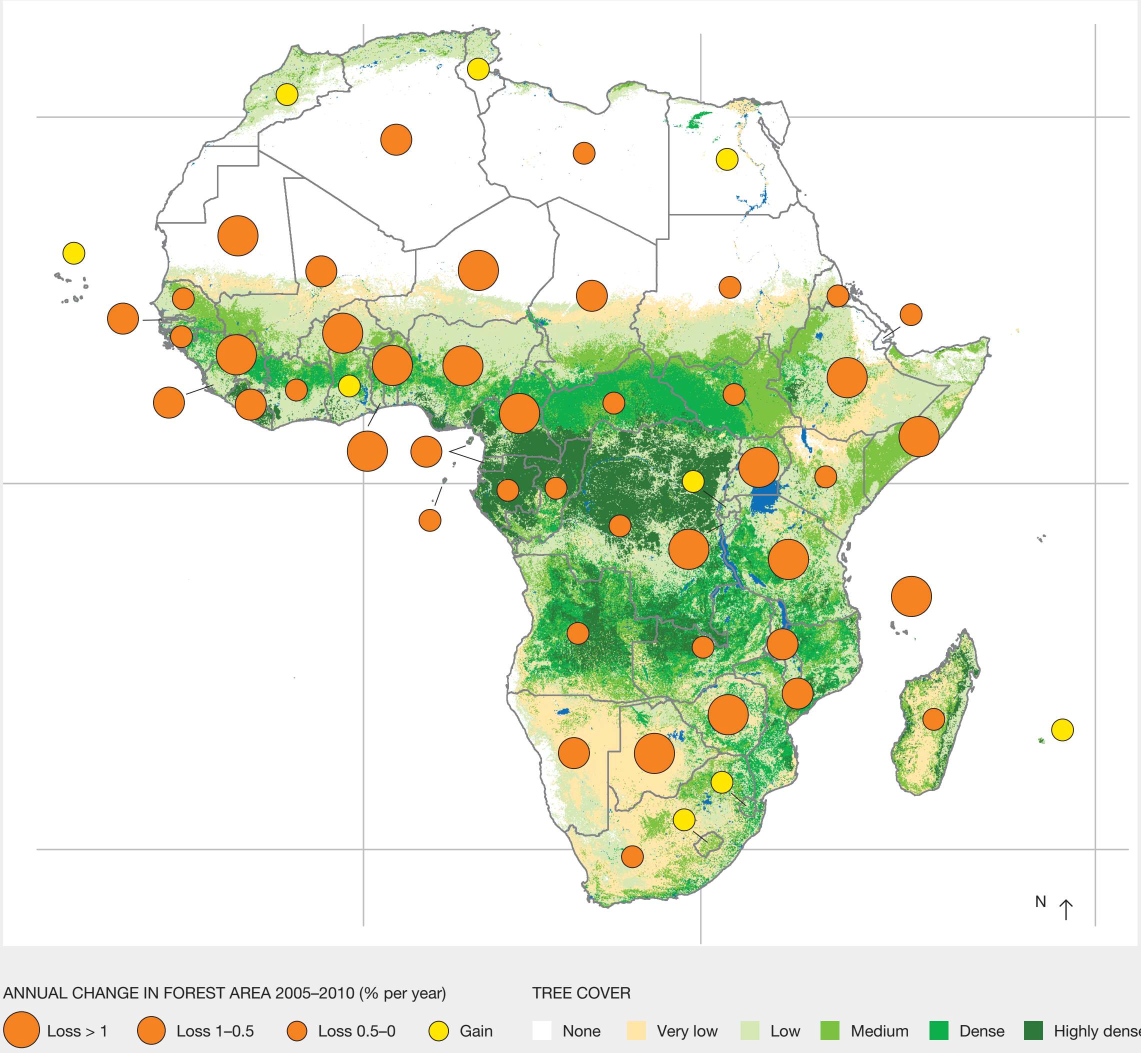
Africa is rich in natural resources with large underground desposits of cobalt, diamond, gold, iron, phosphates, etc. Access to mineral reserves is through opencast or underground mining with impacts on natural areas and biodiversity (Duran *et al.*, 2013). A proportion of 44% of Africa's major metal mines are inside or within 10 km of a protected area (see table below) (Edward *et al.*, 2013). Mineral exploration and exploitation is linked with major infrastructural development, such as roads, railway, ports and hydropower dams. These have direct and indirect impacts on biodiversity including removal, fragmentation and degradation of natural habitats (Duran *et al.*, 2013).

Of greatest concern is the downgrading, downsizing, and degazettement of protected areas as exemplified by the loss of 1,550 hectares of Mount Nimba Biosphere Reserve, a World Heritage site in the Republic of Guniea (Edward *et al.*, 2013).

Examples of Protected Area downgrading, downsizing, and degazettement (PADDD) for mining prospecting or extraction in some African countries. Downgrading relates to a reduction in the level of legal protection, downsizing to a reduction in park area, and degazettement to a removal of formal protection. Source: Edward *et al.* (2013).

Country	Location	PADDD	Year	Area km²	Mining activity
Guinea	Mount Nimba World Heritage site	Downsize	1993	15.5	Iron-ore prospect
Zambia	19 National Parks	Downgrade	1998	63,585	Mining
Uganda	Queen Elizabeth National Park	Downgrade	2005	Unknown	Limestone
DRC	Basse Kando Reserve	Degazette	2006	Unknown	Mining
South Africa	Marakele National Park	Downgrade	2009	Unknown	Unknown
Tanzania	Selous Game Reserve	Downsize	2012	200	Uranium

Figure 4 7 **Annual damage in Forest area 2005–2010 in Africa. Source: Pesche *et al.* (2016).**



1990s, and early 2000s. The actual loss was 3.4 million hectares annually between 2005 and 2010 (FAO, 2010). Some of the main causes have been classified as illegal industrial and artisanal logging, unsustainable mining, commercial agriculture, infrastructure development, expansion of oil palm cultivation and urban demand for wood fuel or charcoal. Deforestation and fires are also linked with agricultural activities such as slash-and-burn. During severe droughts as in El Niño years, African rainforests may become more susceptible to fire. The most destructive fires occur in forests that have burned previously (Cochrane *et al.*, 1999). Deforestation impacts negatively on local and indigenous peoples via loss of natural resources and therefore loss of habitats they rely on for food, medicine, traditional rituals and social stability and the loss of the traditional and cultural knowledge related to the management of these resources and ecosystems (Kipalu *et al.*, 2016).

4.2.2.2.1 Central Africa (Congo Basin)

In a global context, annual deforestation rates are relatively low in Central Africa, compared to other rainforests in Southeast Asia and South America. Population density, small-scale agriculture, fuelwood collection and forest's accessibility are closely linked to deforestation, whereas timber extraction has no major impact on the reduction in the canopy cover (Ernst *et al.*, 2013; Gillet *et al.*, 2016). Given the extent and rate of forest fragmentation from roadside farming and logging, basic simulations suggest that up to 30% of forests will disappear by 2030. The forests of Congo Basin are being harvested at unprecedented rate, in particular, due to rapidly rising demand from China (WWF, 2017). A doubling of gross deforestation rates from 0.11%/year between 1990 and 2000 to 0.22% between 2000 and 2005 was demonstrated (Ernst *et al.*, 2013). However, deforestation in Congo Basin has since considerably decreased (Megevand *et al.*, 2013).

Box 4 4 Africa forest resources assessment statistics.

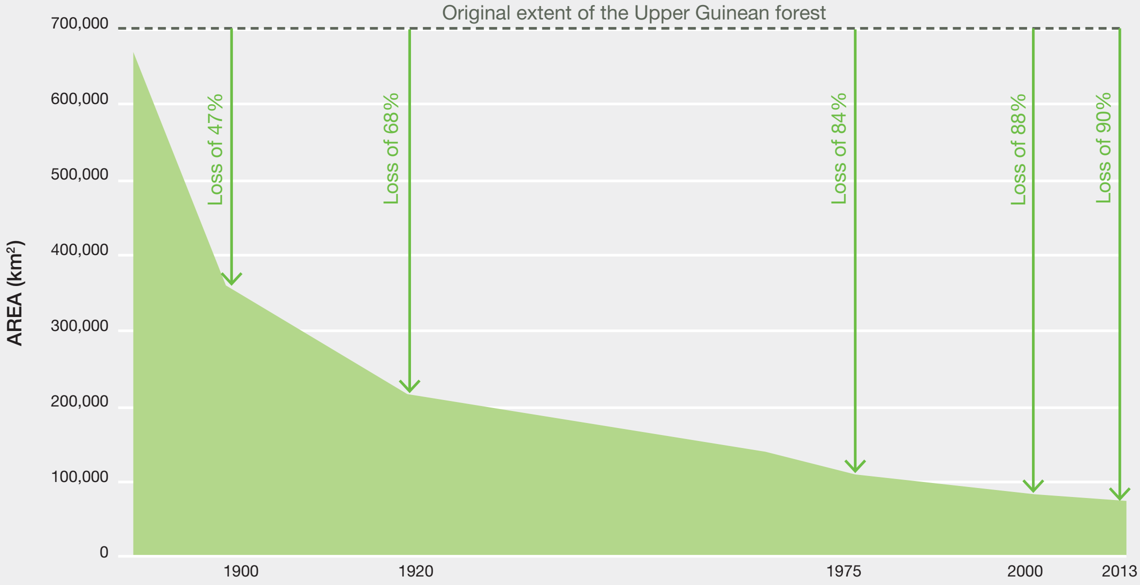
Data collection and reporting leading up to 2015 was guided by a series of workshops and training sessions designed to maximize consistency between reports (FAO, 2016). For Forest Resources Assessment 2015, data were also acquired through the Forest Resources Information Management System, the online data collection portal of FAO. Countries were given templates with data they had submitted for forest resources assessment 2010. Countries were requested to revise and update the former figures when new data were available and then estimate the figures for 2015. In addition to providing the data reported by countries, FAO has worked with national correspondents to provide data assembled from other sources. Most of these are sources previously provided by national governments to the United Nations, including data on population, land area and wood removals (FAO, 2016). Table provided in this Box provides summary statistics for African forest resources assessment.

Variable (unit, year)[a]	Total	Direction of change[b]	Annual change[b] (%)	Data availability[c] (Status/trend)
Forest area (million hectares, 2015)	624	↓	-0.49	H/H
Natural forest (million hectares, 2015)	600	↓	-0.54	H/H
Planted forest (million hectares, 2015)	16	↑	1.34	H/H
Net annual forest change (million hectares, 2010–2015)	-2.8			H/*
Net annual forest change (million hectares, 2010–2015)[d]	-3.1			H/*
Net annual planted forest change (million hectares, 2010–2015)	0.2			H/*
Forest growing stock (billion m³, 2015)[e]	79	↓	-0.37	H/H
Forest growing stock (m³ per hectare, 2015)[e]	128	↑	0.13	H/H
Carbon in above-and below-ground biomass (giga tons, 2015)[e]	60	↓	-0.43	H/H
Carbon in above-and below-ground biomass (tons per hectare, 2015)[e]	96	↑	0.07	H/H
Production (million hectares, 2015)	165	↓	-0.77	H/M
Multiple-use forest (million hectares, 2015)	133	↓	-0.46	H/M
Total wood removals (million m³, 2011)	614	↑	2.12	H/H
Protection of soil and water (million hectares, 2015)	50	↓	-0.15	M/L
Ecosystem services, cultural or spiritual values (million hectares, 2015)	67	↓	-0.30	L/L
Conservation of biodiversity (million hectares, 2015)	92	↑	0.75	H/M
Primary forest (million hectares, 2015)	135	↓	-0.45	H/H
Forest area within protected areas (million hectares, 2015)	101	↑	0.66	H/M
Forest area burned (million hectares, 2010)	19			H/*
Forest area with reduction in canopy cover (million hectares, 2000–2010)	50			H/*

4.2.2.2.2 West Africa

Deforestation has already wiped out a large extent of natural forests of West Africa's with only 22.8% moist forests remaining, many in a degraded state (FAO, 1997). Deforestation and degradation of West Africa's tropical forest areas (e.g., in Nigeria) is occurring due to the expansion of smallholder cocoa farms that depend on environmentally destructive practices like slash-and-burn clearing methods. Most deforestation occurred before 1975, with a loss of 84% of the original forest extent. Between 1975 and 2013, forest removal in the Upper Guinean countries for wood products, plantations, farming and other uses was still ongoing, and resulted in the loss of 28% (65,000 km²) of the forest **(Figure 4.8)**. Deforestation has been associated with the severe outbreak of Ebola in West Africa (Bausch *et al*., 2014). "The destruction of

Figure 4 8 **Evolution of dense forest extent in the Upper Guinean countries. Source: USAID (2014).**



natural habitat of fruit-eating bats drove them closer to human settlements for food and thus exposing human populations to the transmission of the Ebola virus from bats" (The Guardian, 2015).

4.2.2.2.3 Southern Africa

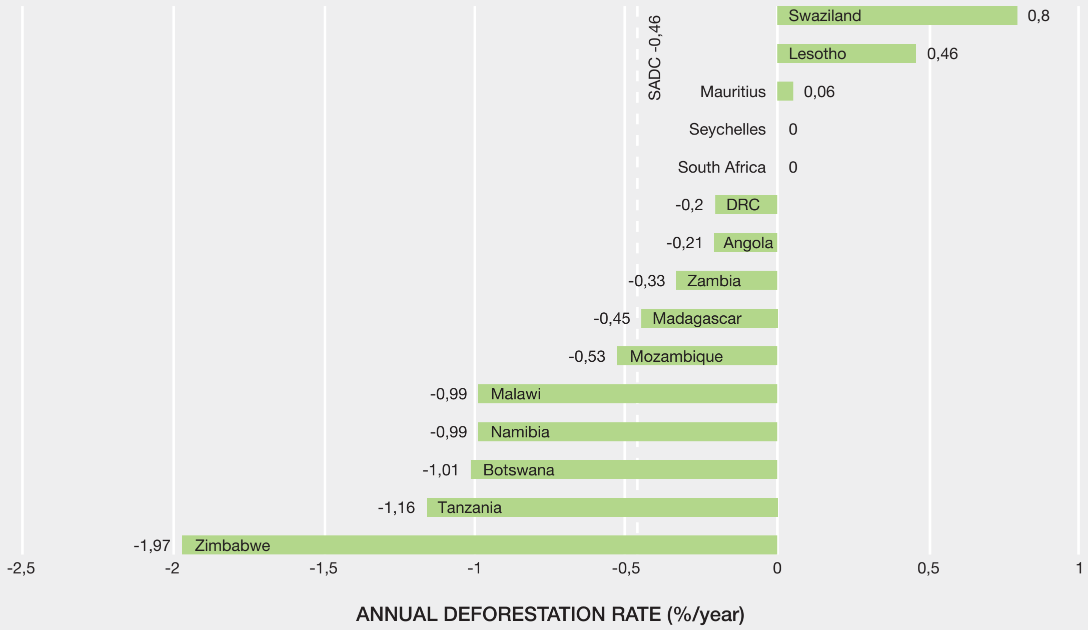
In Southern Africa, deforestation and forest degradation is considered a major problem contributing to greenhouse gases emissions and having negative impacts on biodiversity and the balance of the associated ecosystems (Lesolle, 2012). The annual forest loss in the Southern African Development Community regions was 0.46% (1.8 million hectares) between 2005 and 2010 (FAO, 2010; **Figure 4.9**). Efforts to curb forest fires in southern Africa have involved programs such as the Burning for Biodiversity in Southern Africa project that brings together biodiversity research with capacity building and external communication to promote effective fire and conservation management in South African savannas. Findings from this program highlight that, surprisingly, burning generally had little effect on many faunal groups. This is critical information for more effective fire management for biodiversity conservation and enables a more flexible approach to burning in many conservation areas (FAO, 2010).

4.2.2.2.4 East Africa and adjacent islands

East African coastal forests are a narrow belt with abundant fauna and flora, most severely threatened by deforestation. For this reason, they are considered priority conservation areas globally. The region has 1,366 and 100 endemic plants and animal species, respectively (WWF-US, 2003). Since the arrival of humans 2,000 years ago, Madagascar has lost more than 90% of its original forests. Most of this loss has occurred since independence from France, as a result of local people using slash-and-burn agricultural practices as they try to subsist (WWF, 2001). The coastal forests of Tanzania and Kenya have been reduced to less than 10% of their original area (Sloan *et al.*, 2014). The main causes may be similar (as above) in different countries but the extent forests covers and drivers for deforestation vary among the countries (Naidoo *et al.*, 2013). For example, the Kaya forests in coastal Kenya, for long time has been a hotspot for biodiversity and ecosystem services but in recent decades has been lost due to the interplay of direct and indirect drivers (Githitho, 2005). Additional case studies from East Africa are presented in **Box 4.5**).

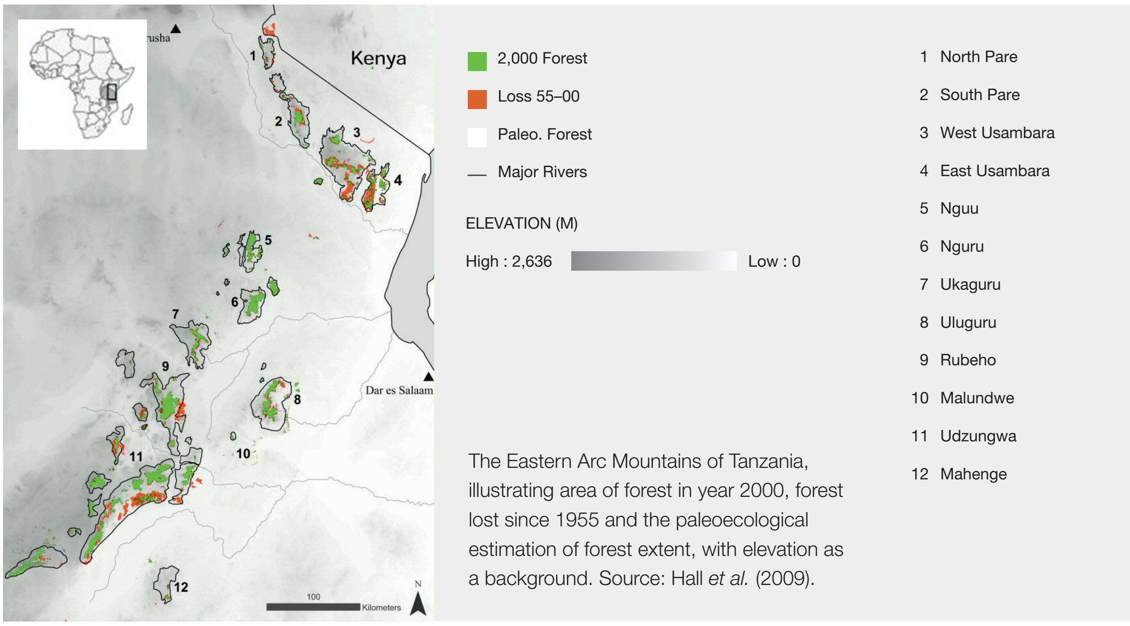
The loss of forest areas in most countries in East Africa and adjacent islands have been associated with increased human settlement and agriculture, inappropriate energy technologies, unplanned urbanisation, unregulated use of forest resources and insufficient local and national intervention (Chapman *et al.*, 2000; Matiku, 2005). Tobacco production was to a great extent responsible for deforestation in East Africa since the early 1900s. The impacts are not only from clearing for farms, but also from the curing process. Approximately 3 hectares of trees are cleared to provide fuel to cure one hectare of tobacco (Lee *et al.*, 2016). The environmental impacts of tobacco farming in large-scale farms also include massive use of water and air and water pollution (Lee *et al.*, 2016).

Figure 4 9 **Annual deforestation rate in the Southern African Development Community regions, 2005–2010. Source: FAO (2010).**



Box 4 5 **Forest Analyses in East Africa.**

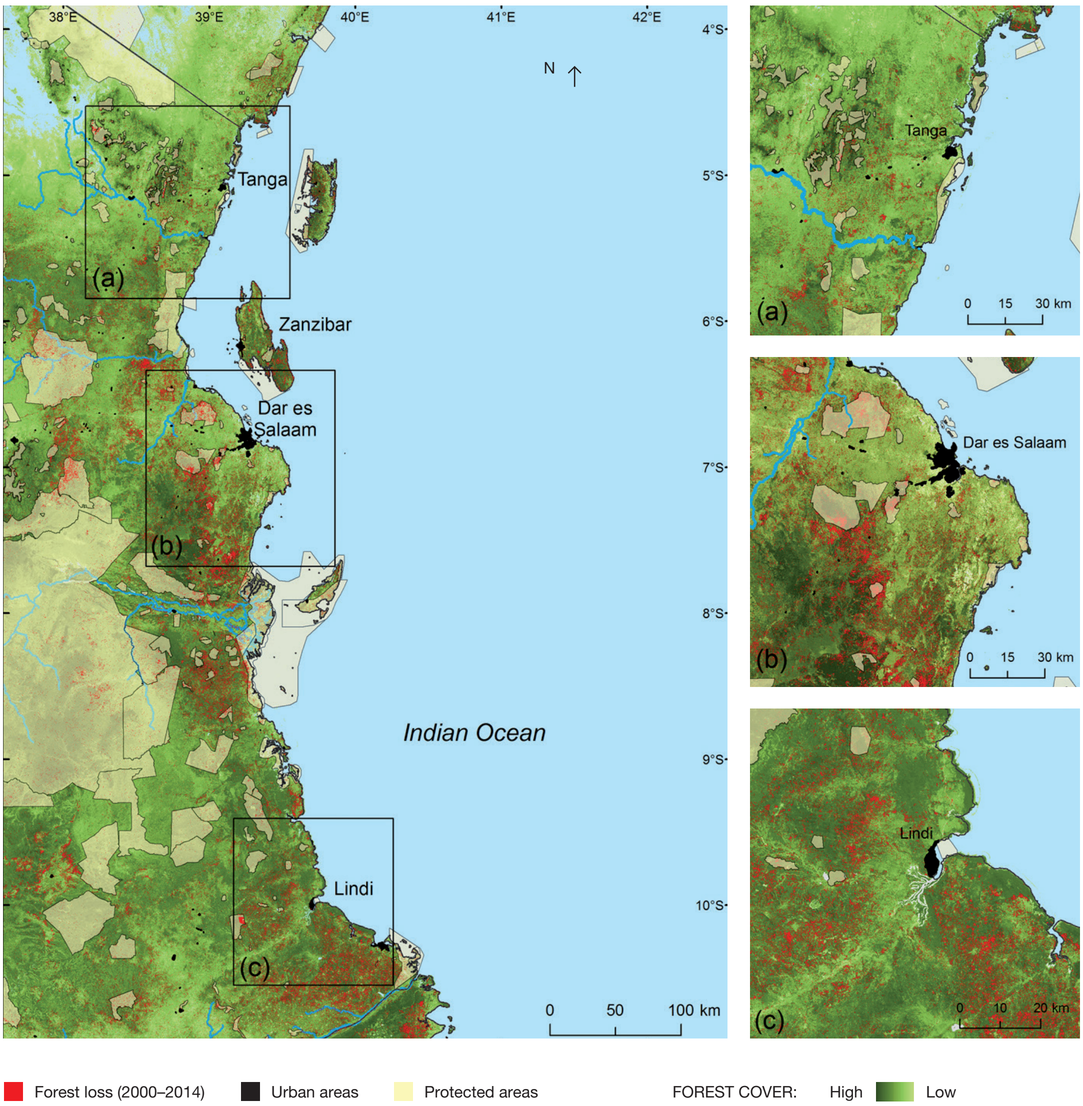
The Eastern Arc Mountains of Tanzania have exceptional global importance for the conservation of endemic plants and animals. Studies show that deforestation has preferentially occurred in the lower and middle elevations of the mountains and that this has happened more in some mountain blocks than others (e.g., Burgess *et al.,* 2017). By linking deforestation trends to the distribution of endemic trees, it was possible to better address concerns in the then Red Listing of threatened trees. The elevational distribution of Eastern Arc closed forest and the processes of deforestation affecting the ecosystem are important factors to consider when developing a comprehensive conservation plan for an ecosystem in which species of concern are restricted to defined elevation ranges (see figure below).



The Eastern Arc Mountains of Tanzania, illustrating area of forest in year 2000, forest lost since 1955 and the paleoecological estimation of forest extent, with elevation as a background. Source: Hall *et al.* (2009).

Box 4 5

Another analysis of changes of state, pressures and conservation responses over 20 years in East Africa, represented by the Tanzanian portion of the Coastal Forests biodiversity hotspot is reported by Burgess *et al.* (2017). Baseline data collected during 1989–1995 was compared with data from a synthesis of published papers and reports, and field work carried out across the region during 2010–2014. It was found that biodiversity endemism values were largely unchanged, although two new species (amphibian and mammal) had been named and two extremely rare tree species had been relocated. However, forest habitat continues to be lost and degraded, largely as a result of agricultural expansion, charcoal production to supply cities with cooking fuel, logging for timber and cutting of wood for firewood and building poles. Habitat loss is linked to an increase in the number of species threatened over time. Human-use pressures remain intense in many areas, and combined with emerging pressures from mining, gas and oil exploration, many endemic species remain threatened with extinction (Burgess *et al.*, 2017; see figure below).



Forest cover and forest loss in coastal Tanzania during 2000–2012. (A) Based on raw data from Hansen *et al.* (2013): (a) Forest change around the East Usambara–Tanga town area in northern Tanzania; (b) forest loss around the capital city, Dar es Salaam; (c) forest change in southern Tanzania, towards the Mozambique border. (B) Based on further analysis and processing to show forest, woodland and mangrove cover and loss and the major urban centres in the same coastal region of Tanzania (analysis from Tabor *et al.,* 2013).

4.2.2.3 Climate change

It is generally agreed that anthropogenic activities including the burning of fossil fuels and unsustainable land-use changes (deforestation and forest degradation) around the world have resulted in a significant increase in the concentrations of heat-trapping greenhouse gases which include CO_2, CFCs, CH_4, and N_2O (Myhre *et al*., 2013). As a continent, Africa has contributed a trivial proportion of global emissions, only 2.5% of fossil fuel emissions in the 1980 to 2005 period, despite having 13.8% of the global population (Le Quéré *et al.*, 2009). Within Africa, greenhouse gases emissions is uneven, for instance, almost 38% of the total was from South Africa alone, rising to 60% if Egypt and Nigeria are included (Canadell *et al.*, 2009). Per capita Africa emissions are among the lowest in the world at 0.32 tons of Carbon/year versus a global average of 1.2 tons of Carbon/ear. What is strikingly unique about Africa's emissions is that just less than half is from land-use change and deforestation (Le Quéré *et al.*, 2009a). High population growth, if current development pathways are left to continue with limited climate-smart technologies adopted, may significantly increase Africa's contribution to greenhouse gases emissions over the next century (Gornall *et al.*, 2010).

Despite Africa's low contribution to greenhouse gases emissions, Africa will be one of the region's most severely impacted by climate change, with the IPCC Fifth Assessment Report emphasizing negative impacts on water availability and food production (Myhre *et al*., 2013). This constrains Africa's ability to develop, unless mitigation measures are undertaken (Wright *et al.*, 2015; Connolly-Boutin *et al.*, 2016). In addition to elevating human pressure on natural resources due to a decline in agricultural productivity, anthropogenic climate change is also anticipated to be a major driver of biodiversity loss; changes in ecosystem structure and function; and the ability of ecosystems to supply nature's contributions to people (Perrings, 2010; Bellard *et al.*, 2012; Scholes, 2016). The degree to which this will impact on biodiversity and the provisioning of nature's contributions to people remains uncertain as it depends on both the global ability to mitigate emissions as well as uncertainty around how the future climate which is already affected by global warming will impact both biodiversity and nature's contributions to people provision (Scholes, 2016). Changes in the seasonality of rainfall as well as within and between season variability could have profound effects on vegetation structure and net primary production (Rohr *et al.*, 2013; Cramer *et al.*, 2015). For instance, biodiversity of the Mediterranean vegetation at the southern tip of Africa (fynbos) is totally dependent on winter rainfall, whilst the savannas are dependent on the existence of a long dry winter period (Mucina *et al.*, 2006). For coastal systems, a rise in temperature, increased storm surge and sea level rise all pose threats, with estuarine systems being particularly vulnerable (Magadza, 2000). Loss of mangrove vegetation from these estuarine systems will exacerbate the storm surge hazards leading to disasters (McIvor *et al.*, 2012).

Globally, climate change is anticipated to have major impacts on species extinctions (Thomas *et al.*, 2004; Jetz *et al.*, 2007; Foden *et al.*, 2013), though the true magnitude of impact is hotly debated and uncertain. The IPCC (2007) estimate, based on a variety of scenarios, that climate change could result in the losses of about 5,000 African plant species, over 50% of some bird and mammal species, and decline the productivity of Africa's lakes by between 20 and 30% by 2100 (IPCC, 2007). About one-fifth of all known species of plants, mammals and birds, and about one-sixth of amphibians and reptiles are found in Africa (Midgley *et al.*, 2007); the regions four biodiversity hotspots together today host 3.5% of the worlds' endemic plant species and 1.8% of endemic vertebrate species in areas that have been reduced by 73.2% and 93.3% relative to their original areal extents (Myers *et al.*, 2000), indicating that even without climate change, there is a high level of threat to Africa's endemic biodiversity (Midgley *et al.*, 2007). Disturbance by fire and grazing are also key components of future global change impacts (Bond *et al.*, 2003). A scenario analysis using land-use, climate change, nitrogen deposition, biotic exchange (alien organisms) and rising atmospheric CO_2 as the five main drivers of future global biodiversity in that order of importance and assuming no interactions between drivers, concluded that human land-use impacts were most critical in savannas and tropical forests, with climate change impacts second-most important, or most important in other ecosystem types in Africa (Sala *et al.*, 2000).

Impacts on both freshwater and coastal systems may also be severe, with sea level rises, changes in upwelling, sea surges, sea temperature changes and pH changes also likely to impact on coastal ecosystems. Increases CO_2 in the oceans will increase water acidity and this, coupled with increased temperature will have profound impacts including coral bleaching (Hoegh-Guldberg *et al.*, 2007) and the de-calcification of shells of molluscs (Parker *et al.*, 2013). At high CO_2 concentrations this may lead to total collapse of coral systems and the multitude of ecosystem functions they support, including being an important component of many fisheries. Most of the large biodiversity-rich lakes on the continent are sensitive to climate change as their water balances are dominated by rainfall on the lakes and evaporation (Spigel *et al.*, 1996). The smaller lakes receive significant water inputs from inflowing rivers as opposed to rainfall, but are equally strongly affected by evaporation and their water balances of the lakes are also affected by abstraction for use in agriculture and industry. The lake waters, for example in Lake Malawi and Tanganyika, are now getting warmer in tandem with the rise in global temperatures, and this has affected fisheries production due to increased thermal stratification which results in less mixing and nutrient exchange between surface and deep waters thus affecting primary production and thus a cascading effect on the aquatic food-webs. The resulting reduction of food availability will affect fisheries and thus livelihoods (Hecky *et al.*, 1994; Bugenyi *et al.*, 1996).

Not only will climate change result in extinctions, but it is also likely to change the structure and function of the biota in many areas (Hole *et al.*, 2009).). Individual species or entire ecosystems will need to, in effect, migrate across the landscape to track suitable climates. The ability of species to migrate will differ per taxa, will be dependent on the existence of migratory corridors, and will be hindered by anthropogenic land-cover change and habitat fragmentation (Hannah *et al.*, 2002; von Maltitz *et al.*, 2007; Baker *et al.*, 2015; Belle *et al.*, 2016). It is probable that future ecosystem will have different structure, function and species mixes compared to the present (Hannah *et al.*, 2002). One consequence is that current reserve networks may need to be re-aligned to account for the climate change. A set of studies in West Africa have found that the current reserves configuration under future climates scenarios will lead to a decreased suitability across the protected area network of 55% for birds, 63% for amphibians, and 63% for mammals (Baker *et al.*, 2015). A similar need for a realignment of conservation areas in response to climate change in South Africa has been shown (Hannah *et al.*, 2007).

The direct impact of globally increased concentration of CO_2 is likely to have profound impacts on the species distribution within the terrestrial environment, and may conceivably be a direct contributor to biome level change (Steffen *et al.*, 2007; West *et al.*, 2012). A recent study (Midgley *et al.*, 2015) shows that the vast African savannas, with its icon fauna and flora, may be partly lost as a direct impact of CO_2 enrichment effects. If emissions continue on a 'business-as-usual' path, by mid-century, CO_2 levels will exceed those last seen more than 25 million years ago–far predating the rise of grasslands and savanna's C4 grasses, which dominate through the continent (West *et al.*, 2012). Having evolved under high CO_2 concentration (Franks *et al.*, 2013), an increase in CO_2 will facilitate C3 plant species ability to rapidly accumulate woody biomass through faster growth, and this will enable them to escape the "fire trap" created from frequent grass fires (Bond *et al.*, 2012; West *et al.*, 2012). There is increasing evidence that a raised CO_2 concentration may favour woody perennials over C4 grasses (Bond *et al.*, 2000; 2012). The large-scale woody plant densification (referred to in Southern Africa as bush encroachment) is regarded as a complex response to multiple drivers including increased grazing pressure with reduced fire (O'Connor *et al.*, 2014). However, the impacts of raised CO_2 may be an additional important driver in this process and may lead to bush encroachment even in well-managed areas. Bush encroachment regardless of its cause, has had profound impacts on the provisioning of ecosystems services, and especially cattle grazing, across vast areas of the savanna, (Donaldson, 1980; De Klerk, 2004; O'Connor *et al.*, 2014) with an estimated 260,000 km^2 being affected in just Namibia. Of particular concern regarding climate change is "tipping points" where ecosystem thresholds can lead to irreversible shifts in biomes (Leadley *et al.*, 2010). Raised CO_2 may cause a tip between savanna and forest systems (Higgins *et al.*, 2012; West *et al.*, 2012).

A number of dynamic vegetation models have attempted to model changes in vegetation functional types in response to climate change (Scheiter *et al.*, 2013; Che *et al.*, 2014). These indicate that extensive shifts in biomes are likely. The role that fire plays in the distribution of future biomes is critical as has been demonstrated by running the same models with fire sub-sections disabled. In Southern Africa the grasslands are likely to retract extensively and be replaced by savanna or forest. Savannas may change to forest in other areas of Africa (Higgins *et al.*, 2012). These dynamic vegetation models suggest savanna vegetation is far less stable than earlier outcomes from simpler niche-based models, where CO_2 and fire effects are not considered, indicated (Midgley *et al.*, 2015). Carbon dioxide fertilization effects may make some plants more drought hardy, and this will slightly compensate for temperature rise. It also means that globally there should be, on balance, an overall greening (Zhu *et al.*, 2016). However, raised CO_2 may also lead to an increased synthesis of secondary compounds in the plant, potentially changing the ratio of carbon to nitrogen and hence reducing palatability (Schadler *et al.*, 2007; Craine *et al.*, 2017). Although data on this is still poorly researched, especially for Africa, impacts could be profound, and may reduce the flow of nature's contributions to people resulting from animal production (Owensby *et al.*, 1996; Milchunas *et al.*, 2005; AbdElgawad *et al.*, 2014; Craine *et al.*, 2017).

Climate change will influence environmental conditions that can enable or disable the survival, reproduction, abundance, and distribution of pathogens, vectors, and hosts, as well as the means of disease transmission and the outbreak frequency hence a major driver to emerging diseases (Wu *et al.*, 2016). These could cause shifts in the geographic and seasonal patterns of human infectious diseases, hence changes in outbreak frequency and severity (Wu *et al.*, 2016). In Africa, the neglected tropical diseases, such as soil-transmitted helminths, are the most common conditions affecting the poorest 500 million people living in sub-Saharan Africa.

Many communicable diseases are water borne and climate change is therefore likely to impact incidences and prevalence of these diseases by increasing the range and seasonal duration of causative pathogens (UNECA, 2011). Climate change induced increased frequency of extreme weather events is likely to exacerbate water-borne diseases (e.g., diarrhoea) and may have major influence on vector-borne disease epidemiology (reviewed in UNECA, 2011). For instance, the Rift Valley Fever, which has a widespread occurrence in the continent, has pronounced periods of virus activity in East Africa during periods of heavy, widespread and persistent rainfall associated with El Niño events (Linthicum *et al.*, 1999; Martin *et al.*, 2008).

Climate change is expected to have direct, and in most cases negative impacts on Africa's ability to produce food crops, though impacts vary extensively by region, climate scenarios used and global circulation model considered (Ringler *et al.*, 2010; Müller *et al.*, 2011; Knox *et al.*, 2012; Ramirez-Villegas *et al.*, 2015). Despite the high variance, and many locations showing increases under some scenarios, both mean and median changes tend to be negative. Different crops are also anticipated to respond differentially to climate change, with a wide range of impacts, which are location and scenario dependent **(Table 4.3; Figure 4.10)**. Maize the staple crop for large parts of Africa will be less severely impacted than wheat, with predicted impacts varying widely, but largely negative. Sugarcane, rice and cassava will be largely unaffected (Knox *et al.*, 2012). Climate change is also anticipated to negatively impact on human access to water resources with rural areas likely to be particularly vulnerable (Kusangaya *et al.*, 2013; Radhouane, 2013).

High within and between seasons, as well as inter-annual, variability of rainfall is a natural feature of Africa. However, the frequency of extreme events has increased in the last few decades, which is most likely linked to a changing climate (discussed in more detail below). Changes to the natural conditions, including the natural variation, consequently affect individual organisms, populations, species distributions, and ecosystem function and composition both directly and indirectly **(Table 4.4)**. For instance, amphibians and migratory birds are particularly affected by changes in climate variability (Pounds *et al.*, 2005; Marra *et al.*, 2005: Miller-Rushing *et al.*, 2008; Carey, 2009).

4.2.2.3.1 Future climate change dynamics

Temperatures in all African countries are expected to rise faster than the global average (James *et al.*, 2013; Belle *et al.*, 2016; **Figure 4.11**) with some areas, such as the Kalahari basin warming at close to double the global mean (Engelbrecht *et al.*, 2015). Rainfall projections are less certain, but, rainfall variability is projected to increase over most areas with most models suggest fewer, but higher intensity rainfall events (Myhre *et al*., 2013). Many areas in Africa are predicted to become drier, despite the global increase in rainfall, especially under high emission scenarios (Myhre *et al*., 2013). Observed data over the past three decades in East Africa has shown a trend

Table 4.3 **Summary of reported impacts of climate change on yield (mean and median changes (%)) for all crops, by subregion in Africa (Notes: *n* = Number of reported mean yield changes, which may include several from the same source for different countries or time slices; NS = not significant). Source: Knox *et al.* (2012).**

Crop	*n*	Mean change (%)	Median change (%)	Crops with significant variations	*n*	Mean change (%)	Crops with non-significant variation	*n*
All crops	257	-7.7	-7.0	Wheat Maize Sorghum Millet	37 12 9 23	-12.1 -7.2 -13.0 -8.8	Rice Cassava Sugarcane	43 8 7
Africa	163	-7.7	-10.0	Wheat Maize Sorghum Millet	10 20 6 13	-17.2 -5.4 -14.6 -9.6	Rice Cassava Sugarcane	5 7 3
Southern Africa	33	-11.0	-15.1	Maize	24	-11.4	Wheat Sorghum Sugarcane	2 3 2
Central Africa	14	-14.9	-12.1	Maize	8	-13.1	Wheat	2
East Africa	35	0.4 (NS)	-2.3	_	_	_	Wheat Maize	2 29
West Africa	34	-12.5	-8.4	Maize	19	-7.4	Wheat Sorghum Cassava	3 5 4
Sahel	24	-11.3	-11.5	Maize Millet	13 6	-12.6 -10.6	Sorghum	3
North Africa	22	0.8 (NS)	-7.3	_	_	_	Wheat Maize	10 12

Table 4 4 **Indicative ecological responses to climate change and variability.**

	Taxon	Observed changes	Observed in	Climate link	Source
Phenology	Numerous plant species	Early and significant flowering and maturity	Western Africa	higher temperatures	Clerget *et al.*, 2004
	Butterfly species	Earlier appearance	Eastern Africa	Early rainfall and increased temperatures	van Velzen, 2013
	Amphibians	Occurrence of earlier breeding	Southern Africa	Global warming	Matthews *et al.*, 2016
	Numerous bird species	Earlier singing and spring migration	Southern Africa	Changes in the climate and the advancement of spring	Simmons *et al.*, 2004
Latitudinal and altitudinal range shifts	Shrubs	Expansion of shrubs in previously shrub-free areas.	Southern Africa	Periods of the high rainfall	Tews *et al.*, 2006
The composition of and interactions within communities	Plants	Erosion of the geographical range of desert plants through population declines and dispersal lags	Semi and extreme desert areas	Decreased water availability and increased temperature	Foden *et al.*, 2007
	Browsers and frugivorous	Decreases species richness and assemblage composition of browsers and frugivorous	Western Africa	Availability of moisture.	Klop *et al.*, 2008
The structure and dynamics of ecosystems	Plants	Increased biomass and abundance of woody plants species, often thorny or unpalatable, coupled with the suppression of herbaceous plant cover.	Arid and semi-arid environments of Africa	Rainfall variability	Kgosikoma *et al.*, 2013

Figure 4 10 **Summary of reported mean yield variations (%) in Africa. Data shown are for all observations for each crop type, for all crop modelling approaches, all general circulation models and all time slices. Where published, the confidence intervals for specific studies are shown. Source: Knox *et al.* (2012).**

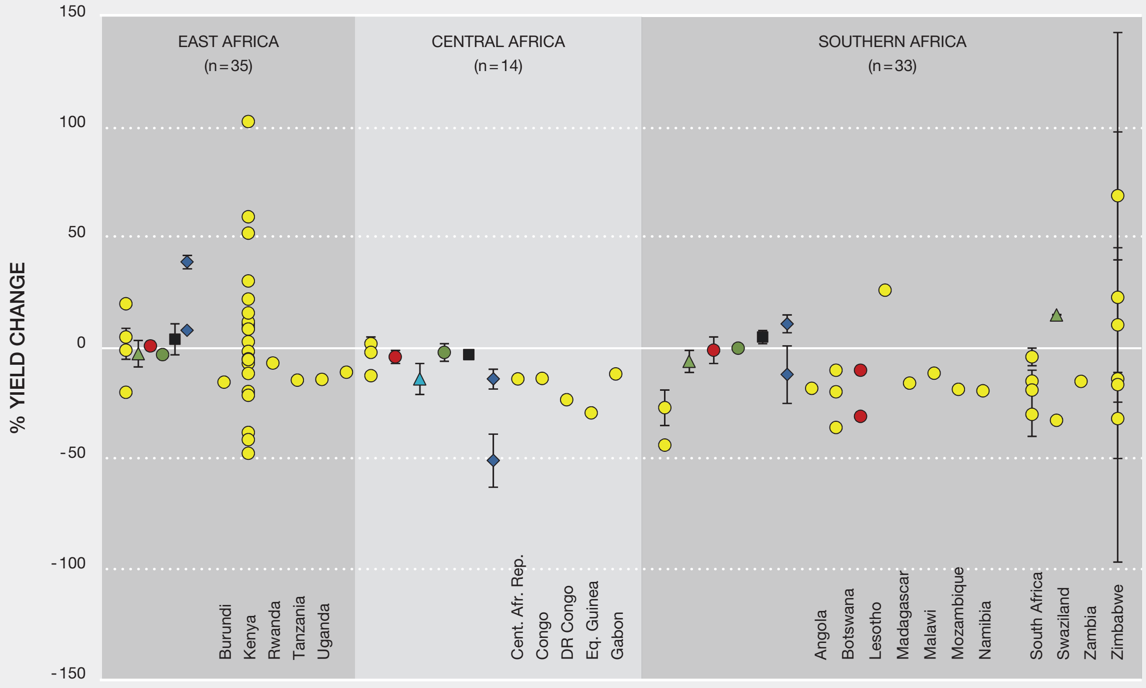


Figure 4.10

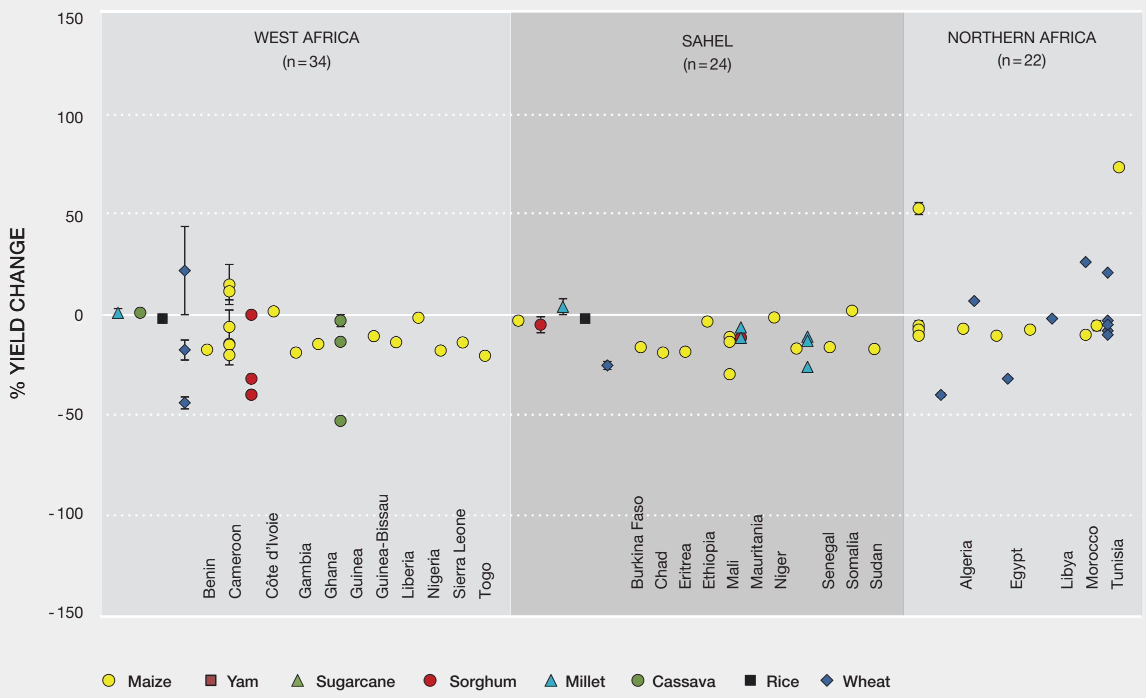


Figure 4.11 **"Observed and projected changes in annual average temperature and precipitation.**

Left panels: Observed annual average temperature change from 1901–2012 (top) and observed annual precipitation change from 1951–2010 (bottom) derived from a linear trend. For observed temperature and precipitation, white areas depict regions which lack sufficient observational data for analysis. Solid colours indicate areas where trends are significant at the 10% level. Diagonal lines indicate areas where trends are not significant. Right panels: CMIP5 multi-model mean projections of annual average temperature changes (top) and average percent changes in annual mean precipitation (bottom) for two time periods (2046–2065 and 2081–2100) under two RCP emissions scenarios. Solid colours indicate very strong agreement amongst models, white dots represent strong agreement, grey areas depict divergent changes, and diagonal lines represent areas with little or no change with respect to current climate variability." Belle *et al.* (2016).

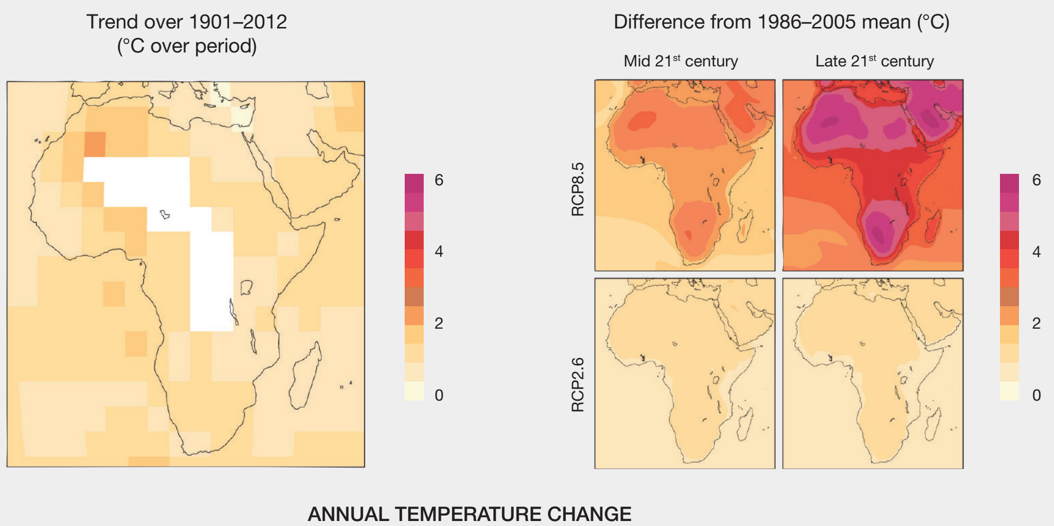
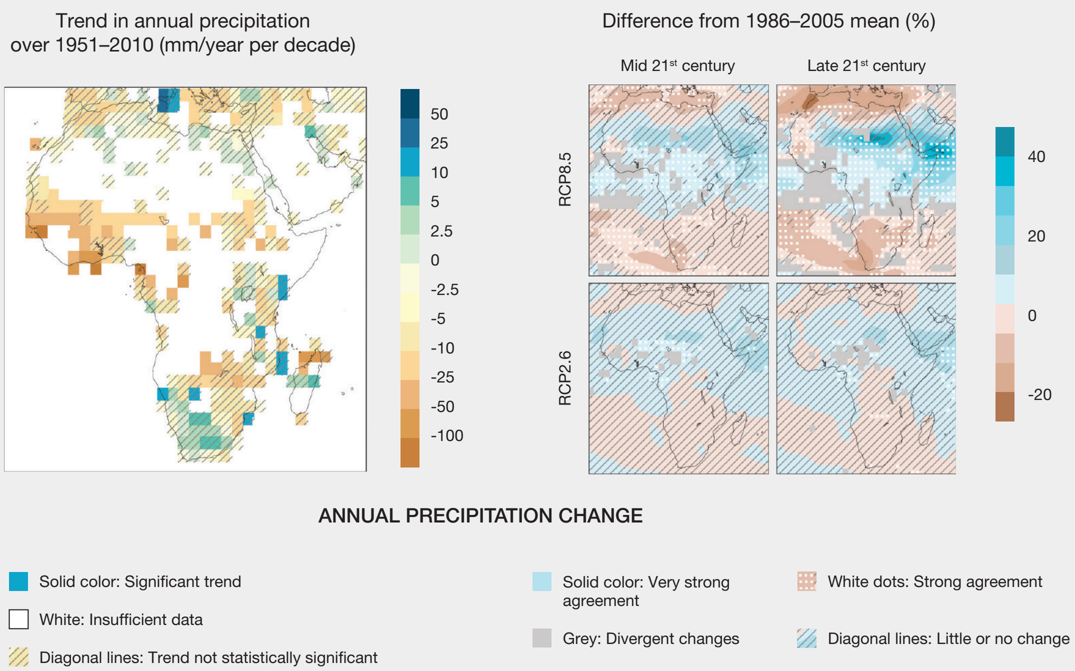


Figure 4 11



to greater aridity, but this is in contradiction to some long-term forecast (Williams *et al.*, 2011; Myhre *et al.*, 2013). The core forest areas of the central Africa may well become wetter with the peripheral woodland and savanna areas becoming drier (de Wasseige *et al.*, 2013). Although in areas of increased rainfall, this may well increase NPP and the provisioning of some ecosystem services, it could have negative biodiversity consequences (de Wasseige *et al.*, 2013).

Research shows that climate change will be more pronounced in high-elevation areas than in adjacent lowlands as the former are warming at a faster rate (World Bank, 2008), and that the pace of climate zone shifts will be higher in such regions than in lowlands (Mahlstein *et al.*, 2013). The mountain ecosystems in Africa appear to be undergoing significant observed changes that are likely due to complex climate-land interactions and the climate change (IPCC, 2007).

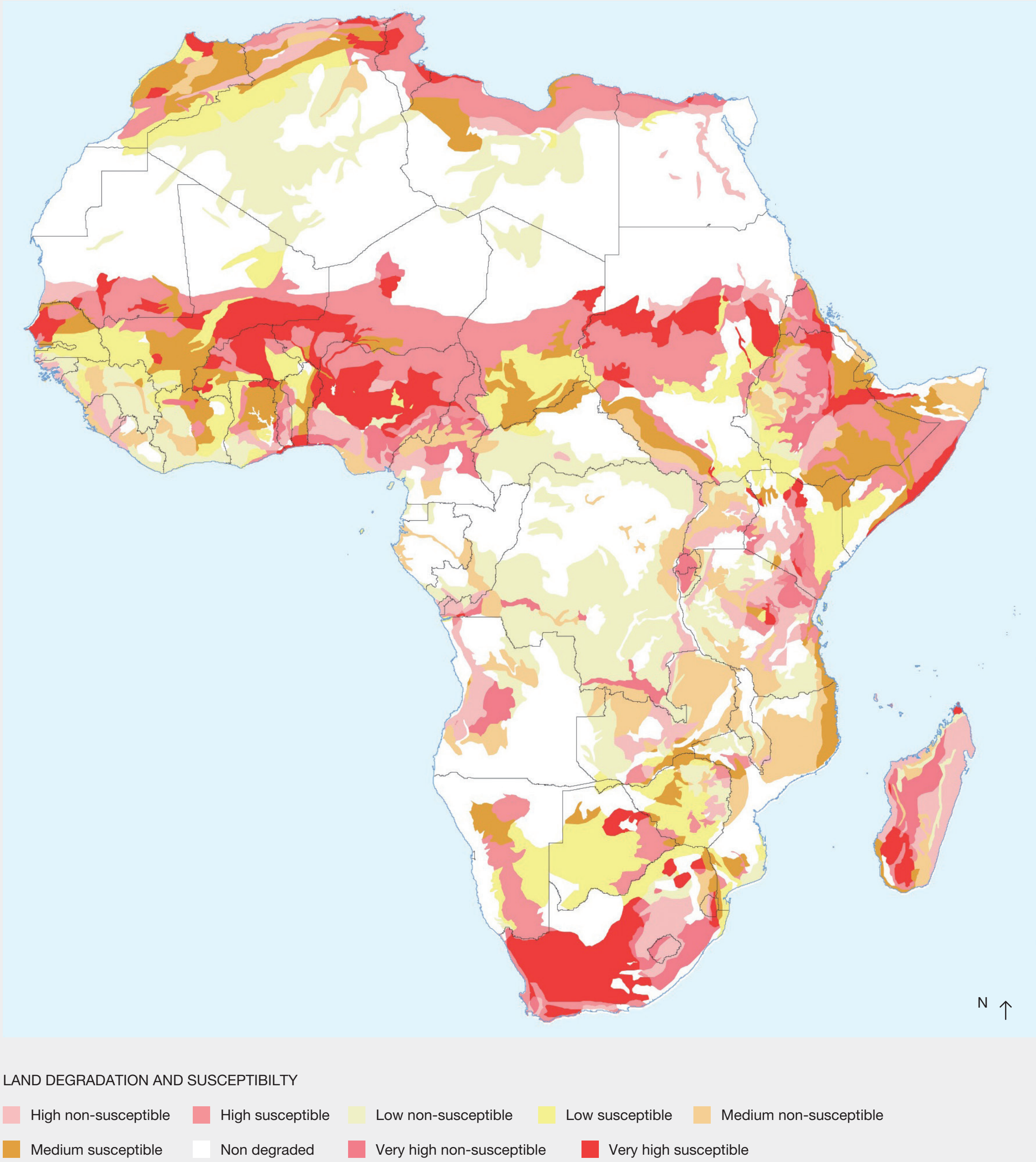
4.2.2.4 Overexploitation

The overexploitation of natural resources is as a direct result of population growth and is rampant in Africa (Chapter 1; section 1.3.7). This is further compounded by high climate variability and change. Without proper interventions, overexploitation leads to a decline in biodiversity, land degradation, increased vulnerability of rural communities to climate change and poverty.

4.2.2.4.1 Rangeland degradation due to overgrazing

Rangelands makeup 88% of the total area of drylands globally (Lal, 2001) and are important for the livelihoods of people in these areas including in Africa. The rangelands of Africa have evolved under a grazing and browsing by indigenous ungulates, both domestic and wild. Grazing patterns are usually regulated by fodder and water availability as demonstrated by the great migration of zebra and wildebeest in the Serengeti/Masai Mara that is associated with limited degradation of the ecosystem. However, movement of livestock and wild animal populations is sometimes limited by extreme events such as droughts, management and the ubiquity of human settlements. The shift in management of both livestock and wild animals as part of developmental initiatives such as drilling of boreholes in fragile Kalahari ecosystem in Botswana has led to increased animal populations and subsequent increased grazing pressure on rangeland ecosystem. Hence, land degradation is prevalent in grasslands and shrublands, especially in North Africa and East Africa and southern Africa (Nkonya *et al.*, 2016). The extent of degradation in Africa has proven difficult to assess (Wessels *et al.*, 2007; Prince, 2016) and this is attributed in part to poor or lack of rangeland monitoring. So far, it is estimated that 500,000 km^2 of land in Africa is degraded and 16% exposed to soil degradation (Bai *et al.*, 2008; Gibbs *et al.*, 2015) **(Figure 4.12)**. However the methodology used to reach these estimates has been strongly criticised (Wessels, 2009).

Figure 4 12 **Degraded land across Africa. Source: UNEP (2006).**



The causes of rangeland degradation are complex (Li *et al.*, 2012) and highly contested, but it is generally agreed that degradation is caused by the interaction of biophysical and anthropogenic factors (Lal, 2001; Kiage, 2013). High and prolonged livestock grazing is particularly blamed for rangeland degradation (Palmer *et al.*, 2013) and loss of biodiversity (Watkinson *et al.*, 2001) through the removal of biomass, trampling, destruction of root systems and soil compaction. Overgrazing leads to loss of perennial and palatable terrestrial species, which leaves the land bare or proliferated by less palatable annuals (also known as increaser species), such as *Aristida congesta,* and subsequent loss of biodiversity. In addition, overgrazing creates conducive environment for bush encroachment and invasion of alien species, which eventually replace the herbaceous vegetation and native plants, respectively. In Southern Africa, it is evident that overgrazed rangelands are encroached by *Senegalia mellifera* (formerly known as *Acacia mellifera*), *Vachellia tortilis* (formerly known as *Acacia tortilis*), *Terminalia sericea* and *Dichrostachys cinerea* as reported in Botswana (Moleele *et al.*, 2002), and South Africa (Palmer *et al.*, 2012) and this is accompanied by major shifts in vegetation composition.

4.2.2.4.2 Overharvesting

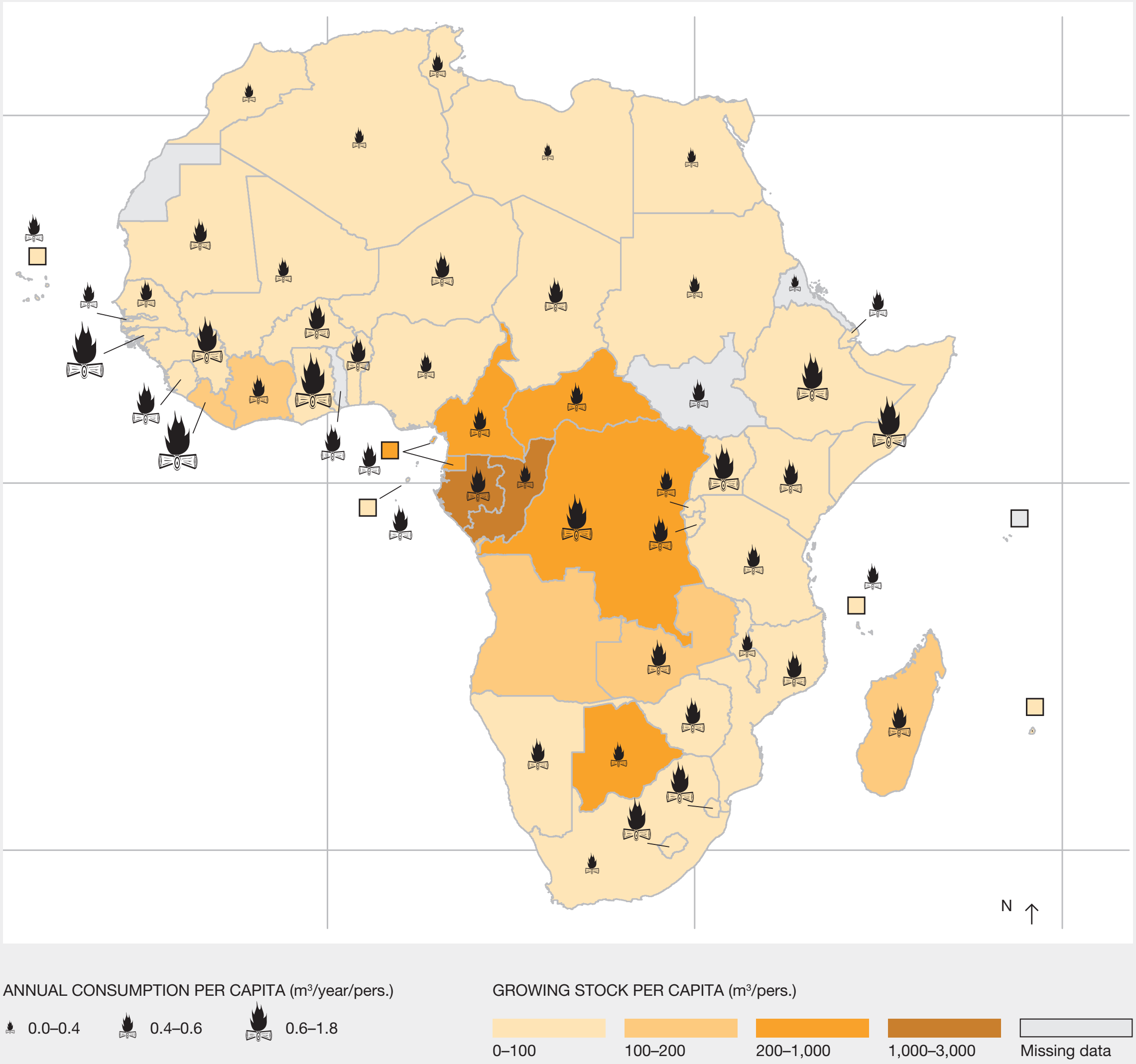
Biomass fuel

Wood-based fuels are key energy source for the majority of the African population contributing at least 70% of total energy consumption in sub-Saharan Africa. Charcoal production is a major cause of local overharvesting of trees in many African countries, with many major cities being largely dependent on charcoal as the primary urban fuel resource. The high rate of urban expansion and dependence on biomass as cooking fuels is driving an exponential increase in charcoal demand. Natural forests are overharvested to meet this high-energy demand both in urban and rural areas. As a result, key woody plant species such as *Anogeissus leiocarpa, Erythrophleum suaveolens, Prosopis africana, Burkea africana, Detarium microcarpum, Lophira lanceolata, Vitellaria paradoxa* are rare in Togo due to overexploitation for charcoal production (Fontodji *et al.*, 2011). Similarly, Tanzania losses 150,433 hectares of forest per year and the projected charcoal demand indicate that 2.8 million hectares of forests will have been lost by 2030 (Msuya *et al.*, 2011; **Figure 4.13**).

Wildlife and other natural resources

Bushmeat, (i.e., the harvesting of wild animals for local consumption or for sale (Cowlishaw *et al.*, 2005)) is a contributor to a decline in mammalian and avian biodiversity throughout most of Africa, particularly in West and Central Africa. Bushmeat is attributed to being a major driver of a decline in animal populations (Bennet *et al.*, 2007) and could well lead to local or total extinction of some species, the great apes being particularly vulnerable (Oates *et al.*, 2000; Obioha *et al.*, 2012). Bushmeat is harvested because it is in effect a more accessible protein resource to communities that are both desperately poor

Figure 4 13 **Annual consumption of charcoal in Africa. Source: Pesche *et al.* (2016).**



and lacking in dietary protein. Bushmeat hunting has socio-cultural importance (Meinert *et al.*, 2003), and is also regarded as a tastier protein than alternative meat (Obioha *et al.*, 2012). Most bushmeat is harvested from communal forests, and as an open-access resource, is easily over-exploited (Obioha *et al.*, 2012).

Although wildlife has culturally been used as a source of food and materials, the scale of the current harvest is unprecedented and is growing rapidly (Swamy *et al.*, 2014). A 2003 estimate was that between one and 2 million tons of bushmeat was being harvested annually from Central Africa alone (Brown *et al.*, 2003). The issue of consumption of meat from African wildlife requires more holistic examination than current work, which implies that it is driven by local needs, cultures, and poverty. It was demonstrated (Brashares *et al*., 2004) that the consumption of bushmeat in Ghana at the turn of the century rose in tandem with the rise in the catch by European Union fishing vessels off the coast of West Africa. This rise was in turn, driven by the rise in European Union subsidies to their distant waters fishing fleet. Another study by Knee (2000) found that in Africa, 68% of bushmeat species are hunted unsustainably. This implies that there is a 32% proportion that is considered to be consumed 'sustainably'. This calls for closer examination, because the term 'bushmeat' has a connotation of illegality, in the absence of terminological distinction from the consumption of 'game meat,' which is widespread, particularly in Southern Africa.

Road networks into the dense forests of Central Africa mean that areas that were too remote to be commercially exploited for bushmeat in the past are now accessible and are subject to over-harvesting (Wilkie *et al.*, 1999; Bowen-Jones *et al.*, 2002). In West and Central Africa an estimated 60% of mammalian species are hunted at a rate that is not sustainable (Fa *et al.*, 2002). On the one hand, livestock in many rural African societies has value beyond protein because it can be used as currency for dowry, settlement of disputes and as assets for long-term investment amongst others. On the other hand, bushmeat is regarded by hunters as 'free' protein and is generally the cheapest source of in urban centres (van Vliet, 2012). Rural-urban migration is a strong driver of urban bushmeat demand. The increased urban demand leads to increased commercialization of bushmeat consumption, thus increasing the likelihood of unsustainable harvesting which is exacerbated by the potential to earn income from bush meant sales (Wilkie *et al.*, 1999; Bowen-Jones *et al.*, 2003). Policy formulation and law enforcement in the arena of consumption of wildlife meat in Africa can positively influence sustainable harvest of bushmeat. Use of wildlife resources can be sustainable in cases where hunter-gatherer groups are few and range across large landscapes that they defend as 'their' exclusive territory (Wilkie *et al*., 2016).

4.2.2.4.3 Wildlife poaching

Wildlife plays an important role in both the natural and human worlds: ecologically as keynote species (Bond, 1994), economically as drivers of tourism (Brown Jr, 1993), and culturally as icons of the African continent (Carruthers, 2010). Of these important wildlife species are Rhinos and Elephants, of which their populations are extremely threatened by poaching for ivory (WWF, 2016; **Figure 4.14**). In Africa, recent surveys suggest that more

Figure 4 14 **Estimated trends in elephant populations for Great Elephant Census study areas with historical data available, 1995–2014. Source: https://doi.org/10.7717/peerj.2354/fig-2.**

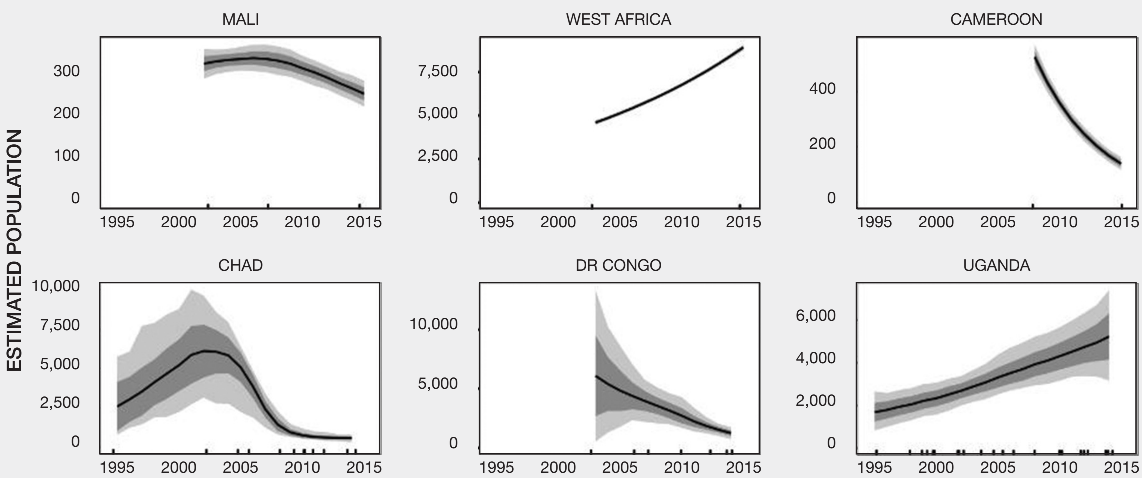
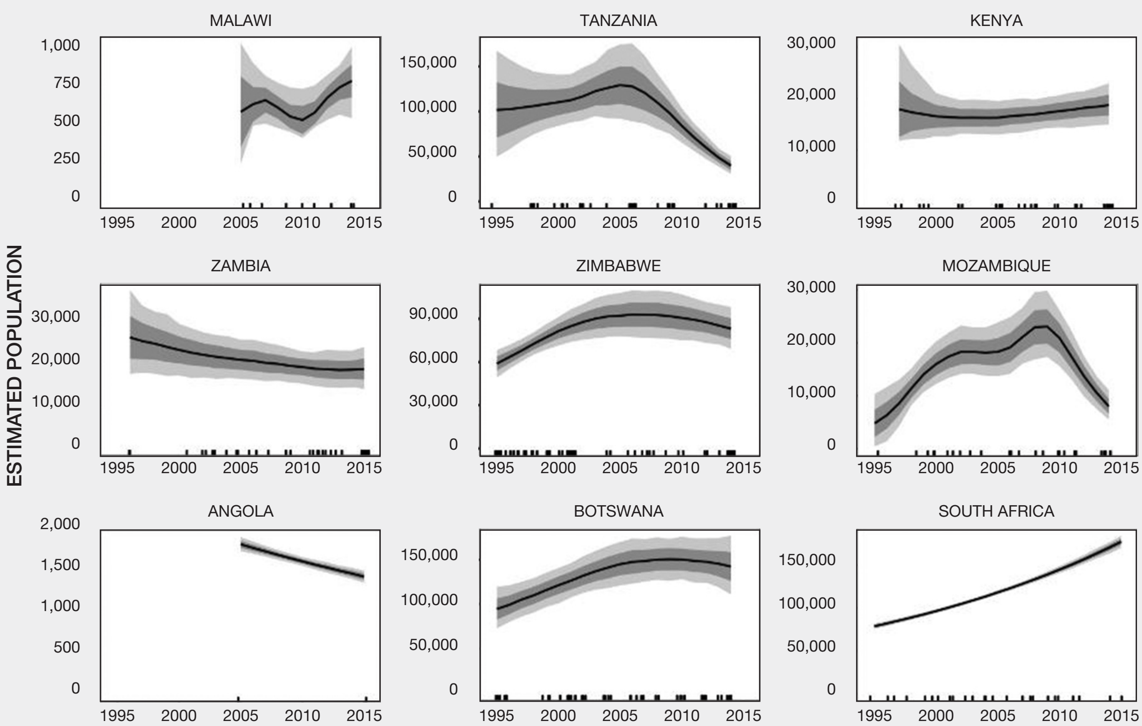


Figure 4 14



than 30,000 elephants are killed per year (UNEP *et al*., 2013; Wittemyer *et al.*, 2014), but there is urgent need to for caution in properly assessing these figures and impacts. The global interest in the plight of elephants is has generally been a positive development, but has led to extrapolations, estimates, and conjecture being accepted as paradigm when it comes to poaching. The much-quoted 30,000 per annum figure is actually described by Wittemeyer (2014) as an extrapolation, but is increasingly accepted as empirical fact. Despite global attention to the plight of elephants, their population sizes is shrinking by 8% per year continent-wide, primarily due to poaching (Chase *et al.*, 2016). A survey by Naidoo *et al.* (2016a) revealed that approximately $25 million worth of economic benefits that poached elephants would have delivered annually to African countries via tourism is lost. These lost benefits exceed the anti-poaching costs necessary to stop elephant declines across the continent's savannah areas (Naidoo, 2016b).

To effectively address the status of elephants, the IPBES Regional Assessment for Africa requires a higher level of resolution so as to avoid the 'trap' of an 'ecosystem services' approach bleeding into biodiversity considerations. The assignment of monetary values 'losses' to poached elephants is flawed in that the values are based on potential commercial gains from the 'legal' (licensed) consumptive use of the same species. This analysis is difficult to apply to countries like Kenya, which don't practice sport hunting, because to photographic tourism, the attraction of elephants to tourists is qualitative, not quantitative. This approach also diminishes the intrinsic value of elephants as part of Africa's natural heritage, and biodiversity as a keystone species. African nations therefore run the risk of valuing their biodiversity exclusively from the perspective of external observers and consumers thereof. This can already be seen in the copious discussions around impacts of 'poaching', without similar treatment of mortality from 'hunting', 'cropping', 'culling', and other 'conservation' and 'management' methods.

Similar to elephants, rhinos have given conservationists cause for concern for many decades, there have been regular reports of their deteriorating status in several countries in particular South Africa (Biggs *et al.*, 2013). South Africa is home to more than 90% of the world's 20,000 white rhino, and 40% (more than 80% together with its neighbour Namibia), of the 5,000 remaining black rhino (Biggs *et al.*, 2013). Yet, poaching in South Africa has, an average, more than doubled each year over the past 5 years **(Figure 4.15)**. The year 2015 was the worst year in decades for rhino poaching-although South Africa reported a small decrease (van Noorden, 2016). If poaching continues to accelerate, Africa's remaining rhino populations may become extinct in the wild within 20 years (Ferreira *et al.*, 2012). The loss of economic value caused by illegal poaching is significant, as is made evident in **table 4.5**.

Figure 4 15 **Annual rhino poaching in South Africa, Kenya and Zimbabwe since 2000. Data source: http://www.poachingfacts.com/poaching-statistics/rhino-poaching-statistics/.**

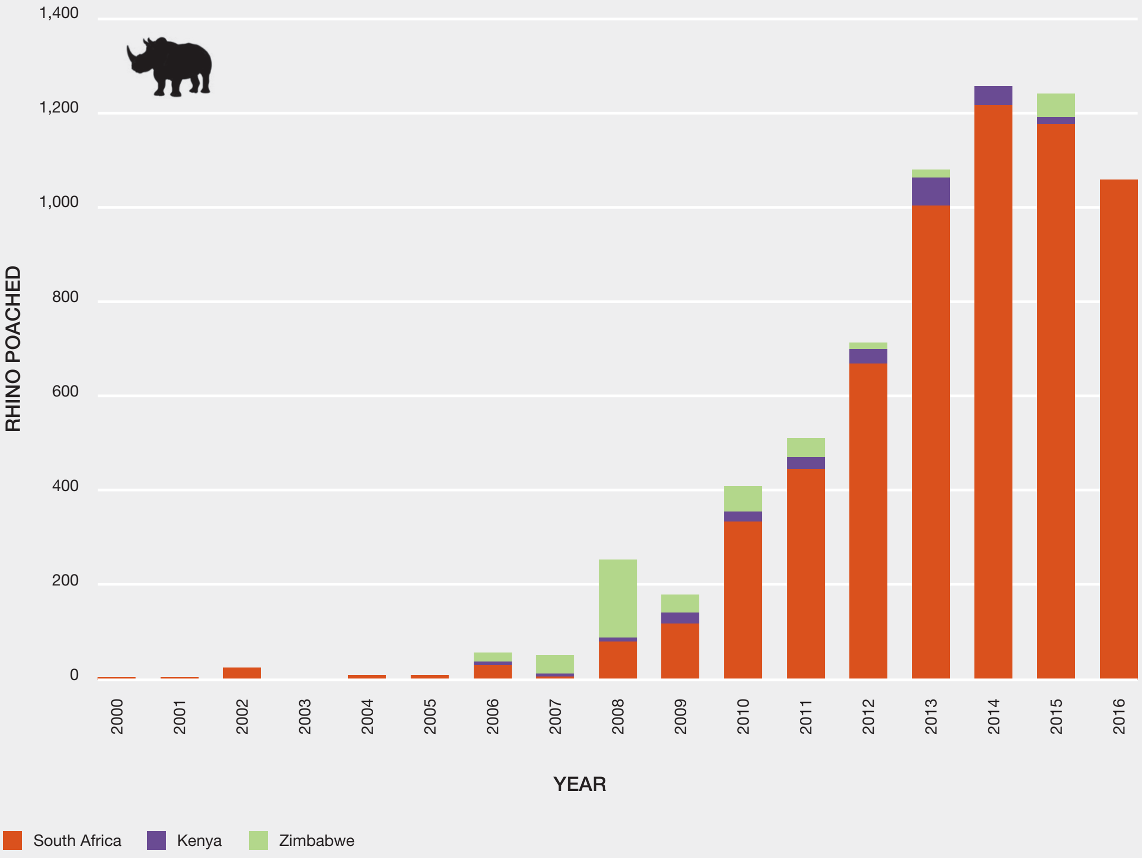


Table 4 5 **Economic value lost due to Rhino poaching. Source: Smith *et al.* (2015).**

	South Africa	Namibia	Kenya	Zimbabwe
Total loss of potential legal income per year	€133 million	€0.26 million	€4.5 million	€16.9 million
Total loss of natural capital 2006-2012	0	0	0	€360–544 million
Total loss of natural capital per year				€51–76 million
Total economic loss per year	€133 million	€0.26 million	€4.5 million	€68–93 million

4.2.2.4.4 Overfishing

Overfishing refers to extensive fishing beyond considered sustainable levels (FAO, 2010; Nguyen, 2012). Overfishing within inland waters usually occurs for direct consumption or for national economic development, however in most large lakes and deep-sea fisheries, export or foreign vessels drive it. Marine and coastal environments are of ecological and socio-economic importance to African states (Diop *et al.*, 2011). These ecosystems are diverse and provide the continent with valuable goods and services. In South Africa alone the direct contribution of marine and coastal resources to the economy is significant, contributing more than 35% of the gross domestic product (Diop *et al.*, 2011). Local and global demand for fish and rapidly growing populations that depend on freshwater and marine fisheries are the main causes of overfishing in Africa (Arthurton *et al.*, 2006; Diop *et al.*, 2011).

As the world's human population grows, so does the demand for marine food sources and the number of individuals whose livelihoods fully or partly depend on it (Garcia *et al.*, 2010). In North Africa, a subregion with very limited freshwater resources, overfishing is has impacted aquatic resources including 5 species of freshwater fish and 23 aquatic plants, 6 of which are listed as threatened under the IUCN Redlist (IUCN, 2013). In East Africa, many villages around the shores have free access to coastal waters and with this easy accessibility, overfishing tends to occur to support increasing demands on resources to support poor families (McClanaban, 1987). Majority of fish stocks in West African waters is depleting due to overfishing and other drivers (Nguyen, 2012; **Box 4.6**). Increased demand of fish from foreign nations such as European Union, Japan, Russia and China and government's greed and corruption in West Africa have the greatest influence in overfishing (Nguyen, 2012). The overfishing leads to the conflicts between the artisanal and commercial fisheries due to the competition for the same fishing grounds (physical conflicts) and/or common resources (technological conflicts). These conflicts affect the ecosystems and the well-being of the fishermen (Djama, 1992; Bennett, 1998). Institute for security studies (2007) reported that many African countries will have collapsed fisheries and degraded marine environments in the near future. This is not too far from the truth since the British Marine Resources Group reported in 2005 that South Africa harvested about 320,000 tons of Patagonian Toothfish within 2 years while the Total Allowable Catch set by the government was 450 tons/year. It is thus clear to see that fisheries are being overexploited.

4.2.2.5 Invasive Alien Species

Invasive alien species are considered one of the most serious threats to the conservation of biodiversity and ecosystem services in Africa and, according to IPBES glossary, are defined as animals, plants or other organisms introduced directly or indirectly by people into places out of their natural range of distribution, where they have become established and dispersed, and are generating a negative impact on local ecosystems and species.

4.2.2.5.1 Treaties and conventions for a regional collaboration to deal with invasive alien species in Africa

Africa has recognised the importance of controlling the introduction of damaging invasive alien species through several agreements and protocols. The African Union's New Partnership for Africa's Development, in its Framework Action Plan for the Environment, identifies Invasive Alien Species (IAS) as one of its core program areas. In addition, the African Convention on the Conservation of Nature and Natural Resources, adopted in 1968, required Parties to prohibit the entry of "zoological or biological specimens, whether indigenous or imported, wild or domestic" that may cause harm to protected areas. Moreover, the Protocol concerning Protected Areas and Wild Fauna and Flora in the East Africa Region (UNEP, 1985) called for the adoption of appropriate measures to prohibit the intentional or accidental introduction of IAS, which may cause significant changes to the subregion. The World Trade Organization Sanitary and Phytosanitary Agreement empowers individual country's plant protection organisations to draw up measures that are strong enough to prevent the introduction of pests that may arise through trade.

Other protocols developed by subregional bodies also address some aspects of controlling IAS include the Treaty for the Establishment of the Eastern African Community, Treaty of the Southern African Development Community, and the Treaty establishing the Common Market for Eastern and Southern Africa. The African Convention on the Conservation of Nature and Natural Resources required parties to strictly control the intentional and accidental introduction of invasive alien species, including modified organisms and to endeavour to eradicate those already introduced where their consequences are detrimental to native species or to the environment in general. The Forest Invasive Species Network for Africa was created in 2004 to coordinate the collation and dissemination of information relating to forest invasive species in sub-Saharan Africa for sustainable forest management and conservation of biodiversity. Economic

Box 4 6 **Case study: Overfishing in Senegal.**

In Senegal fish is the main source of protein (UNEP, 2002; Iossa *et al.*, 2008; Nguyen, 2012) and accounts for about 75% of all protein consumption (UNEP, 2002; Nguyen, 2012). Consumption is by both the rural and urban populations because fish is affordable compared to mutton and other protein sources (Iossa *et al.*, 2008). Most people in Senegal live below the poverty line (Iossa *et al.*, 2008) and therefore fish is essential for people in this country. Fisheries sector generated about 600,000 direct and indirect jobs in Senegal (UNEP, 2002), for this reason fishing is important for livelihoods. Overfishing which leads to depletion of marine ecosystems is a threat to, not only biodiversity of marine ecosystems, but also to Senegalese people who depend on these ecosystems for nature's contributions to people (Iossa *et al.*, 2008; Nguyen, 2012). Most of the fish catches are used for direct human consumption (Nguyen, 2012). Eighty percent of fish exports that originate from Africa are supplied to the European market, and 66% of the total exports from Senegal are supplied to Europe (Nguyen, 2012).

Box 4 7 Case study: conflicts of interest on plant Invasive Alien Species (IAS).

Invasive alien species may provide benefits to people through both commercial and non-commercial uses, thus causing policy dilemmas. Local populations are more like to come to terms with invasive alien species especially when they benefit from them. This may generate conflicts of interest between local communities and governments. Examples include the use of prickly pear (*Opuntia ficus-indica*) in South Africa (Shackleton *et al.*, 2011), Black Wattle (*Acacia mearnsii*) in South Africa (Shackleton, 2007; Aitken *et al.*, 2009), Mesquito (*Prosopis juliflora*) in Ethiopia (Mwangi *et al.*, 2005), *Acacia mearnsii* on Reunion Island (Tassin *et al.*, 2012) and many species in Madagascar which are used as medicinal plants (Kull *et al.*, 2011). Malagasy people have rapidly developed a new local knowledge on the medicinal uses of invasive plants. However, conflicts of interest evolve, and the balance between benefits and loss can change. In Lake Baringo, Kenya, local people have recently come to consider Mesquito beneficial for production of charcoal. Conversely, on the Highlands of Madagascar, Mimosa (*Acacia dealbata*) is still considered by the rural populations as beneficial (Kull *et al.*, 2007). The use of IAS may represent an efficient control means, but such an option seems difficult to legitimate in the absence of clear national policies and strategies in the management of IAS (Tessema, 2012).

tools such as taxes, subsidies, permits are not well suited to deal with the problems caused by invasions. Molecular biology tools and global positioning system-enabled tools are utilized in diagnostics and surveillance. Conflicts of interest may appear about IAS at local scales. While some authors consider that claims about the benefits of invasive alien species are unsubstantiated (Witt, 2010), some studies reveal that benefits to people may also be possible (see case study below). Scenarios on the extension of invasive alien species remain scarce in Africa. Maundu *et al.* (2009) suggest that nearly 50% of Kenya's surface area has a 30% or more probability of being invaded by *P. juliflora*.

4.2.2.5.2 The main types of invasive alien species impacting biodiversity and ecosystem services in Africa

Compared with other continents and cultures, invasive alien species remain poorly documented in the African continent (Witt, 2010), except East Africa, the Republic of South Africa and the islands of western Indian Oocean (Mauritius, Seychelles, Reunion Island). Invasive alien species threaten all subregions in Africa and affect wetlands, forests, drylands, freshwater bodies, estuaries, deltas, marine, coastal and other ecosystems, mainly where areas have been disturbed by human activities. They occur in all major taxonomic groups, including viruses, fungi, algae, plants, fish, amphibians, reptiles, birds and mammals. Within plants, ornamental invasive alien species represent the highest proportion of invasives (Tassin *et al.*, 2007). The IAS pressure is regularly increasing with time, as shown in Kenya (Stadler *et al.*, 1998), on Reunion Island (Tassin *et al.*, 2006) and in Zimbabwe by Maroyi (2012), who has recorded from herbarium records the strongest increase of IAS records from 1941 to 1960.

Beyond the orthodox definition of invasive alien species restricted to introduced species, native species can also be invasive (Valéry *et al.*, 2009). The famous Red Billed Quelea (*Quelea quelea*) is native to Africa but takes advantage of native or artificial grasslands and seed crops to establish in millions of individuals. On poor and eroded soils of humid regions, as Batéké plateau, coast lowlands of Gabon, or slopes of western Indian Ocean islands, the fern *Dicranopteris linearis* seems to forbid the natural succession process (Kueffer *et al.*, 2004). On Mayotte, the native liana *Merremia peltata* colonizes the forest canopy, making them to collapse under their heaviness and traction (Tassin *et al.*, 2015). In humid forests of Gabon, some *Zingiberaceae* are assumed to compromise the regeneration of other native plant species. Bush encroachment by native undesired woody species has an estimated extent of 26–30 million hectares in Namibia and 10–20 million hectares in South Africa (Bester, 1999; Kraaij *et al.*, 2006).

4.2.2.5.3 Assessment of impacts of invasive alien species on biodiversity and ecosystem services in Africa

Invasive alien species affect biodiversity and nature's contributions to people (e.g., food production and water supply, waste assimilation, recycling of nutrients, conservation and regeneration of soils, pollination of crops, seed dispersal) globally and regionally (African continent including islands) and have significant impacts on the economy and livelihoods (including on human health, water security, fire and the productive use of lands). For instance, white cassava mealybug and larger grain borer pose direct threats to food security. The impacts of invasive plants is also high in the continent because more than 80% of the population comprises small-scale farmers who are dependent on natural resources for their survival (Witt, 2010). For instance, in the lowlands of Ethiopia, *Parthenium* (*Parthenium hysterophorus*) is perceived as the most important weed by 90% of the rural population (Tamado *et al.*, 2000). It prevents germination through allelopathy and competition in crops and natural stands. There is a need to understand the status, trends, distribution, impact, control measures and the policy options for control and eradication of invasive alien species.

Invasive alien species have a strong impact on rural production and ecosystem services in Africa **(Table 4.6)**. Yet,economic assessments of invasive alien species impacts have been rarely conducted outside South Africa **(Box 4.8)**. A recent assessment in six East African countries (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda) has provided an estimated annual production losses to smallholders, due to some invasive alien species on maize (spotted stem borer, maize lethal necrosis disease, *Parthenium*), bean and pea (leaf-mining flies), and tomato (tomato leaf-miner), estimating losses of between $894.4 and $1099.7 million (Pratt *et al.*, 2017). The economic impacts of water hyacinth (*Eichhornia crassipes*) infestations in seven African countries have been estimated at between $20 million and $50 million annually (Joffe *et al.*, 1997); impact costs across Africa may exceed $100 million annually (Boy *et al.*, 2013). The environmental

Box 4 8 **Case study: Costs of Invasive Alien Species in South-Africa.**

Invasive alien species cover about 10% of South Africa and use 3.3 billion m^3 of water/year (the equivalent of about 7% of all water resources) (Department of Water Affairs in South Africa, 2010); they mainly consist in Australian trees and shrubs and Northern Hemisphere pine species which have been introduced into habitats with suitable climatic and edaphic conditions for growth and spread. Moreover, 2.95% of the runoff is a direct consequence of plant invasions. In a water scarce country, where demand exceeds available water in almost all catchments, this added stress is a major concern (Le Maitre *et al.*, 2016). The Convention on Biological Diversity estimated that Africa spends close to $60,000 million/year to control invasive alien species (Boy *et al.*, 2013). In the South African Cape Floral Kingdom, invasive tree species cost $40 million/year for a control program (Matthews *et al*., 2004). The total cost of invasion on the Agulhas Plain alone amounts to $11.75 billion (van Wilgen *et al.*, 2001). In the Western Cape Province, invasions have allegedly reduced the value of Fynbos (Western Cape Mediterranean scrub vegetation) ecosystems by over $11.75 billion (van Wilgen *et al.*, 2001). Control of invasive rats and mice costs the world roughly $2.7 billion/year (Pimentel *et al.*, 2001).

Table 4 6 **Most important invasive alien species in Africa, and their impacts.**

Species	Impact	Sites of Africa	References
Plant species			
***Acacia* sp. (Australian acacia species)**	Invade fallows and natural areas	South Africa (Cape Province); Reunion Island	Witkowski, 1991; Moll *et al.*, 1992; Holmes *et al.*, 1997; Tassin *et al.*, 2012
***Chromolaena odorata* (Siam weed)**	Has taken over pastures, farmlands and wilderness areas; affects plant communities and disrupt forest successions; may seriously impact the populations of western lowland gorillas in Southern Cameroon	Sub-Saharan Africa, including the Serengeti-Masai Mara area	van der Hoeven *et al.*, 2007; Boy *et al.*, 2013
***Eichhornia crassipes* (Water Hyacinth)**	Covers large areas of lakes and wetlands and interferes with navigation, irrigation and water supply; affects fish breeding patterns particularly cichlids	Whole Africa	Wanda *et al.*, 2001; Waithaka, 2013;
***Lantana camara* (Lantana)**	Common in fallows and plantations; has invaded almost every Protected Area; facilitates fires	Southern and eastern Africa	Boy *et al.*, 2013
***Leucaena leucocephala* (Leucaena)**		Sub-Saharan Africa.	Boy *et al.*, 2013
***Mimosa pigra* (Giant Sensitive Plant)**	Invades wetlands, swamps and floodplains	Sub-Saharan Africa	Witt, 2010; Boy *et al.*, 2013
***Parthenium hysterophorus* (Parthenium weed)**	Impacts on crop yields and wilderness areas; contain potents allergens affecting grazing and browsing animals; taints the milk	Eastern Africa	Witt, 2010; Boy *et al.*, 2013
***Prosopis juliflora* (Mesquite)**	Invades pasture lands and has become a noxious weed	Ethiopia, Kenya	Mwangi *et al.*, 2005; Witt, 2010; Tessema, 2012
***Salvinia molesta* (Kariba Weed)**	Blocking waterways and diminishing fish stocks.	Whole Africa	Boy *et al.*, 2013
***Senna spectabilis* (Cassia)**	Dominates understorey in forested areas, and affects the food supply of chimpanzees	Tanzania, Uganda	Turner, 1996; Nashida, 1996; Boy *et al.*, 2013
***Striga* sp. pl. (Striga)**	Invade crops (cereal and legumes)	Whole Africa	

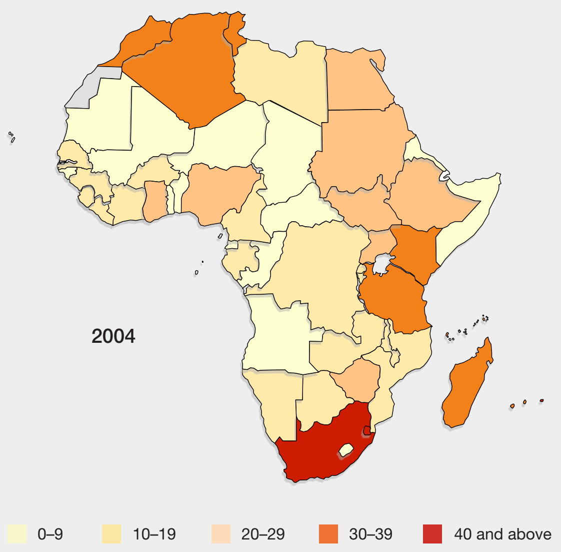
Table 4 6

Species	Impact	Sites of Africa	References
Animal species			
***Acridotheres tristis* (Mynah)**	Competition with native birds	West Indian Ocean islands	
***Procambarus clarkii* (Louisiana crayfish)**	Disappearance of submerged vegetation, freshwater crabs, predation of fish eggs and tadpoles; damage to fish catch and disruption of fishing gear; destabilization of freshwater otter prey base; damage to dam and reservoirs	Freshwater ecosystems of Eastern and Southern Africa	Howard *et al.*, 2003 Ogada *et al.*, 2009
***Lates niloticus* (Nile Perch)**	Reduced by half the native haplochromine cichlid fish species of Lake Vicotria through predation	Lake Victoria	Ogutu-Ohwayo, 1999 Pringle, 2005
***Oncorhynchus mykiss* Rainbow Trout)**	Disappearance and local extinction of endemic mountain catfishes		Cambray, 2003; Woodford *et al.*, 2004
***Rattus rattus* (Rat)**	Impact on crops, and on native flora and fauna	Whole Africa	

impact of invasive alien species in Africa on the wilderness remains poorly documented. Invasive alien plant may have deleterious effects on wilderness, and the impact of Australian plant species on the vegetation of Fynbos has been deeply documented (Witkowski, 1991; Moll *et al.*, 1992; Holmes *et al.*, 1997). Conversely, it may commonly provide new resources or habitats for native animals in Africa, for instance African sunbirds (Geerts *et al.*, 2009). So, the impact of IAS is complex because they may have both positive and negative environmental impacts at the same time, depending on the context. For instance, in Mayotte, *Acacia mangium* controls erosion on highly degraded lands (paddza), but also facilitates fires (Kull *et al.*, 2008). In South Africa, *Acacia melanoxylon* also produces opposite effects (Geldenhuys, 1986).

The current pattern suggests the number of invasive alien species in African countries have increased markedly in the last decades, with 207 identified in South Africa, 104 in Tanzania, 107 in Kenya and 103 in Morocco alone (see **Figure 4.16**). South Africa is the only country in sub-Saharan Africa having a sustained and funded program to deal with invasive alien species (Boy *et al.*, 2013), specifically plant species. It has set up a large Working for Water Program which has cleared about 1 million hectares of land invaded by alien plants, offering job to 20,000 people from disadvantaged communities (Department of Water Affairs in South Africa, 2010; Boy *et al.*, 2013). More efforts are needed to combat invasive alien plants across the continent in order to improve benefits African peoples might receive from nature's contribution to people.

Figure 4 16 **The incidence of invasive alien plants in Africa in 2004 and 2017. Data sources: For 2004, Chenje *et al.* (2006) and for 2017, http://www.iucngisd.org/gisd/.**



4.2.2.6 Pollution (soil, water, air)

The section assesses literature regarding extent and patterns of soil, water and air pollution as drivers for changes in biodiversity and nature's contributions to people. Such assessment is based on the spatial location bearing in mind Africa's existing ecological zones. Pollution causes could either be anthropogenic or natural with the former escalating at an alarming rate in Africa. Pollutants that affect biodiversity in Africa are characterized as either chemical, physical or biological and the spatial considerations are evaluated with regard to whether the pollutants are air, water or soil pollutants; point or non-point source with a subregional focus.

4.2.2.6.1 Soil Pollution

Non-point anthropogenic chemical contaminants of soil that are of great concern in Africa include the agrochemicals whose great rise has been mainly as a response to need to feed the growing population. This is worsened by the changing lifestyles of a large majority of Africans, from agricultural to urban dwelling persons, whose labour input in the farmlands have to be replaced with mechanization and application of herbicides (Freire *et al.*, 2014). The current urban population is about 40%, an increase from 15% in 1960 and is expected to soar to 60% by 2050 (Obeng-Odoom, 2013). Use of increased varieties and quantities of pesticides have been recorded in a number of countries concomitant with urbanisation, population growth, and expansion of agriculturally dependent economies in Africa (Nonga *et al.*, 2011; Quinn *et al.*, 2011; Byerlee *et al*., 2013). Changes from hand-held tools to use of machinery including aerial spray of pesticides and agrochemicals in general confer worse effects on biodiversity. This is especially true because the resultant drift affects more non-target organisms. This has been reported for wildlife in Maasai Mara of Kenya that neighbours large-scale wheat farms, (Lambert, 1997; Schulz *et al.*, 2001; Muchane *et al.*, 2012; Odido *et al.*, 2013).

The fate of the pesticides is modified by climatic conditions and in Africa these present challenges that may be different from those in better-studied regions of the world. The stable breakdown products of the widely studied p,p'-(dichlorodiphenyl)-1,1,1-trichloroethane (DDT) and a number of other widely used pesticides such as chloracetanilides are found to play more important roles in the environment than their parent compounds in Africa thus causing toxicities that have longer term and probably more devastating effects on living organisms (Kiflom *et al.*, 1999; Karlsson *et al.*, 2000; Osano *et al.*, 2003). In addition, a number of pesticides, which have already been banned or have restrictions in their usage (because of their toxicity in the environment) in other parts in the world are still used in large and increasing quantities in Africa (Wandiga, 2001), an area that invites formulation and application of sound policies. Of great concern and interest in Africa are the chemicals covered in the Stockholm Convention on Persistent Organic Pollutants, especially the DDT. The need to safeguard human health against malaria has attracted controversial consideration of continued use of DDT albeit under strict conditions including obligations to investigate use of alternatives in Africa (Anon, 2004; Bouwman, 2004).

A number of restricted persistent organic pollutant pesticides including aldrin, dieldrin, endrin, heptachlor and toxaphene have been used beyond the effective dates of ratification of the convention by the user countries in Africa and their residues have been found in various compartments in the environment (Quin, 2011; Barnhoorn *et al.*, 2015). There is a rising concern of persistent organic pollutants produced unintentionally through a number of anthropogenic processes such as compounds that include the polychlorinated dioxins, polychlorinated dibenzofurans and polychlorinated biphenyls, and hexachlorobenzene. The processes associated with these include several municipal and industrial combustion processes, application of chlorine for bleaching in pulp production and thermal processes in metallurgical industry most of which are on the rise in Africa.

In addition, stockpiles of unused chemicals pose grave danger of leakages or irresponsible disposal to the environment. Urgent action needs to be taken to identify, manage and destroy stockpile while taking care not to allow recycling or reuse of the stockpiles and where possible carry out remediation of contaminated sites. An initiative like the African Stockpiles Program approved by the Global Environmental Fund and implemented by the World Bank may relieve African nations of the stockpiles but it has faced challenges of laying down groundwork logistics for its implementation (Bouwman, 2004). Salinization of soil, common consequence of irrigation programs, deserves more attention, given the increasing demand for increased acreage of irrigated land across the continent (Hussain *et al.*, 2004; Orindi *et al.*, 2005; Oweis *et al.*, 2006).

Industrial – based soil contaminants are of growing concern because of the increase ownership of motor vehicles, mining, and industries in general. Vehicular exhaust pollutants comprising polyaromatic hydrocarbons and tetraethyl lead (which is now in decline due to conversion to unleaded fuel) are deposited on the ground along the motorways and are increasing quantities of toxic metals deposited on the ground (Olade, 1987; Davies *et al.*, 2005). Of particular concern is increase in soil pollution with increasing activities in both artisanal and large-scale mining, a situation which is worse when compared to mining activities in developed nations and one that is attributable to improper management of the tailings (Narendrula *et al.*, 2012). The biological pollutants of the environment is a new phenomenon brought to fore especially with the introduction of biotechnology in agriculture. There is a rising worry that new genetic materials may be introduced in the environment with devastating consequences to existing species.

Pollution from natural causes may occur after eruptions of the numerous active volcanic mountains in Africa exemplified by the frequent rage of the Virunga Mountains whose plumes are displaced over a long distance and causes changes the quality of rainwater including acidity (pH up to 2), increase concentrations of Fluoride (up to 2,400 mg/L), Chloride (up to 1,750 mg/L) and Sulphide (up to 10,000 mg/L). These events have detrimental effects on the equatorial rain forest, and likely impose possible strain on the dwindling populations of gorillas (*Gorilla beringei*) (Delfosse, 2005; Plumptre *et al.*, 2007; Vaselli *et al.*, 2008). Specifically, the gorillas whose censual population stood at a finite 360 in 2003, face dual (anthropogenic and natural) challenges such as fragile and explosive political strife and raging volcanic activities of the Virunga Mountains (Kalpers *et al.*, 2003; Vaselli *et al.*, 2008; Gray *et al.*, 2010).

4.2.2.6.2 Water Pollution

Alongside the pesticides, an increased application of inorganic nutrients including the phosphate and nitrates, has been witnessed and consequences of eutrophication of downstream water bodies have been a concern (Saad, 1980; Oberholster *et al.*, 2009; Nyenje *et al.*, 2010; Van Ginkel, 2011). Besides the non-point source draining of agrochemicals (pesticides and nutrients) into the water bodies, industries and the growing urban centres in the African continent are already exerting considerable pressure on the ecosystems of both marine and freshwater bodies. Emergence of dead zones, sequel of nutrient fed into the sea from agricultural catchment and rise in dissolved carbon has been on the rise worldwide (Lavelle *et al.*, 2005; Diaz *et al.*, 2008) and the African seas will not be exceptions especially in areas draining regions with escalated intensive agricultural practices. This is worsened by the well-known natural coastal upwelling associated with western boundary of landmasses, which are productive but unfortunately suffer for severe hypoxia (<0.5 ml O_2/litre), a condition already affecting the south Atlantic west of Africa and other parts of the world (Díaz *et al.*, 2008). So far, the total export of nutrients (nitrogen and phosphorous) by the African rivers increased by 10 to 80% (Yasin *et al.*, 2010) and rivers draining ivory Coast's mainland are already oversaturated with CO_2 (Kone *et al.*, 2009). Evidence that Africa aquatic ecosystems are already suffering the wrath of application of pesticides upstream abounds (Odada *et al.*, 2004; Hecky *et al.*, 2006). Toxic levels of pesticides capable of altering endocrine, survival and health of aquatic organisms have been found in a number of lakes and rivers in Africa (Mugachia *et al.*, 1992; Kidd *et al.*, 2001; Ezemonye *et al.*, 2008; Okeniyia *et al.*, 2009). The lack of innovative solutions and unclear policy guidance has led to reintroduction of Dichlorodiphenyltrichloroethane (DDT) into farming systems and for mosquito control in many countries in Africa in the recent past to remedy recalcitrant continental problems without regards to environmental quality (Cork *et al.*, 2005).

Pollution of the water bodies with heavy and toxic metals could either be from non-point agricultural sources, e.g., cadmium contaminated agricultural fertilizers or point sources like the industrial and municipal effluents. High concentrations of the toxic metals including mercury, lead, cadmium, and copper have been established in both benthic and pelagic aquatic organisms in lakes and rivers of Africa (Campbell *et al.*, 2003; Kishe *et al.*, 2003; Ramlal *et al.*, 2003; van Aardt *et al.*, 2004; Campbell *et al.*, 2005). Industrial and municipal derived contaminants including the polychlorinated biphenyls (PCB) and dibenzofurans; Dioxins and dioxin like PCBs; and endocrine disrupting compounds have been detected in water, sediments and tissues in South Africa, Lakes Malawi and Victoria, and River Nile among other water bodies (Bootsma *et al.*, 1993; Bootsma *et al.*, 2004; Coimbra *et al.*, 2007; El-Kady *et al.*, 2007; Mdegela *et al.*, 2010; Olujimi *et al.*, 2010; Wepener *et al.*, 2012; Ssebugere *et al.*, 2013; Omwoma *et al.*, 2015). There is already a growing evidence of the ramifications of these chemical on health especially reproduction aquatic organism in a number of water bodies (Barnhoorn *et al.*, 2004; Manickum *et al.*, 2014). With the current rise in urbanisation and aspirations for industrialisation captured in various visions of the African countries, it is expected that emission of metals, chlorinated hydrocarbons, and endocrine disruptors into the water bodies will increase.

Physical pollutants of the water bodies include suspended matter arising from soil erosion (a consequence of poor land-use management) and thermal pollution due to emission of inadequately cooled water from the industries along the lakes, oceans and rivers in Africa. In a number of East African lakes namely Victoria, Tanganyika, Malawi, Albert, Kivu and Edward, thermal pollution characterised by a circa 0.2–0.7°C rise in temperature, over a period of 6 decades, has been attributed to climate change (Vollmer *et al.*, 2005; Bates *et al.*, 2008). The rise in temperature influences the thermal stratification and internal hydrological dynamics of the lakes. The resultant increased stratification reduces water movement across thermocline thereby inhibiting upwelling and mixing that provides essential nutrients to the food web. The rise in the temperature in water may enhance degradation of organic pollutants and is known to increase alkylation of mercury (Bates *et al.*, 2008).

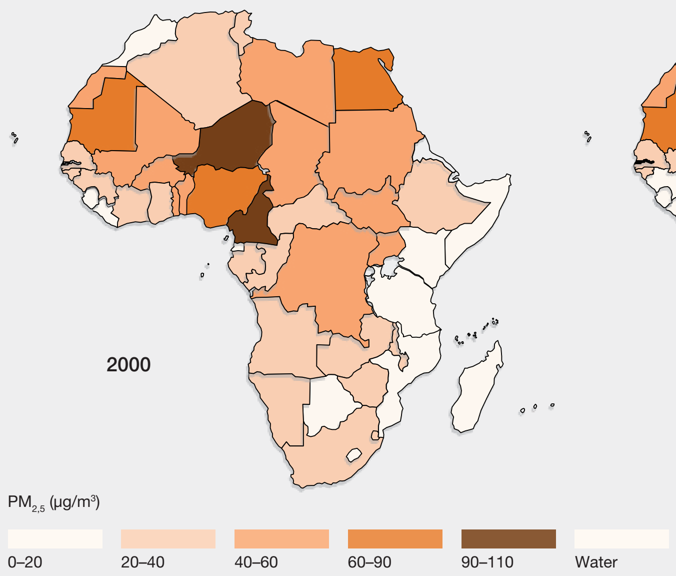
There has also been a burgeoning use of plastic in the continent, due to plastics desirable qualities of cheapness, durability, lightness and low mass. The consequence of this is high rates of contamination of the environment with plastics, in some cases up to 10% of the solid waste contaminants comprises plastics (Heap, 2009; Naidoo *et al.*, 2015). Plastics are transported to the marine ecosystem by wind, flash floods, urban drainages and rivers, currently impacting life forms (aquatic and bird species) in a number of ways. Plastics cause entanglement, gut impaction, transfer of toxic organic chemicals, and changes of habitats among others in the African oceans (Vegter *et al.*, 2014). Specifically, exposures to degraded plastics particles (the microplastics) confers toxic endocrine disrupting effects of phthalates and Bisphenol-A, which are normal compounds used the manufacture of the plastics (Talsness *et al.*, 2009).

4.2.2.6.3 Air Pollution

Important chemical pollutants emitted from the various anthropogenic activities include oxides of sulphur (Sulphur oxide, Sulphur dioxide, and sulphate), noxious nitrogen gas (Nitrogen monoxide, Nitrous oxide, Nitrogen dioxide) ammonia (NH_3), volatile organic compounds, and carbon monoxide (CO). The effects of these on ecosystems is growing with the growth of the related anthropogenic activities i.e., urbanisation and industrialisation. The African urban centres have grown tremendously in the last thirty years, a trend that is on a continuous rise (Obeng-Odoom, 2013). The internal combustion engines of motor vehicles, power generation plants and other industrial machinery notoriously produce toxic gases, Nitrous oxide, Sulphur oxide and carbon monoxide. The propensity for formation of tropospheric (bad) ozone from the precursor Nitrous oxide are greatly enhanced in presence of Ultraviolet radiation. Thus, comparable pollution in the tropics may exact more adverse effects on sensitive species of diverse plants and animals than in the better studied temperate regions where it has been observed that photochemicals have resulted in shifts of vegetation from ozone sensitive to ozone tolerant ones (Barker *et al.*, 2012). Sulphur dioxide and hydrogen sulphide emitted from power plants especially the coal fired ones and paper and mill factories have already resulted to acid rains in various parts of Africa (Europe *et al.*, 2006; Nduka *et al.*, 2008; Josipovic *et al.*, 2010). The most relevant sources of NH_3 in Africa are municipal effluent, farmyard/feedlot manure, and inorganic mineral fertilizers (Carmichael *et al.*, 2003). The extent of production of dioxin from incineration of municipal waste, a common practice in Africa, has not been evaluated. However, given the rise in the quantities of wastes, this is expected to contribute to air pollution in many parts of the continent. Particulate matter (PM- the most health-damaging components characterized as PM2.5) is generated by a combination of anthropogenic and natural courses. According to the latest air quality database from World Bank, particulate matter levels in most parts of Africa are decreasing **(Figure 4.17)**.

The rate of urbanisation supersedes the rate of development in many of the poorer African nations. The long distances of unpaved dirt road in addition to deforested bear grounds in heavily settled area are important sources of dust in many parts of Africa. Various mining activities in Africa contribute too much of the PM2.5 in the atmosphere and studies reveal detrimental effects on biodiversity (Munnik, 2010; Ana, 2011; Gathuru, 2012). Africa is also faces a number of natural sources of air pollutants including Sulphur oxide, Nitrous oxide and dust. These arise from eruption of active

Figure 4 17 **Variation of $PM_{2.5}$ air pollution, mean annual exposure by country in Africa for the years 2000 and 2015. The darker the shade, the higher the value. Source: World Development Indicators (2017).**



volcanic mountains; emissions from hot springs in the eastern rift valley from Ethiopia through Kenya and northern Tanzania; dust from the Saharan desert, pan surfaces, and ephemeral lakes in South-Western Africa; methane emission by the termites; and methanogenic bacteria in the swamps. In particular, the continual expansion of the Sahara has led to four-fold increase of dust (Prospero *et al.*, 1986; Bryant, 2003), which is mostly disturbed and therefore laden with Iron. Iron-laden dust has been observed to deposit in the Equatorial Atlantic and could enhance nitrogen fixation and consequently exacerbate occurrence dead zones at ocean (Tegen *et al.*, 1995). The physical anthropogenic pollutants like noise, light, and radioactive materials, are also known to hamper biodiversity in various ways.

4.3 LINK BETWEEN NATURAL AND ANTHROPOGENIC DRIVERS

There is interplay between multiple drivers of biodiversity and ecosystem services **(Figure 4.18)**. Most direct anthropogenic drivers are a consequence of interaction between indirect drivers and natural drivers. It is often the direct interaction of humans with the natural environment that causes land conversion from natural systems to agriculture, or degradation of the natural or agricultural systems. However, factors that determine how humans interact with the environment are extremely complex. There is an interplay between the natural features of the land, institutional factors and economic factors. Features such as soil characteristics, climate and terrain determine the likelihood of degradation under different land-use interventions. Institutional factors set the 'rules of the game' and these are determined by cultural and traditional values, local and national institutional structures, religious beliefs, policy and legislation. These institutional aspects define how things are done in the society. Finally, economic aspects determine the demand for produce, which will impact on how the land is used. This demand may be local for subsistence needs, but is increasingly global in nature (Hubacek *et al.*, 2002).

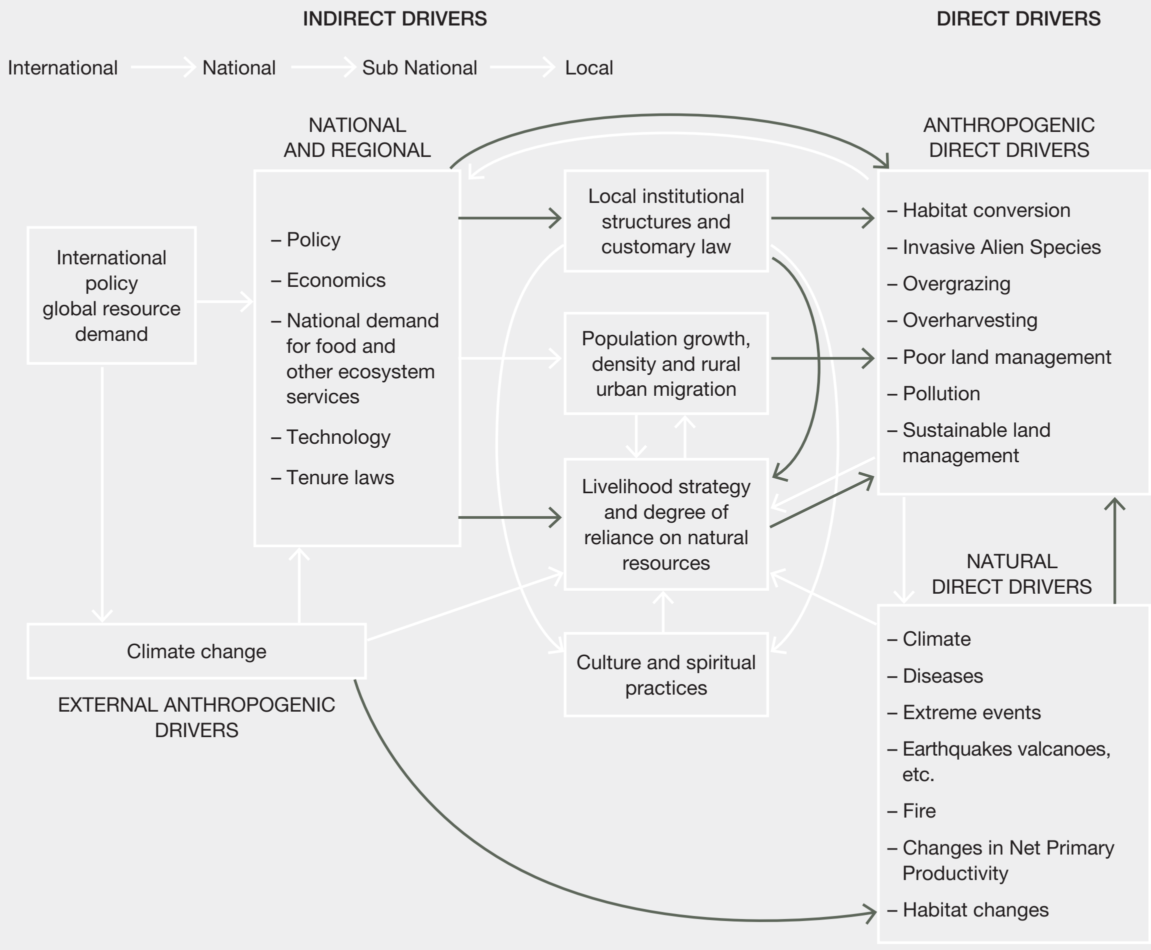
4.3.1 Link between anthropogenic and local drivers

At the local level a growing human population creates an increased demand for agricultural and other natural products. In Africa this translates mostly into an increased area under agriculture, rather than agricultural intensification, though there is a growing trend towards intensification (Perring *et al.*, 2015). The link between resource degradation and society is complex, but it is widely accepted that degradation both causes and results from socio-economic conditions such as poverty (Reynolds, 2007). Although poverty and increased population have been linked to resource degradation (Malthus, 1798; UNFPA, 2001; de Sherbinin *et al.*, 2008), this causation is contentious (Malik, 1999; Geist *et al.*, 2001; Bremner, 2010), with recent studies suggesting that in many cases it is global consumption patterns that have far greater impacts on degradation than the poor (Current *et al.*, 2004; Dietz *et al.*, 2007; Bremner *et al.*, 2010). However, there are cases where increasing population can lead directly to increased pressure on the land and increased degradation (Coppock, 2016). But, population does not always lead to increased degradation (Tiffen, 1994). In many cases it is the strength of local institutions that allow sustainable management of communal resources (Ostrom, 1990), but in the Machakos example, changes in policy (particularly relating to tenure), technical and political support all played a part (Tiffen, 1994). Africa has embarked on a wide range of projects involving devolution of natural resource management to local communities in the forestry and wildlife sectors in response to renewed understanding of the importance of local institutions in resource management (Shackleton *et al.*, 2001; Roe, 2009; Chevallier *et al*., 2016).

Poverty tends to force people to have greater reliance on the environment and this can lead to degradation as the meeting of short-term survival needs may be more important than long-term sustainability. This is especially true during times of stress such as during a drought. Though poverty is often associated with degradation, a lack of poverty (wealth) is no guarantee that degradation will not take place, especially if policy gaps, or perverse policy outcomes, allow inappropriate land management practices. Despite this, in most respects the poor have a far smaller environmental footprint than the rich (Fischer-Kowalski *et al.*, 2011; Ivanova *et al.*, 2015; Kenner, 2015). Large-scale migration to towns, and increased urban affluence, place a high demand on rural areas to increase food production. The increasing extent of urban poor, living in slum areas associated with Africa's large cities place unique threats to the environment through their requirements for cheap food and fuel, as well as the local impacts (Satterthwaite *et al.*, 2010). The need for cash in an increasingly cash-based economy is changing resource use from traditional consumption to marketing. There is probably no community left in Africa who does not require some level of cash income. This can drives new behaviour which will differ from the traditional livelihood resource use patterns such as charcoal production and the sale of bushmeat to urban centres (Bennett *et al.*, 2007; Zulu, 2010; Bolognesi *et al*., 2015; Neufeldt *et al*., 2015).

Traditional, religions and cultural structures, local indigenous knowledge, ability to access technologies, poverty and access to land have a powerful impact on local level land-use practices. Care for, and understanding of, their environment

Figure 4 18 **A schematic representation of the complex interactions among drivers. Indirect and natural drivers impact local individuals and communities through complex chains leading to direct anthropogenic drivers.**



is a strong driver of resource use, some of this deeply embedded in traditional knowledge and belief systems. Many local institutional structures have been weakened through centralized governance in colonial and post-colonial government systems (Chevallier *et al.*, 2016). These are determined by tradition, access to capital, access to markets, availability of technology, and inherent productive capacity of the area, tenure regimes any many other factors. Traditional structures should not be over romanticized, as although they often promote sound resource management, there are also cases of greed and rent-seeking behaviour by the local elite (Chiweshe, 2016; O'Laughlin, 2016). Households may well be forced to overexploit resources due to poverty, especially during drought years. Reduced size of farms due to population expansion may force households to undertake destructive activities such as overgrazing or unsustainable harvesting of fuelwood products. As there is a global shift to a cash-based economy, households are under increased pressure to find economic opportunities from the land.

4.3.2 Link between anthropogenic and national and regional drivers

National rules and regulations define how people can legally use the land (Chevallier *et al.*, 2016). This therefore constitutes one of the biggest single drivers of land-use activity. However, it is the state's ability to police these rules and regulations that will determine if they are adhered to at the local level. Many land-use practices such as charcoal production or harvesting of wild animals are illegal, but due to inadequate enforcement, are still widespread (Bennett *et al.*, 2007; Zulu, 2010; Bolognesi *et al.*, 2015; Neufeldt *et al.*, 2015). In addition well-intended legislation in one sector of the economy might provide perverse incentives for resource destruction in other sectors of the economy (Zulu, 2010). Macroeconomic policy has far-reaching impacts as to how communities engage with resources. Macroeconomic and political aspects of the economy often drive the status of local development. Taxes and economic incentives are the two key instruments available from an economic perspective to govern land-use activities. This determines options available to local residents in terms of the types of practices they can undertake. For instance there is ongoing debate over large-scale foreign direct investments in land versus small-scale farming (Cotula *et al.*, 2009; Vermeulen *et al.*, 2010; Hall, 2011; von Maltitz *et al.*, 2011).

115% between 2000 and 2050 globally (Alkemade *et al.*, 2013). This will require more grazing area, and rangelands will experience further degradation and biodiversity loss. In addition, use of local livestock breeds such as Tswana cattle in Botswana are often ignored in favour of heavy exotic breeds due to market demand and this could facilitate loss of national biodiversity.

4.3.3 Link between anthropogenic and global drivers

Increased global demand of ecological services such as tourism increases pressure on ecosystems. Africa is affected by both import and export policy, with cheap food imports often having negative feedback into the agricultural economies. Exports drive new agricultural practices and crop choices. Global trade on commodities dependent on natural resource such as cash crops (e.g., horticulture in Kenya and Ethiopia) and beef (cattle production in Botswana and Namibia for the European Union market) has been shown to contribute to degradation of natural ecosystem and loss of biodiversity (Swanepoel *et al.*, 2010). The demand for beef is projected to increase by

4.3.4 Link between anthropogenic and natural drivers

A number of studies suggest that it is during or after extreme events that degradation processes are initiated (Frank *et al.*, 2015). These could be from cyclic climates, or impacts from global climate change. For instance a prolonged drought could lead to heavy overgrazing, especially if artificial water points are provided, resulting in the removal of almost all ground cover. This would then make the area extremely vulnerable to erosion if there is an intense storm following the drought. **Table 4.7** attempts to map how different natural degradation drivers might impact with direct anthropogenic drivers.

Table 4 7 **Enhancement of natural drivers by anthropogenic drivers of change.**

	Natural climate and weather patterns	Extreme events (droughts, cyclones, floods)	Wildfires	Diseases	Earthquakes, tsunamis, eruptions
Habitat conversion	Erosion and runoff for bared soils	Can enhance floods	Deforestation facilitates wildfires–wildfires maintain deforestation	Loss of marshes can reduce disease risks (malaria)	Could destroy natural habitats
Resource overutilization	Erosion and runoff for bared soils	Can enhance droughts effects through depleting plant cover–often high reliance of natural products due to agriculture collapse	Deforestation facilitates wildfires, which facilitate biomass depletion Human-induced fires lead to wildfires (honey harvesting, promoting grazing)	Resource overutilization may affect health and facilitate diseases	(No effects)
Management practices	Erosion and runoff for bared soils	Can enhance droughts effects through depleting plant cover	Bad pasture management can facilitate wildfires	Agro-ecological practices may enhance soil biological activity, then reduce crop diseases	(No effects)
Invasive alien species	Can decrease or increase erosion and runoff	Dispersal of invasive alien species on a larger range	Some invasive alien species plants can facilitate wildfires–increase fire intensity and destroy soil	Some invasive alien species are pathogens for human, cattle, crops	(No effects)
Pollution	Air pollution and water pollution may be exacerbated by climate change	Extreme events can concentrate pollutions, and or move then into river systems	Smokes from wildfires enhance air pollution	Allergies caused by pollution	(No effects)
Climate change	More extreme droughts, more severe floods, greater chance of erosion, greater chance of invasion	More extreme more frequent greater severity (of droughts floods	More extreme, hotter fires More often (but depends on biomass accumulation) Possible biome shift to no fire.	Greater chance of disease range expansion	(No effects)

4.3.5 Link between anthropogenic drivers and climate change

Climate change is a unique anthropogenic driver of change that its impact is spatially decoupled from the source, and in that at the local scale, communities can only adapt to impacts, but cannot change the scale of the impacts through their local actions (Harrison *et al.*, 2016). There are a number of complex interactions between climate change and the natural environment, potentially decreasing the ability of the natural environment to sustain the same level of the provisioning on nature's contributions to people. The impact is likely to be most severe in drylands (Huang *et al.*, 2017) and the combined increase in temperature, decrease in rainfall and change in seasonality will prove exceptionally problematic to livestock production (Descheemaeker *et al.*, 2017).

Climate change may radically alter species composition and distribution in the natural environment, and in so doing change the available mix of nature's contributions to people that is available to support livelihoods. This may have dramatic changes on livelihood strategies including farming practices. Climate change may well alter the distribution and likelihood of many diseases. It is also expected to alter natural fire regimes, potentially increasing the possibility of mega-fires, which have devastating human and environmental impacts. With regards to invasive alien species, evidence suggests that Water fern (*Azola filiculoides*), Water hyacinth (*Eichhornia crassipes*) and the Kariba weed (*Salvinia molesta*) will expand towards suitable habitat found in the Western Cape Province and along coastal areas in South Africa (Hoveka *et al.*, 2016). The rate and extent of this spread will depend on local climate, vegetation and disturbance contexts (Clements *et al.*, 2011).

4.4 INDIRECT DRIVERS OF CHANGE

Africa's development outcomes for the coming decades will be determined by a number of drivers of change, and the policy changes adopted by African countries in response to changing world conditions (AfDB, 2011). Cumulatively, these drivers are likely to create dramatic changes for the African continent and the global environment with which the continent interacts. Africa has some of the most abundant natural resources in the world, including its biodiversity. The continent's development trajectories are projected to increase impacts on ecosystems. Economic growth, through production and consumption chains, human settlements and infrastructure development, will be a key driver of change. Many states in Africa have a vision to become emerging economies in the coming decades. This is compounded by rapid population growth and urbanisation, policy and cultural changes, and global resource demand especially for food, energy, water and other extractives. With increasing raw material extraction for economic growth and weak institutional arrangements, countries in Africa are experiencing unprecedented rate of resource exploitation in recent time (Ozor *et al.*, 2016). For example, increased exploitation and clearing of forests for timber and agriculture, though it has economic benefits, may result in loss of biodiversity and reduction of the potential of forests to provide nature's contributions to people (Hawthorne *et al.*, 2011; Roué *et al.*, 2016).

4.4.1 Policy Changes

4.4.1.1 Economic policies

Since the advent of independence for most African countries, the African continent has struggled with a seemingly endless array of development challenges which range from civil war and political instability to disease epidemics, chronic food insecurity and pervasive poverty (AfDB, 2011). Africa's prospects for economic development will largely depend on the policies it implements to take advantage of its vibrant young population, its abundance of natural resources and its considerable human capital. Ending all forms of poverty is the highest priority for Africa (AMCEN, 2015; AU, 2016) hence policies and strategies for national governments, regional communities and development partners are geared towards this goal (AU, 2016). This is exemplified by the planned $360 billion African Development Bank Programme for Infrastructure Development in Africa (PIDA) to address projected infrastructure needs by 2040 (AfDB, 2010). The risk on biodiversity and ecosystem services, associated with major infrastructural development such as the Grand Inga Dam in DR Congo or the Lamu Port South Sudan Ethiopia Transport corridor in Kenya, are immense. In a bid to chart a way to sustainable development, a number of countries in Africa (e.g., Kenya, Mozambique, Rwanda, South Africa, Tunisia, Republic of Congo, etc.) are developing green economy policies to guide sound management of natural resources and their sustainable use.

4.4.1.2 Environmental policies

Although the future is shrouded in uncertainty, some of the parameters that will determine Africa's future in biodiversity conservation are visible today. What is required is a clear-sighted analysis to identify the challenges and opportunities that lie ahead. This is because biodiversity conservation is mainly implemented through management of protected areas policy (Iritie, 2015).

Weak or inadequate policies in the conservation of biodiversity and ecosystem services have resulted in local extinctions or reduction in the diversity and richness of some species. A lack of harmony in national policies across regions has resulted in incoherent and sometimes unregulated exploitation of species such as elephants and lions. Formulation of appropriate policies at regional level, or harmonization of existing ones to ensure coordinated approach is likely to lead to effective conservation of biodiversity and transboundary ecosystems. A good example is the 520,000 km^2 Kavango Zambezi (KAZA) Transfrontier Conservation Area (TFCA) in the Okavango and Zambezi river basins at the convergence of Angola, Botswana, Namibia, Zambia and Zimbabwe borders. KAZA-TFCA provides safe corridors for wildlife movement between its 36 national parks, game reserves, community conservancies and game management areas. Recognising biodiversity and ecosystems as natural capital would enhance value to functions and services they provide. This would require that countries undertake valuation of their natural capital. That economic value of many protected area systems has not been undertaken and this may lead to the view that they contribute minimally or have no value for a country's economic development.

4.4.2 Governance systems

Governance is a timeless phenomenon that humans experience in their interaction with people and nature. In the present human can alter the conditions of the entire planet by through innumerable acts of decision-making that affect nature or, in a more institutional sense, innumerable acts of exercising power, authority and responsibility with direct relevance to nature (Crutzen, 2006). Governance has thus to do with policy (stated intentions backed up by authority) and with practice (the direct acts of humans affecting nature). In between, it has to do with the complex web of conditions understanding, communicating, and allocating power and resources – which create matches and mismatches between the two.

Governance for the conservation of nature seeks a balance between the requirements of human and economic development and those of conserving biological diversity. The key major international policy expressions are the Sustainable Development Goals, the Convention on Biological Diversity and the UN Framework Convention on Climate Change. Attention should also be focused at the national and local levels, and on area-based measures in particular. In reality, the policy and practice of conservation have always been enmeshed with the struggles for 'power over nature' that have unfolded throughout history. Considerations of governance–that is, who holds *de facto* power, authority and responsibility to take and implement decisions – are crucial for biodiversity conservation. In the distant past, the interaction between people and the environment were more likely shaped by patterns of necessity and adaptation than by 'decisions'. For example hunter-gathering lifestyle in many parts of Africa allowed livelihoods to be sustained with limited disturbance of the ecosystem functions.

Through time, landscapes and seascapes were identified as 'units', or territories of different people, often on the basis of different perceived vocations and patterns of interactions between people and nature. With the increased complexity of societies, expanded communication and trade, enhanced knowledge of the environment and enhanced technology to exploit its riches, both such interactions and units have changed, sometimes dramatically through decisions taken by relevant people and authorities. Similarly, the units (a village territory, a country, an administrative region, and the property of a given family) are increasingly more politically determined than determined on the basis of the intrinsic properties of the ecosystems.

Previous generations of people on the African continent had much less access than many of us to stored information, but an amazing capacity to learn and accumulate observations and experiences, in particular regarding specific places. Through time, acting and receiving feedback from nature consolidated into bodies of local knowledge and skills, varieties of carefully selected seeds and breeds, and allocation of different uses to different units in the landscapes and seascapes, based on deep knowledge and understanding of their potential. Many indigenous peoples and local communities continue to govern and manage their landscapes drawing from these accumulated observations and experiences. Throughout history, however, humans not only perceived and adapted to their ecosystems, they also affected them in important ways (Goudie, 1990). This began with the use of fire, the movement of seeds by hunter-gatherers and the changes to soil and waters made by agriculturalists (Goudie, 1990). Our landscapes and seascapes are delineated into administrative units where decisions about such units have mostly to do with how they will to be utilized for socio-economic developed and how much importance is given to considerations of sustainability and the conservation of ecological and cultural values. In other words: are the pressures of urbanisation, trade, infrastructure, industry, agriculture, aquaculture, mining, logging or large-scale tourism going to be reined in? Do decision-makers uphold the local ecological and cultural values by declaring that at least a given area is 'protected', that a watershed should not be altered, or that a given species is endangered and must be cared for? The compromises struck by policymakers about these questions are at the heart of today's governance of the conservation of biodiversity. And, in many such situations, the fundamental decision is about breaking the landscape or seascape into governance sub-units – some dedicated to development and others to conservation – generally under different governing bodies.

A country's governance systems have a direct impact on biodiversity conservation. Yet the state is no longer the sole actor responsible for managing environmental externalities (Agrawal *et al.*, 2007). Participatory management policy guidance, conveyed in connection with the IUCN (Dudley, 2008), has shown their limits in Central Africa (Joiris *et al.*, 2014). Hence the need for contextualized sustainable management systems. Ratification and mainstreaming of International multilateral environmental agreements in national policies will be key to making significant contributions to the sustainable management and use of biodiversity. For instance, the Convention on Biological Diversity's Article 6 is an unqualified commitment requiring Member States to develop a national biodiversity strategy and action plan (NBSAP) (or an equivalent instrument), and to integrate conservation and sustainable use of biodiversity into sectoral and cross-sectoral activities. NBSAPs therefore provide an opportunity to address threats to biodiversity through policy integration in a country's development agenda.

The Convention on Biological Diversity and the Sustainable Development Goals embrace the three principles of inclusion, equity and justice which resonate with Africa. Equity has three dimensions, which create an enabling environment for effective biodiversity conservation; recognition, procedure and distribution **(Box 4.9)**.

Some African states are promoting the implementation of articles 8 and 10 (c) of the Convention on Biological Diversity, the Nagoya Protocol and the United Nations Declaration on the Rights of Indigenous People in order to preserve and maintain knowledge, innovations, technologies and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and encourage the equitable sharing of the benefits arising from the utilisation of such knowledge innovations and practices (Lewis, 2010; AU, 2013).

4.4.3 Economic systems

Economic activity involves process that combines physical inputs and human efforts to produce goods and services for the improvement of human well-being. A wide range of economic factors influence how human use and impact on biodiversity and ecosystem services. Some of these include macroeconomic development pathways and fiscal regimes. Macroeconomic

Box 4 9 Principles of inclusion, equity and justice, as embraced by CBD and the SDGs (Source: Convention on Biological Diversity Capacity-Building Workshop for Africa on Achieving Aichi Biodiversity Targets 11 and 12, 21 -24 March 2016, Entebbe, Uganda).

Recognition
- Recognition and respect for human rights.
- Recognition and respect for statutory and customary property rights.
- Recognition and respect for the right of indigenous peoples to self-determination.
- Recognition of different identities, values, knowledge systems and institutions.
- Recognition of all relevant actors and their diverse interests, capacities and powers to influence.
- Non-discrimination by age, ethnicity, language, gender, class or beliefs.

Procedure
- Full and effective participation of recognised actors in decision-making.
- Clearly defined and agreed responsibilities of actors.
- Accountability for actions and inactions.
- Access to justice, including an effective dispute-resolution process.
- Transparency supported by timely access to relevant information in appropriate forms.
- Build on rights-holders' customary governance and management arrangements
- Identification and assessment of costs, benefits and risks, and their distribution and trade-offs.

Distribution
- Effective mitigation of any costs to Indigenous Peoples and local communities.
- Benefits shared among relevant actors according to one or more of the following criteria: equally between relevant actors or according to contribution to biodiversity conservation, costs incurred, recognised rights, or the needs of the poorest.
- Benefits to the current generation do not compromise benefits to future generations.

development discourses, policies and strategies on the continent have long been based on maximising African nation's economic growth and development, with limited change in the structure of Africa counties' economies over the past five decades (AfDB *et al.*, 2015). Economic activity and growth are influenced by the dispensation of natural resources, including ecosystem services (natural capital), the number and skills of humans (human capital), market reach (trade), institutional and policy environment and more strongly by available technologies. In Africa primary activities based on the exploitation or extraction of natural resources (i.e., biomass; fossil fuels – coal, oil and gas; metal ores and non-metallic minerals) continue to dominate (Collier, 2002). With Africa's economic growth of 3.6% in 2015 (AfDB *et al.*, 2016) and expected 5% in 2016 (AfDB *et al.*, 2015), there is no evidence of decoupling between biodiversity loss and current development pathways based on increasing demands for ecosystem services accompanied by large-scale habitat transformation.

The rich resource base in many African countries has been a major driver and engine of economic growth in the region. Foreign exchange earnings from resource exports enabled African countries to import important intermediate inputs and also finance some national development programmes. In as much as African countries benefited from their resource endowments, some of these resources are non-renewable. Their rapid depletion by the current generation will limit their capacity to meet the consumption needs of the future generations, especially if there is no investments in assets that support future growth, (UNCTAD, 2012). Most developing countries have in the last three decades transitioned considerably in the latest wave of globalisation from primary export commodities to manufactures (Collier *et al.*, 2002). However, Africa has not broken into the global market for manufactures and remains heavily dependent on primary commodities (Collier, 2002). This places increasing high demand for natural resources by emerging and developed economies. Pressure on the African biodiversity and ecosystems has been immense and persistent, (Nelson *et al.*, 2005).

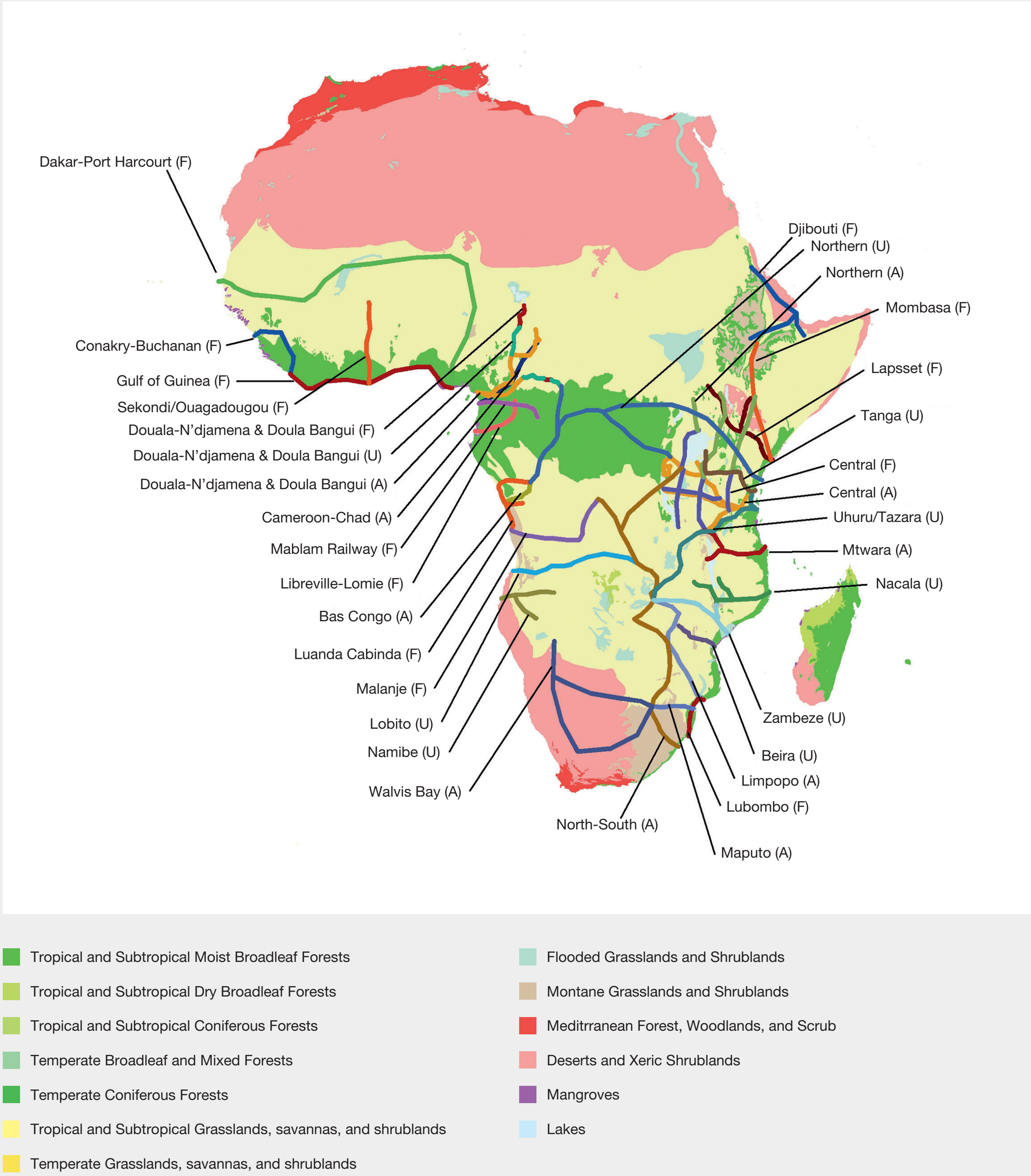
Economic growth requires development and improvement of physical and institutional infrastructure to facilitate transportation, marketing, settlements, public services, and private-sector activities (Nelson *et al.*, 2005). Further the proposed development corridors would involve largescale expansion of infrastructure resulting in increased pressure on the environment and biodiversity (Laurance *et al.*, 2015). The development of planned infrastructure will play a major role impacting on ecosystems. Infrastructure development is an important direct driver of biodiversity change **(Figure 4.19)**.

Joint research by WWF and AfDB identified the Ecological Footprint of all African countries as increasing by 240% between 1961 and 2008. Africa was projected to be in a "biocapacity deficit" by 2015, i.e., the demand for resources and ecological services is now greater than the capacity of Africa's ecosystems to produce such useful biological materials and absorb waste flows generated by its populations (AfDB, 2015). This is particularly worrying given the growing reliance of African economies on the exploitation of renewable natural capital (AfDB, 2015). While the basis for the continent's development is increasingly broad, extractive sectors still act as a major source of export earnings and account for a significant share of Gross Domestic Product and its growth in many countries across the continent (AfDB, 2015).

Africa's primary commodities dependence has been attributed to a poor investment climate that is policy-related and handicaps manufacturing and agricultural processing that are intensive in transactions are considered a feasible means of lowering these costs in a coordinated way in order to enable the continent reach competitiveness in manufacturing (Collier, 2002). In addition, the African Union has promoted intra-African trade, by developing a trade action plans, i.e., Action Plan for Accelerated Industrial Development of Africa and Program for Infrastructure Development in Africa. However, the subsequent infrastructural development has improved trade but had negative impacts on the biodiversity and ecosystems functions and services.

To counter this, there has been a widespread development green economic strategies and policies in Africa to enable sustainable development in the region. A typical definition is that "green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies" (OECD, 2011). Green growth must be compatible with poverty alleviation strategies that address ecological scarcity, a major contributing factor to the vulnerability of rural economies. Green growth has focused on renewable technologies and climate change adaptation strategies such as reducing the emission of greenhouse gases, (OECD, 2011). Green growth has focused on renewable technologies and climate change adaptation strategies. Green economy policies have been developed with incorporation of biodiversity conservation. However, the concept of Public-Private Partnerships will require caution to ensure private companies engage fairly with local communities under the Prior Informed Consent principle. Hence, tackling the structural problem of the geographical clustering of impoverished households in marginal and remote areas with poorly integrated and functioning markets should be a focus for development policies that address changes in biodiversity and ecosystem services.

Figure 4 19 **Map of future development corridors and likely scenarios of development pressure on African ecosystems. Legend: A = already active; F = planned for the future; U = upgrade planned or underway. Source: Laurance *et al.* (2015).**



According to the United Nations Conference on Trade and Development (UNCTAD) report of 2012, the total domestic material extraction (i.e., biomass; fossil fuels – coal, oil and gas; metal ores and non-metallic minerals) increased from 2.8 billion tons in 1980 to 5.3 billion tons in 2008 in Africa, representing an approximate increase of 87% **(Figure 4.20)**. This increase is in line with global trends although Africa's share in global extraction increased only marginally (UNCTAD, 2012). Biomass (e.g., agriculture, forestry, and fishing) is the most dominant material type extracted in Africa, accounting for 30% of overall material extraction in 2008. It increased from 1.7 billion tons in 1980 to 2.8 billion tons in 2008. Animal feed, particularly grazing activities (livestock breeding accounts for a high share in total land-use in many

African countries), accounted for 58% of biomass extraction in 2008.

While the share of biomass in domestic extraction varies across African countries, it is important to note that non-renewable resources are increasingly playing an important role in several African countries. The average domestic material extraction per capita between 1980 and 2008 fell from 5.9 to 5.4 tons despite the global average increasing from 8.6 to 10.2 tons **(Figure 4.21)**. During this period, high population growth resulted in the per capita domestic material extraction stagnation.

It is clear that there has been an increase in Africa's global market shares in exports of biomass due to higher increases in trade in other world regions. The transition

Figure 4 20 **Global and African domestic material extraction (billions of tons). Data source: http://www.materialflows.net/materialflowsnet/home/.**

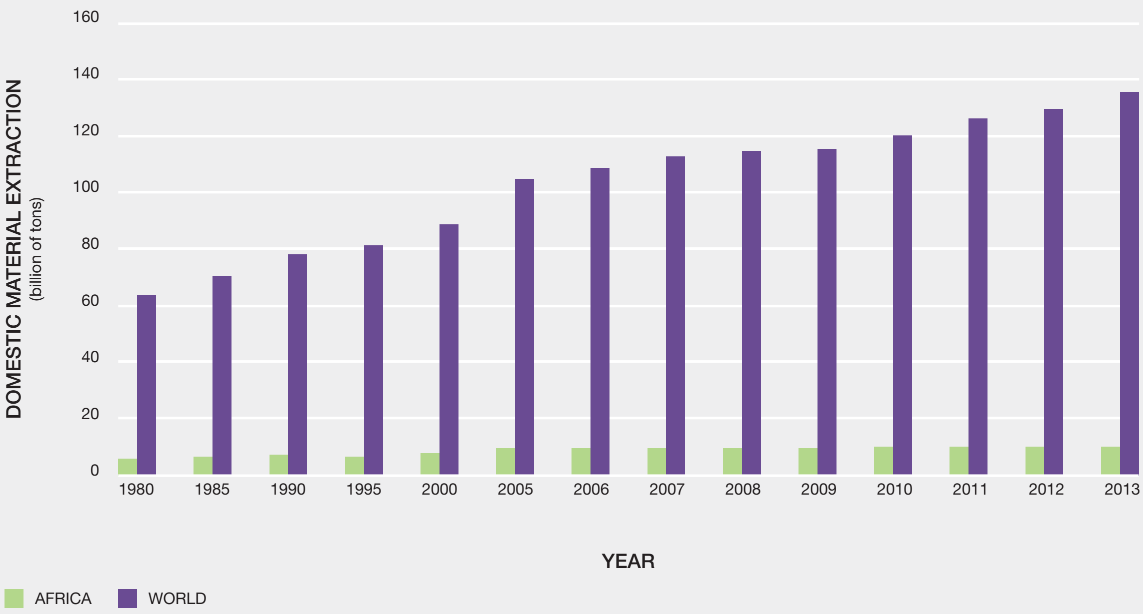
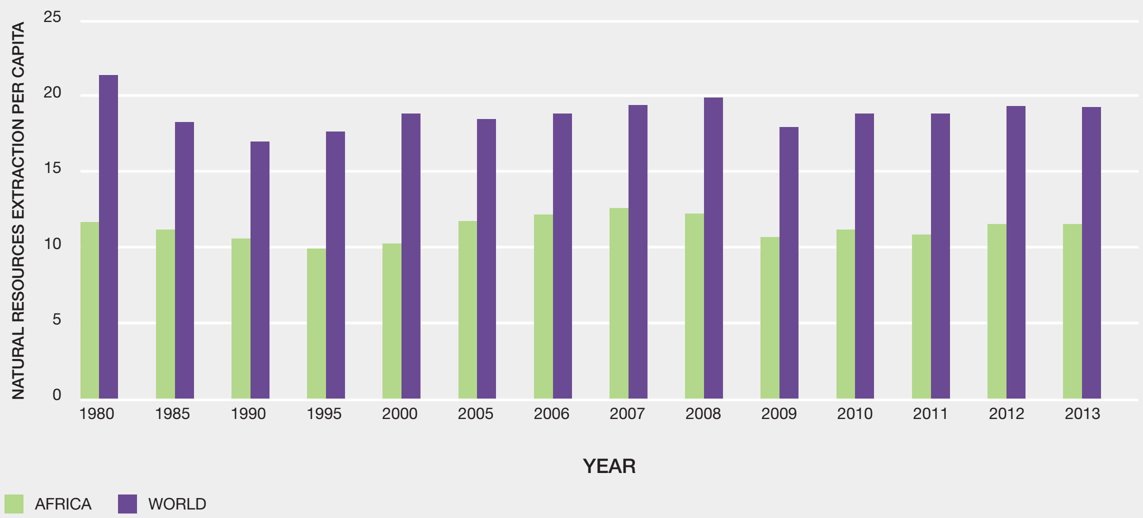


Figure 4 21 **Natural resources (material) extraction per capita: Africa regional average and world average for the period between 1980 and 2008. Data source: http://www.materialflows.net/materialflowsnet/home/.**



from an agrarian to an industrial regime results in increased environmental pressures. Consequences range from climate change, waste pollution, deforestation, desertification and degradation of freshwater resources, to the loss of biodiversity (UNCTAD, 2012).

There is a growing consensus that growth alone will not be enough for the continent to fulfil its aspirations. Debates on sustainable development pathways in Africa see various policy options and alternatives put forward (AfDB *et al.*, 2015):

- Industrialisation proposed as the mainstay of the African structural transformation, by emulating past policies of developed and emerging economies for full integration into world trade;
- The services industry as the new pillar of structural transformation because jobs in services continue to expand (e.g., outsourcing, new information and communication technologies);
- Pushing for further natural resources production, investing natural resource revenues wisely and simultaneously developing industrial policies which could diversify economies;
- Prioritising agriculturally-based growth given the current share of agriculture in employment; and
- Green growth strategies, calling for dramatic changes in production and consumption modes.

While each option tends to prioritise one sector or approach, some key institutions (e.g., African Development Bank) are working towards improving the quality of Africa's growth by coupling inclusive growth (e.g., equality of treatment and opportunity, deep reductions in poverty and a correspondingly large increase in jobs) to green growth strategies (AfDB *et al.*, 2015). It is thus imperative that its economy becomes more diversified over the next two decades in order to sustain future export-driven growth. Africa Development Bank and the World bank have noted that economies that do not diversify from their fossil or limited resource dependency, and/or fail to give adequate attention to the ecological impacts of resource extraction, will face the challenge of stranded assets, increasingly competitive global markets, and degraded ecological and infrastructure systems in the future (AfDB *et al.*, 2015).

One may highlight the lack of practical fiscal regimes to finance the required shifts in behaviour towards pro-biodiversity development pathways. Indeed, current fiscal systems worldwide typically ignore environmental and social externalities and are focused on taxing (or exonerating from tax) capital and labour. Defined by the Organisation for Economic Co-operation and Development and World Bank as a 'range of taxation and pricing measures that can raise fiscal revenues while furthering environmental goals', environmental or green fiscal reform has been and is being implemented in different ways on the African continent (van Kerckhoven *et al.*, 2014). The pool of available tools includes environmental tax reform, the reform of environmentally harmful subsidies, (auctioning) permits to pollute or exploit a resource, charges, levies and fines for environmentally damaging activities, as well as the wider discourse on getting the prices right which incorporates positive incentives such as payments for ecosystem services.

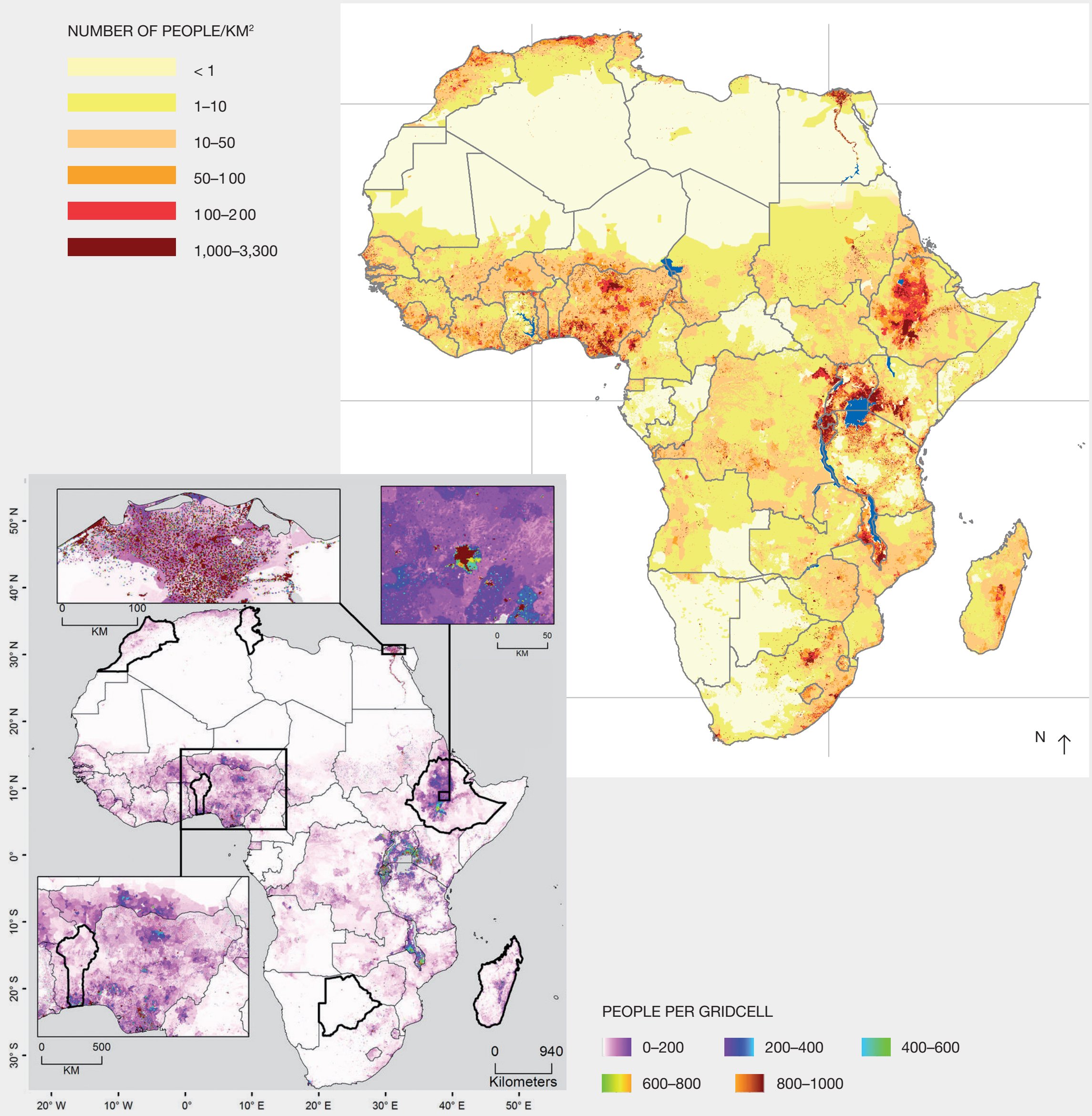
4.4.3.1 African Economic Community

The African Economic Community is composed of multiple regional blocs also known as. These consist primarily of trade blocs with many overlapping memberships. Regional integration and trading blocs were created as a means to achieve sustained development and increase participation in the global economy (Ntara, 2016). Poverty levels in the blocs remain high suggesting low impact of the regional economic communities in enhancing socioeconomic development in partner states (Sako, 2006). Majority of the poor live in rural areas and depend directly or indirectly on terrestrial, inland waters and marine natural systems for income generation. Thus by not stemming poverty overexploitation of these resources has contributed to accelerated degradation impacting on biodiversity and nature's contributions to people.

4.4.4 Population growth, migration and urbanisation

The African population is projected to nearly double from around one billion in 2010 to almost two billion by 2040, and may well reach 3 billion by 2070 (UN, 2014; Boke-Olén *et al.*, 2017; **Figure 4.22**). Countries that have the highest population growth rate in sub-Saharan Africa include Zimbabwe (4.36%), South Sudan (4.12%), Malawi (3.3%), Niger (3.28%), Burundi (3.28%) and Uganda (3.24%) (World Atlas, 2016). This rapid population growth is impacting urbanisation, a driving force behind many socio-environmental issues (Heynen *et al.*, 2006). Human migration in Africa besides rural-urban trends is also caused by conflicts in the region, deprivation of communities to their rightful land due to private acquisitions and infrastructural development, leading to disruption of ecosystems. The adverse effect of global warming will also increase rural-to-urban migration thus

Figure 4 22 **Population density in Africa in 2010 (left) and 2050 (right) (population datasets and SSP 2 and RCP 4.5). Source: Pesche *et al.* (2016); Boke-Olén *et al.* (2017).**



putting more urban infrastructure at greater risk due to extreme weather events. Available evidence suggests that natural population growth in cities is more important than migration and displacement in explaining the role of humans in influencing environmental change on the African continent (Parnell *et al.*, 2011).

4.4.4.1 Urbanisation trends

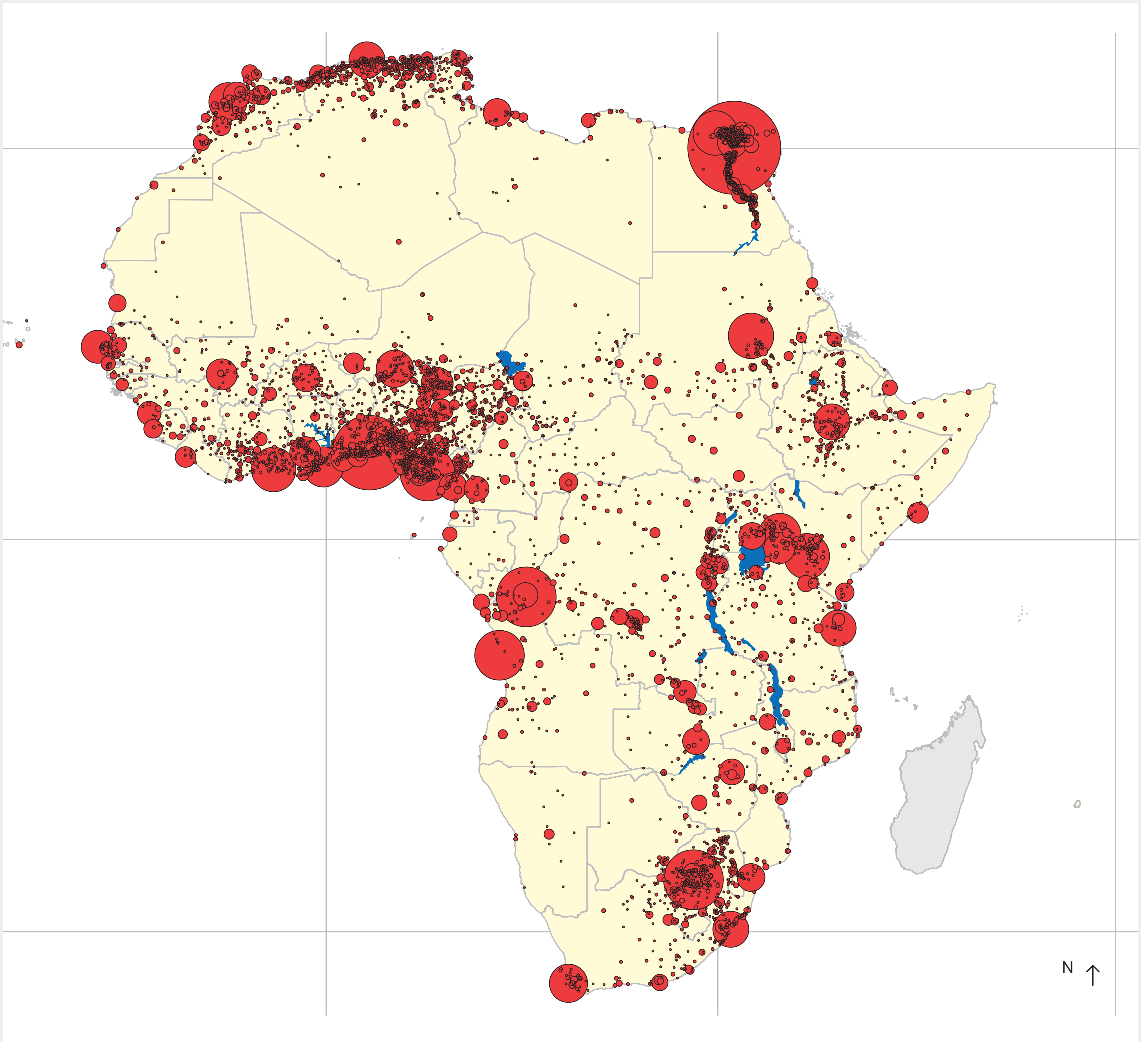
In 2003, 39% of Africa's 850 million people lived in urban settings and this is projected to rise to 54% by 2030 (Hay *et al.*, 2005). Overall, about half of the African population, i.e., 1.2 billion people, will live in a city by 2050 (Hay *et al.*, 2005). However, there are large variations in the patterns of urbanisation across African regions **(Table 4.8)**.

North Africa has a higher proportion of urban population (47.8%) relative to sub-Saharan Africa (SSA) (32.8%) **(Figures 4.23 & 4.24)**. Available data suggests that more than 50 million people in Africa will migrate to cities from rural areas with the cities growing twice as fast (by 100 million) just through natural in-city urban population growth. African cities will expand by 150 million people by 2020 (Parnell *et al.*, 2011).

Table 4 8 **Urbanisation in African subregions: percent of populations in urban areas. Source: UN (2011).**

Region	1950	1975	1995	2025
East Africa	5.5	12.3	19.4	44.7
Central Africa	14	27	34.2	61.5
Southern Africa	37.7	44.2	51.4	74
Western Africa	9.7	24.1	35.7	65.7
North Africa	25.8	39.3	47.2	65.3

Figure 4 23 **Urban population distribution across Africa (i.e., urban agglomerations of over 10,000 inhabitants). Source: Pesche *et al.* (2016).**



SIZE OF URBAN AGGLOMERATIONS (No. PEOPLE)

10,000 · 100,000 · 500,000 · 1,000,000 · 5,000,000 · 10,000,000 · Missing data

Rural-urban migration **(Figure 4.25)**, pro-urban development strategies, and high population growth rates are among the main causes of urbanisation in Africa. Searching for alternative livelihoods or economic opportunities mostly influences rural-urban migrants. There is therefore a great need for policies in the continent that encourage sustainable and equitable development by, for example, directing growth to areas where it can be sustained or redirecting urban expansion to more energy-efficient areas (IPCC, 2013).

4.4.4.2 Environmental outcomes of urbanisation

Urban populations interact with their environment and change their environment through consumption of food, energy, water, and land. In turn, the polluted urban environment that is a function of consumption of resources and production of waste affects the health and quality of life of the urban population. Many of the effects of urban areas on the environment are not necessarily linear. Bigger urban areas do not always create more environmental problems. And small urban areas can cause large problems. Much of what determines the extent of the environmental impacts is how the urban populations behave–their consumption and living patterns–not just how large they are (Torrey, 2004). Further, development of infrastructure in urban areas enables them to cope better with the demands posed by the concentration of large numbers of people in limited spaces. Thus, wastewater works and drainage systems are critical to supporting urban populations and to mitigating the impacts of waste and pollution on the environment.

4.4.4.2.1 Land and wildlife habitats degradation

The pressure on ecosystem functions and services, particularly water and food (plant and animal based) causes an increase on the dependence on and demand for conversion of natural ecosystems into production landscapes, hence compromising biodiversity. Among the many human activities that cause habitat loss, urban development produces some of the greatest local extinction rates and frequently eliminates the large majority of native species (Marzluff, 2001). Also, urbanisation is often more lasting than other types of habitat loss. Throughout much of New England, for example, ecological succession is restoring forest habitat loss from farming and logging, whereas most urbanised areas in that region not only persist but continue to expand and threaten other local ecosystems (Stein *et al.*, 2000). In addition, most policies prioritize human settlements or other land-use over wildlife.

Figure 4 24 **Rates of urban population growth for different African subregions. Note: South Africa and not southern Africa in this context. Source: https://esa.un.org/unpd/wup/cd-rom/.**

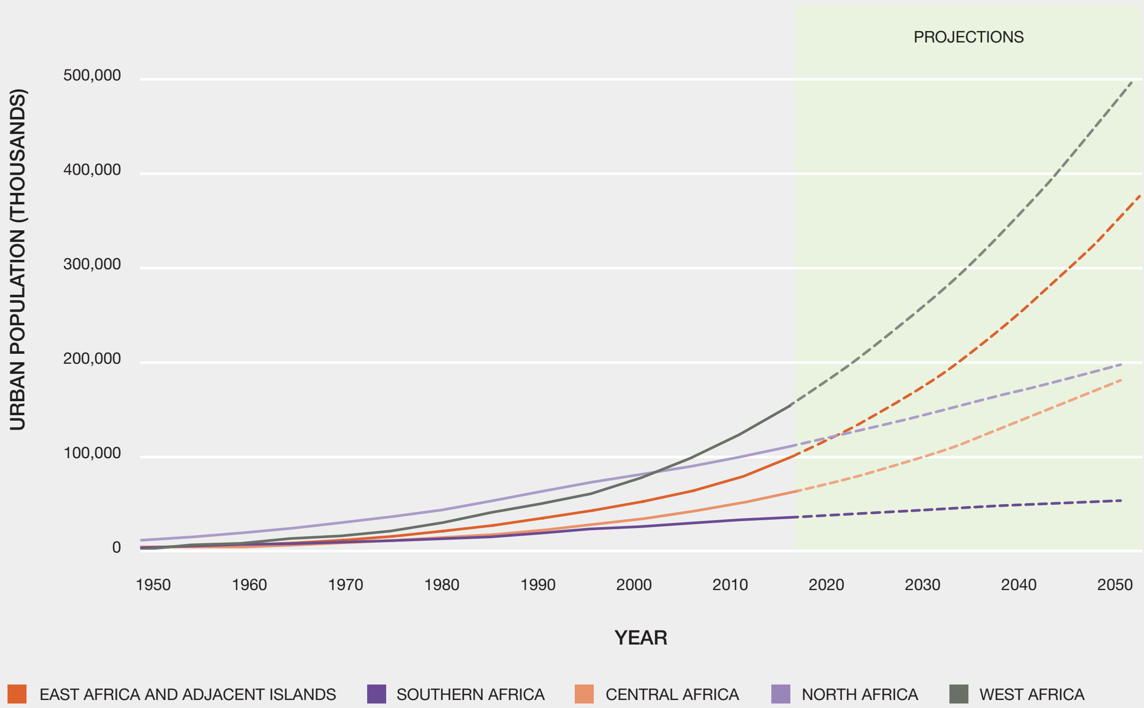
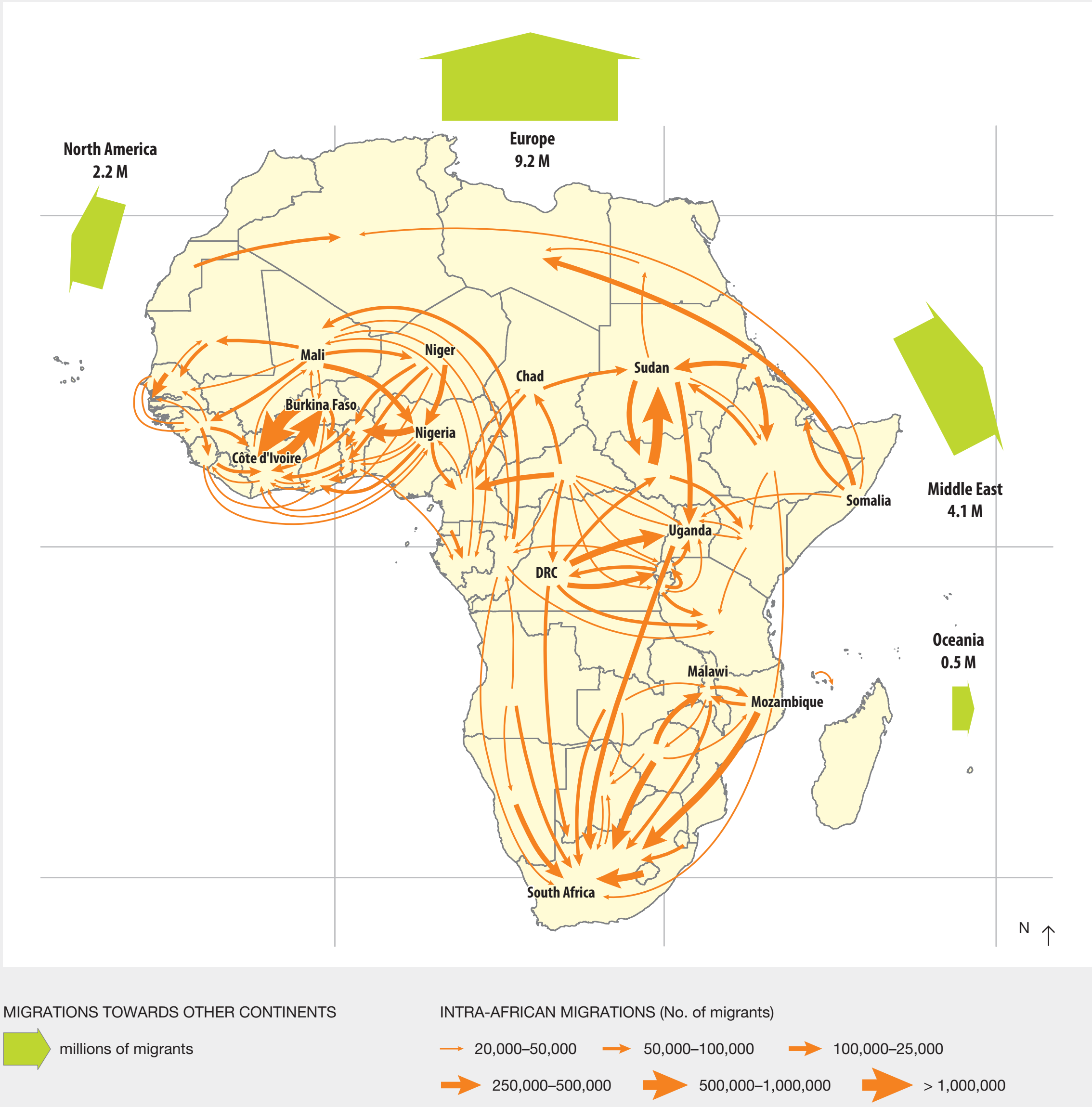


Figure 4 25 **Population migration across Africa and from Africa to the rest of the world in 2015. Source: Pesche *et al.* (2016).**



This has led to fragmentation of wildlife habitats and populations and reduced ecological connectivity. Policies that have historically excluded communities in biodiversity conservation has led to loss of indigenous practices, and increased incidences of human/wildlife conflicts.

4.4.4.2.2 Energy systems and climate change

Both population and urbanisation have been reported as key drivers in increased emissions in Africa. Africa has among the highest population growth rates in the world. Moreover, urban populations are responsible for more emissions than rural populations. Energy consumption for electricity, transportation, cooking, and heating is much higher in urban areas than in rural villages. At a local scale, urban consumption of energy helps create heat islands that can change local weather patterns and weather downwind from the heat islands. The heat island phenomenon is created because cities radiate heat back into the atmosphere at a rate 15–30% less than rural areas (Torrey, 2004). Primary Energy Consumption in Africa has risen from 261.7 metric tons of oil equivalent (million tons) in 1998 to 435 million tons in 2015 (Statista, 2016) showing a rise of 66% in 17 years. In South Africa, only 16.9% of the final energy consumption was renewables in 2012 (Statista, 2016). At COP 21 in Paris, Parties to the UNFCCC reached a historic agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. Among the global strategies in reducing greenhouse gas emissions from fossil fuels is the development of alternative fuel sources. One such is use of liquid biofuels in the transport sector whose growth in production and consumption will increase due to, among other reasons, mitigation of biodiversity loss (Brenan *et al.*, 2009). Production of such fuels must be both technically and economically viable. Hence, be competitive in pricing; requiring low to no additional land-use; enabling air quality improvement, and; requiring minimal water use (Brenan *et al.*, 2009). Technological application in the exploitation of microalgae could meet these conditions and therefore make a significant contribution to meeting the primary energy demand, while simultaneously providing environmental benefits (Brenan *et al.*, 2009).

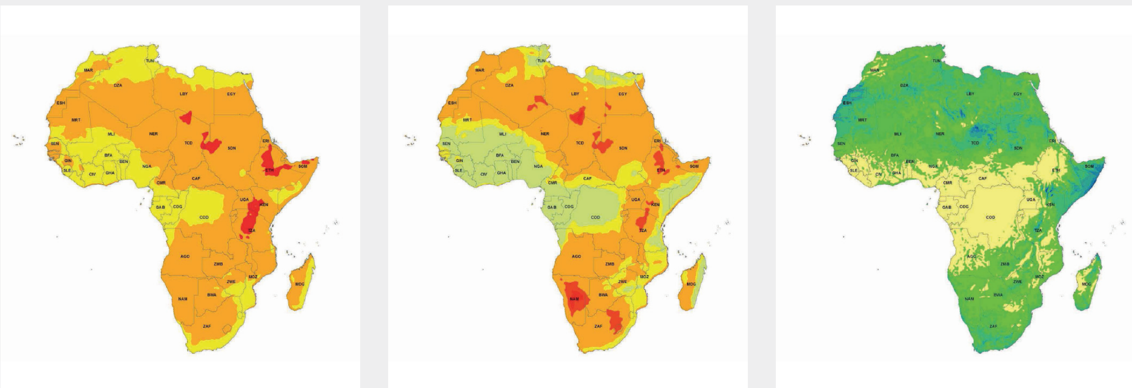
Electricity generation using solar energy directly (photovoltaic) or indirectly (concentrating solar power) has grown exponentially worldwide over the last decade (Hernandez *et al.*, 2014). Affordability of solar energy technologies and technically accessible energy for large areas of Africa **(Figure 4.26)** makes it appropriate to bridge energy needs in the continent. It is estimated that theoretical potential for solar energy for Africa is 1120 Petawatt hours (PWh) being 660 PWh for concentrating solar power and 460 PWh for photovoltaic (Hermann *et al.*, 2014). These potentials have been estimated for areas in the continent that excluded regions critical for biodiversity conservation such as protected areas, wetlands, floodplains, and forests; as well as agricultural land, cities and urban areas (Hermann *et al.*, 2014).

However, solar energy systems installed as utility-scale solar energy enterprises, may have impacts on biodiversity and ecosystem services during construction, operation or decommissioning (Hernandez *et al.*, 2014). Locally, concentrating solar power impact biodiversity losses where there is vegetation clearance and gradation of soils; and by fragmenting landscapes, they create barriers to movement of species and their genes leading to regional impacts (Hernandez *et al.*, 2014).

Adopting widespread use of utility-scale solar energy enterprises may therefore lead to biodiversity losses at local and regional scales. Solar energy technologies if installed as distributed systems with relatively small capacity (e.g., <1 megawatt) and integrated into existing built environments (e.g., roof-top photovoltaics) will likely have negligible direct effects that adversely impact biodiversity (Hernandez *et al.*, 2014). This would have more beneficial outcomes through reduction in use of fossil fuel in power generation. Studies on impact of other renewable energy technologies on biodiversity show that wind farms affect distribution of birds, with significant effects on non-breeding individuals (Hötker *et al.*, 2006). The birds were also shown to avoid the wind turbines particularly with high hubs; however, the wind turbines did not form a barrier to movement of some species such as cormorants and grey heron that were able to alter direction or height of the flight path (Hötker *et al.*, 2006). Studies in North America (Arnette *et al.*, 2008) show widespread and often extensive fatalities of bats having increased with the development of wind energy. Given the high potential for wind energy in Africa (Mukasa *et al.*, 2013), care should be taken in positioning as this influences collisions. Habitats with high casualty rates include bare mountain ridges, where there is a sharp change in relief (for example at plateau edges), and wetlands (Hötker *et al.*, 2006).

Figure 4 26 **Overall resource potential for photovoltaic, concentrated solar power and wind technologies for Africa.**

Potentials calculated based on solar irradiation and average wind speed. Dark orange and red areas indicate best suited locations for solar energy systems while dark green and blue areas are best suited for wind. Source: Hermann *et al.* (2014).



PV SUITABILITY CLASSES (GHI) | CSP SUITABILITY CLASSES (DNI) | WIND SUITABILITY CLASSES (Average wind speed)

Use of liquid biofuels in the transport sector, driven largely by policies focused on achievement of greater energy security, and mitigation of greenhouse gases emissions has increased globally (Brennan *et al.*, 2009; Webb *et al.*, 2012). Such benefits are yet to be proven from current applications (Webb *et al.*, 2012). Across Africa, the major catalyst for biofuel expansion has been market driven with perceived potential for export to emerging international biofuel markets (Gasparato *et al.*, 2012). This followed the ratification of the European Union Renewables Directive 2009/28/EC leading to large-scale land acquisition by private firms from Organisation for Economic Co-operation and Development (OECD) and non-OECD countries to develop biofuel plantations in several African countries (Gasparato *et al*., 2012). Other drivers have included policies regarding fuel security due to rising oil prices (von Maltitz *et al.*, 2012), economic development, and growing support from bilateral and multilateral donors (Acheampong *et al.*, 2014).

Impacts of biofuel production on biodiversity and ecosystem services can be inferred from the direct impacts of land conversion of natural ecosystems into biofuel feedstock plantations (Campbell *et al.*, 2009). This is of major concern for Africa since large areas of land, totalling 7.55 million hectares have been allocated to foreign investors for biofuel production (GRAIN, 2013). This process, described as land grab (GRAIN, 2013), has consumed large areas distributed within different parts of Africa including the Eastern region accounting for 33% (2.46 million hectares), Western 29% (2.23 million hectares), Southern 14% (1.05 million hectares), Central 8% (601,000 hectares), and the Indian Ocean Island of Madagascar 16% (1.2 million hectares) of total area dedicated to biofuel plantations. In areas where biofuels are grown in existing agricultural land, farmers are compelled to move to marginal lands that are unproductive or infertile (Acheampong *et al*., 2014), hence generating controversy due to their impact on food security (Brennan *et al.*, 2009).

Following the European Union–27 mandate that sets a 2020 target for consumption of biofuels equivalent to more than 40 million tons, global demand for biofuels is now predicted to reach 172 billion litres by 2020, up from 81 billion litres in 2008 (GRAIN, 2013). This may give new impetus for conversion of more land to biofuel plantations increasing concern to potential loss of biodiversity and natures contributions to the people of Africa. Democratization of the energy market would lead to application of unconventional technologies in energy production, e.g., on-site productions on demand that would exclude challenges affecting biodiversity and ecosystem functions and services associated with large production, storage, transport and distribution. Similar technologies may be applicable in water provision, for example, in the extraction from air to assure provision in areas of water deficit. Some existing technologies, for example drones, will in future play important roles in protection of biodiversity.

4.4.4.3 Vulnerability incomes

4.4.4.3.1 Health issues

A study in the North West Province of South Africa revealed that the improved socioeconomic circumstances observed in the wealthiest urban areas were accompanied by superior nutritional status, lower mean blood pressure, better health behaviours (lower smoking, drinking and HIV infection rates), lower measures of all indices of psychological pathology and higher scores of psychological well-being (Vorster *et al.*, 2000). These subjects also had the highest fat intake and serum cholesterol levels. Farm workers were identified as the most vulnerable group, having inadequate diets, highest scores for psychological symptomatology and the lowest scores for psychological well-being (Vorster *et al.*, 2000). Yet, according to UN-Habitat, sub-Saharan Africa has a slum population of about 200 million people, 61.7% of its urban population (AfDB, 2015). Only 84% of the continent's urban dwellers have access to potable water while 54% to sanitation (Brixiová *et al*., 2013). The relatively fewer slums in North African countries is mainly attributed to better urban development strategies, including investment in infrastructure and in upgrading urban settlements. In contrast, SSA has the lowest proportion of urban population (32.8%), but the highest proportion of slum dwellers (65%). Considering different plausible scenarios, Keiser *et al.* (2004) estimate an annual incidence of 24.8–103.2 million cases of clinical malaria attacks among urban dwellers in Africa.

4.4.5 Technology developments and application

Biotechnology, and information and communication technology together with industrialisation of Agriculture and Food Processing technologies will play a key role in improving Food Security without negatively impacting on biodiversity and nature's contributions to people by 2050 when the world population is expected to reach nine billion people. Due to unprecedented growth in human population, the need to increase food production has been technology-dependent based on intensification of management on land newly converted or already under agriculture at a major cost to biodiversity (Deguines *et al.*, 2010). In Africa, this has been accomplished through the use of high-yielding crop varieties, chemical fertilizers and pesticides, irrigation, and mechanization. The process of intensification fell under the general heading of "the Green Revolution," which began in the 1960s with the transfer and dissemination of high-yielding seed (Matson *et al.*, 1997). Agricultural intensification has had negative local consequences, such as increased erosion, lower soil fertility, and reduced biodiversity (Matson *et al.*, 1997; Tscharntke *et al.*, 2005; Firbank *et al.*, 2008). It has also led to the decrease in both pollinator diversity and pollination services (Deguines *et al.*, 2010). Studies in France (Deguines *et al.*, 2010) has shown that benefits of agricultural intensification decreases with increasing pollinator dependence; hence intensification does not increase the yield of pollinator-dependent crops but decreases the stability of their yield over time**.**

Reduction in plant biodiversity due to intensification leads to changes in the community composition including for beneficial pest complex–herbivorous insects, their natural enemies (predators and parasitoids), and microbial community (Matson *et al.*, 1997) which are fundamental to many functions of soil systems, such as nitrogen cycling, decomposition of wastes and mobilisation of nutrients. The consequence may be higher losses due to high pest densities in monocultures. Agricultural intensification through use of genetically modified crops have been suggested as beneficial to biodiversity as yield improvements on existing agricultural land would lead to reduction in conversion of land into agricultural use (Carpenter, 2011). Also, by decreasing insecticide use, increasing the use of more environmentally friendly herbicides and facilitating the adoption of conservation tillage, genetically modified crops would contribute to increasing agricultural sustainability (Carpenter, 2011). Adopting technologies such as drought or salinity tolerance would alleviate the pressure to convert high biodiversity areas into agricultural use by enabling crop production on suboptimal soils. This would be of particular relevance to sub-Saharan Africa, expected to experience prolonged periods of low soil moisture due to climate change. More research on this technology is, however, necessary as genetically crops may potentially affect the "fitness of other species, population dynamics, ecological roles, and interactions, promoting local extinctions, population explosions, and changes in community structure and function inside and outside agroecosystems (Gertsberg, 2011).

The convergence of food needs and those of energy and water is conspicuous in Africa where 560 million people lack access to electricity in the sub-Saharan area while 621 million rely on solid fuels for cooking (WHO *et al.*, 2009). The challenge therefore is to develop environmentally sound energy systems that will conserve biodiversity and reduce carbon footprint. Renewable energy technologies, though requiring a complex set of environmental trade-offs to develop, would be an alternative to fossil fuel-based energy. Of the renewable energy sources, geothermal power has been considered the most attractive being relatively benign in nature (Mutia, 2010). Most geothermal resources are a challenge to developers since they are located in remote scenic, wild and protected areas (Mutia, 2010). A classic example where geothermal power generation and biodiversity conservation are coupled is at the Hell's Gate National Park in the Kenya's Rift Valley since 1984. However, anecdotal information suggests that wildlife diversity and biomass has been on the decline following recent expansion of the plant generation capacity (Mutia, 2010). This would call for caution in future development of geothermal power plants in protected areas.

4.4.6 Insecurity

Sustainable development thrives best in an environment of good governance, peace and security, but armed conflict remains a major obstacle to development in several parts of the continent (Hanson *et al.*, 2009). Environmental crime can be subdivided broadly into wildlife, pollution and water management crimes; that exploit resources in an illegal manner and destroy the environment in contravention to national, regional and international environmental laws (Nellemann *et al*., 2016; UN, 2016; UNOCD, 2016). The maintenance of an environment of peace and security is therefore one of Africa's foremost development imperatives. Apart from its costs in human and material terms, conflicts impede production, damage infrastructure, prevent the reliable delivery of social services and disrupt societies. Africa is the most sub-divided continent, with small and fragmented economies that undermine the continent's position in the global development arena. In spite of the long-standing commitments and the emphasis placed by African leaders on the process of regional integration, this has been slow and therefore, remains a major challenge for development in Africa (UNECA, 2004; 2005).

Environmental crime is not restricted by borders, and may impact on region's economy and security. For instance, poaching and illegal wildlife trafficking undermines the livelihoods of natural resource dependent communities, damages the health of the ecosystems they depend on, and the criminal activity and corruption associated with trafficking restricts the potential for sustainable investment and development needed in new economic activities and enterprises (UNODC, 2016). A significant proportion of both wildlife and pollution crime is carried out by organised criminal networks, drawn by the low risk and high-profit nature of these types of crime. The same routes used to smuggle wildlife across countries and continents are often used to smuggle weapons, drugs and people. Indeed, environmental crime often occurs hand in hand with other offences such as passport fraud, corruption, money laundering and murder (UNODC, 2016).

Box 4 10 The Environmental Crime crisis in DRC and Somalia.

Indeed environmental crimes have been considered grave issues in DRC and Somalia by the UN Security Council, the assessment reveals that the scale and role of wildlife and forest crime in threat finance calls for much wider policy attention, well beyond those regions. Conflicts have been associated with breakdown of social structures among communities. This leads to loss of identity and cohesion among affected people. Since inherent cultural systems of resource use tend to have elements of conservation, their breakdown would result to loss of ecosystem functions and services, and concomitant human well-being (Summers *et al.*, 2012).

Terrorist groups are also known to participate in illegal trade in wildlife products to fund their illegal activities. In case of overharvesting of species populations, there would be loss of ecosystem services to local communities. Conversely, loss of access to biodiversity and ecosystem services associated with resource overuse, e.g. from exclusion of communities from fishing grounds, drying up of inland water bodies for example due to over abstraction in upstream areas, draining of wetlands may also lead to radicalisation of societies and development of terror groups references). The construction of dams upstream of rivers currently focuses on energy and agriculture sectors with little concern of for downstream users. In several cases, the deprivation of water downstream due to lack of socio-ecological water release mechanisms affects livelihoods is a cause of exclusion and conflict. There have been suggestions of possible links between insecurity and access to resources, e.g., drying of Lake Chad and the rise of Boko Haram; The emergence of Somali Pirates/Al Shabab and the departure of Japanese and Korean fishing vessel that were responsible for the decline of fisheries off the Kenya/Somalia coast (Aljazeera Africa, 2010).

4.4.7 Cultural practice and spirituality

In many cultures in Africa decisions about nature arise from the spiritual and ancestral beings who are part of nature, and affect us much more than we are able to affect them. Some people perceive nature as benign and sacred, to be treated with reverence and moderation. Cultural practices among many societies in Africa have exhibited values, beliefs and norms that preserve biodiversity and ecosystems. For example, among the coastal societies in Kenya, important forest blocks have been preserved through the Kaya customary laws. In many other cultures, for example, the Masai, Samburu and Pokot, clans are believed to have blood relations with different animal species, hence, killing of those species are prohibited leading to their preservation. Moreover, local indigenous knowledge held by communities plays an important role in conservation. However, there is need for consideration of the impact of infrastructure development on biodiversity, technological innovations and increasing demand for animal products on culture, spirituality and indigenous and knowledge.

Local and indigenous communities are important partners in conservation, leading to the development of conservation approaches that revolve around indigenous and local knowledge. In the Tharaka area of north-central Kenya, the communities have two levels of justice to protect riparian areas along streams and rivers (Mburu *et al.*, 2016). Women respond first to violation of protected sacred sites by fining transgressors, hence administer the first line of justice while the second level is administered be male elders. The marine waters, sandy beaches, coastal calcareous sand dunes, saline and non-saline depressions, inland ridges, limestone plateau, inland siliceous sand formations, and manmade rain-fed farms in north-western coastal Egypt support diverse floras and faunas, some of which are endemic and threatened (Bidak *et al.*, 2015). The biodiversity here is a source of economic activities and other traditional uses by the Bedouin communities. The sustenance of these goods and services are driven by traditional knowledge and practices (Bidak *et al.*, 2015). The Samburu have natural resources law that rotates around grazing management (Oguge, 2016). This entails (i) segregation of landscape into grazing, settlement and watering areas; (ii) designation of dry season grazing areas; (iii) prohibition of cutting the *Acacia tortilis* tree; (iv) prohibition of burning forests and grasslands. Community elders are the custodians and enforce the law through penalties that vary with regularity of commission.

Cultural practices and spirituality has contributed to enhancement of biodiversity and ecosystem services in the arid and semi-arid area of Tharaka Kenya. The communities here are involved are reverting to traditional knowledge that includes bringing back indigenous seeds for food, trees, fruit-trees, etc. (Mburu *et al*., 2016). Thus far their efforts have resulted in re-establishment of food crops including millet (3 varieties), sorghum (5 varieties), yams, green grams (3 varieties), cow peas (5 varieties), pigeon peas, pumpkin, a traditional squash (manthanga). This has contributed to food security and increased resilience to climate change as dependent on rain agriculture. The community have also resumed the use of millet in traditional rituals in the sacred sites. This has led to a selection process that targets varieties with characteristics considered unique: i.e., early maturation, large seeds, good seed formation, structure of millet heads, ease of grinding (dhengerembe), agronomic responses to soil moisture (low or high).

While the value of biodiversity is more widely appreciated now than in the past, the pressure on wild lands and unique habitats are also rising rapidly due to encroaching human population and intensified resource extraction. Recent studies (Halmy *et al.*, 2015) has shown that increased sedentary lifestyle of the Bedouins has led to new land-uses such as irrigated agriculture, quarrying, and establishment of summer resorts for recreation and tourism; hence affecting sustainability of the coastal area resources (rangelands and salt marshes) in north-western Egypt (Halmy *et al.*, 2015). Above case studies, though not exhaustive, indicate how indigenous and local knowledge bases contribute to conservation of biodiversity, ecosystem services and livelihoods in Africa. However, future scenarios will need to take into cognisance the development agenda that will embrace urbanisation, extractives and infrastructure. These will impact on biodiversity and ecosystem services directly but also indirectly by affecting communities' cultures and inter-generational knowledge transfer. We also learn from the cases potential to create communities that are economically empowered, socially cohesive, and strong on environmental stewardship based on culture and spirituality.

Community-based conservation is now integrated in biodiversity conservation policies and practices in Africa. It takes various approaches: indigenous and community conserved areas, sacred spaces and communal areas. Indigenous peoples and community conserved territories and areas are spaces governed by them with evidently positive outcomes for the conservation of biological and cultural diversity (Roe *et al*., 2009). IUCN World Parks Congress of 2003 defined them as *"natural and/or modified ecosystems containing significant biodiversity values and ecological services, voluntarily conserved by (sedentary and mobile) indigenous and local communities, through customary laws or other effective means"* (UICN, 2009). Sacred spaces are areas that have spiritual relevance for communities, the zones in which the concept of sacredness is invoked to mark a distinction between the divine and the profane (Roe *et al.*, 2009). In many places, these are recognised as marking a distinction between spaces imbued with spirituality and the spaces of everyday life. They represent the symbolic connection between humanity and the forces that drive nature. Ghana has recognised the oldest community protected area in Africa, the Boabeng Fiema Monkey Sanctuary, created in 1975. Other examples of indigenous and community conserved areas are well known in Africa: the Wechiau hippo sanctuary in north-western Ghana officially recognised in 1999, the Urok Islands community protected marine area in Guinea Bissau recognised in 2005, the village hunting zone of Boumoana in eastern Burkina Faso, the sacred forests in the centre of Benin and the south-eastern of Togo, the villages hunting zones in Central African Republic and the zones of cynegetic interest in the south-eastern and north of Cameroon) (UICN, 2009). In these spaces, revival or modification of traditional practices and/or new initiatives succeed in protecting and restoring natural resources and cultural values of the communities. The communities management decisions and efforts lead to the conservation of habitats, species, genetic diversity, ecological functions/benefits and associated cultural values, even when the conscious objective of management is not conservation (for example, it may be livelihoods, security, safeguarding cultural and spiritual values). The community-based areas also meet social needs, such as maintaining local culture, increasing opportunities for income generation, and improving health and well-being.

The Communal Areas Management Program for Indigenous Resources, well known as CAMPFIRE, is a program developed largely around the concept of managing wildlife and wildlife habitat in the communal lands of Zimbabwe for the benefit of the people living in these areas. It was one of the first programs to consider wildlife as renewable natural resources, while addressing the allocation of its ownership to indigenous peoples in and around conservation protected areas (Frost *et al*., 2008). During 1989–2001, CAMPFIRE generated over $20 million of transfers to the participating communities, 89% of which came from sport hunting. The scale of benefits varied greatly across districts, wards and households. Twelve of the 37 districts with authority to market wildlife produced 97% of all CAMPFIRE revenues, reflecting the variability in wildlife resources and local institutional arrangements. The Program has been widely emulated in Southern and Eastern Africa. The impact on rural populations was important in terms of social infrastructures. Biodiversity benefits have been witnessed since CAMPFIRE's inception; elephant numbers increased, buffalo numbers are either stable or witnessing a slight decrease, and habitat loss diminished. Another example of community-based conservation can be drawn from Namibia, whereby some nature conservancies cover their operating costs with income derived from trophy hunting and from tourism (Naidoo *et al.*, 2016a). The two activities together provide the greatest incentives for conservation on communal lands in Namibia. A singular focus on either hunting or tourism would reduce the value of wildlife as a competitive land-use option and would have grave repercussions for the viability of community-based conservation efforts in Namibia, and possibly other parts of Africa (Naidoo *et al.*, 2016a).

Despite increasing recognition of community-based conservation initiatives in international conservation policies, there is still great neglect in terms of their effective and appropriate recognition in national policies and practices (Rwabiteta, 2002). When they have no legal recognition within a country, they may also not be recognised or respected by private entities and neighbouring communities. In such cases, they are vulnerable through land and water being appropriated or reallocated for an alternative use.

They may also suffer of changing value systems, increased pressure on natural resources and other internal tensions. They are exposed to both external and internal threats: imposed development and resource exploitation processes, such as mining and resource extraction, logging, tree plantation, industrial fishing, sea dredging, land conversion to large-scale grazing or agriculture, urbanisation and major infrastructure (roads, ports, airports, dams, tourism).

4.5 POSITIVE DRIVERS OF CHANGE

This section address measures taken to conserve and use biodiversity sustainably. It considers how positive drivers of change of biodiversity have positively contributed to nature's contributions to people and to good quality of life. There will be a particular focus on protected areas, multilateral agreements, sustainable land management and improved interventions on management of land degradation in Africa. These are measures taken to conserve and use biodiversity sustainably, with tangible benefits for both people and the environment. The section on land degradation and restoration will be kept to a minimum considering that there is a thematic assessment that is entirely focusing on this subject.

4.5.1 Protected areas as a driver of positive change

Protected areas make an important contribution not only to conservation of wild species, but also the ecosystems in which these wild species live (Cantú-Salazar *et al.*, 2010; Muhumuza *et al.*, 2013; Stolton *et al.*, 2015). Africa is one of the continents with of the last remnants of intact natural landscapes that have not been totally transformed by agriculture, human settlements or industrial development. Protected areas contribute to a broad range of socioeconomic and cultural values (ecosystem services or nature's contributions to people) than just conservation of biodiversity (Cantú-Salazar *et al.*, 2010).

In the past, the contributions made by protected areas were taken for granted and their values underestimated especially when they were considered as simple measures to protect particular species or habitats of interest. However, an ecosystem services approach to protected areas received a major boost in the early 2000s due to growing recognition of their socioeconomic value beyond biodiversity conservation (Costanza *et al.*, 1997; MA, 2005; Kettunen *et al.*, 2013). Thus, the conservation of biodiversity (species, genetic diversity within species and of habitats and ecosystems) is critical for ecosystem function and nature's contributions to people (Cardinale *et al.*, 2012).

The proportion of terrestrial and inland waters areas covered by Protected Areas in different regions of Africa are 19.1% in Central Africa, 14.8% in Eastern Africa, 5.8% in Northern Africa, 20.4% in Southern Africa, and 15.5% in Western Africa (Barnes, 2015). Thus only Central and Southern African regions have attained the Aichi Biodiversity Target 11 on terrestrial Protected Areas. Conversely, the continent has attained only 1.7% protection of the marine environment. Basing on area coverage alone as a measure of progress could result in establishment of large protected areas, which have little value and under little threat, neglecting areas where protection is most needed (Barnes, 2015).

The concept of protected areas that involves forceful removal of indigenous people from their land dates back to the establishment of the Yellowstone National Park in the United States of America in 1872. This model was unfortunately been replicated around the world. Even today, indigenous and local communities are often stereotyped as small-scale consumers undermining the important role they play in shaping our environments into eco-sociological landscapes. The last two decades have seen greater appreciation of the role of traditional knowledge and practices in preserving biodiversity, motivated by indigenous peoples desire to live in their ancestral lands and safeguard local food security (Langton *et al.*, 2005; Chibememe *et al.*, 2014). The subsistence role rather than productivity role of diverse indigenous economies including fishing, hunting, herding and agriculture provide positive benefits to the environment. The disenfranchisement of local communities from traditional governance and management role in relation to natural resources is now more and more opposed by international conventions and non-governmental organisations. Several international and national frameworks are now supporting the development of community-oriented protected areas. Through the Convention on Biological Diversity for example, nations are now making considerations in their National Biodiversity Strategy and Action Plans to strengthen indigenous and local community involvement *in situ* conservation.

Following the World Parks Congress of 2003 in Durban, the theme 'Benefits beyond Boundaries' gave impetus to the wildlife conservancy movement, particularly in sub-Saharan Africa (Bushell *et al.*, 2007). The wildlife conservancy was adopted as an effective model to involve local communities in the conservation of wildlife as well as a tool through which to share financial benefits of the same. The model has shown promise, notably in Namibia where cash proceeds from hunting is paid directly to conservancy committees for use in management (Weaver *et al.*, 2008). Other benefits accruing from this situation are improved attitude of local communities towards conservation practice, and increased involvement of locals in the safari hunting industry. The community conservancy model has also seen rapid expansion in East Africa, particularly in Northern Kenya driven by strong donor support and changes in wildlife conservation policy to include community participation. A major difference between this, and the southern African scenario is that the use of wildlife is non-consumptive, save for a few locations where shooting of various game birds is practiced. The primary purpose of the conservancies therefore, is to provide and maintain a tourism product. This fundamental basis has been the root of many challenges including loss of grazing rights due to creation of exclusive tourist zones, erratic income due to the fickle nature of the tourism industry, amongst other challenges. The most important challenge has been the introduction of a livelihood dependent on skills, contacts and other resources that local communities do not have or cannot access. The resultant discontent has occasionally manifested in violent resource competition and failure of tourism enterprises (Ogada, 2016). The cautionary lesson of these outcomes is that the sustainability of community conservancy model depends on its application, higher resolution to accommodate the socio-economic and cultural differences that occur across sub-Saharan Africa. Community-based protected areas have involved especially no-take zones for certain fisheries resources, managed entirely by communities. In East Africa, Beach Management Units are common around freshwater and marine resources for co-management and governance of fisheries resources. The success of any community-oriented protected area system depends on respect for the rights of access communities while at the same time ensuring wise and sustainable use (Kanyange *et al.*, 2014).

However, in cases of conflicting legislations in co-management of Protected Areas, governance dilemmas occur leading to habitat degradation and unsustainable harvest of ecosystem goods, for example in the Mount Marsabit National Park in Kenya (Roba *et al.*, 2004; Robinson, 2013). This policy approach has been severely criticised largely due to a) low added value for local communities, b) short-term vision, integrated projects of conservation and development that worsen conservation problems because they generate new inhabitants and therefore population pressure and overexploitation of resources, c) persistence of competition problems between hunting and, d) agriculture, ambiguous effects on incentives for conservation (Iritie, 2015). Although these areas are protected, many of them can go through periods of heavy poaching as described in section 4.2.2.2.3 on protected areas in terrestrial and inland waters.

4.5.1.1 Protected areas in terrestrial and inland waters

The distribution of a strong network of protected areas spreads across Africa (Wegmann *et al.*, 2014; **Figure 4.28**). Clear evidence of the role these have played in the conservation of biodiversity has been demonstrated. The rates of stocking of protected areas, especially with megaherbivores are a critical determinant of vegetation cover change within versus outside protected areas (Owen-Smith, 1988). In addition, contrasting land-use adjacent to protected areas causes fragmentation and loss of habitats. High vegetation cover loss has been recorded in some protected areas compared to their surroundings, thus requiring particular conservation attention as this makes connectivity among protected areas very difficult (Wegmann *et al.*, 2014; **Figure 4.27**).

Protected areas however have their limits. Western *et al.* (2009) found that census conducted on Kenya's wildlife populations showed declines in wildlife populations within protected area and adjacent reserves over a 30-year period. In some protected areas the declines were similar to non-protected areas (Western *et al.*, 2009). Losses were in part due to poor coverage of seasonal ungulate migrations. It is thus important to monitor and quantify impact of conservation policies and strategies on wildlife populations in particular and biodiversity in general (Western *et al.*, 2009; Lindsey *et al.*, 2014). Thus an integrated landscape approach to conservation planning is important in ensuring suitable habitats for wildlife is conserved in state, private and community-based conservation measures. It is also important to note that many African protected areas are not functioning as effectively as originally intended, in part due to limited resources to maintain these areas as strictly protected and/or to enforce relevant legal frameworks (Lindsey *et al.*, 2014). According to Lindsey *et al.* (2014), other reasons include: a) rapidly expanding human populations, poverty and open-access systems resulting in widespread bushmeat poaching and habitat encroachment; b) underfunding of responsible conservation agencies resulting in inadequate law enforcement; c) reliance of the same agencies on extracting revenues from concessionaries who manage operations within protected areas; d) poor efforts in access and benefit sharing with communities; amongst others. The combined effect of these challenges has been a major reduction in wildlife densities in many protected areas (Craigie *et al.*, 2010) and related poaching and illegal trade in wildlife products (Ingram *et al.*, 2017). A major knowledge gap in this arena, which needs to be addressed is the impact of sport hunting on the populations of various species of megafauna in Africa. The current assumption of nil effect is scientifically untenable.

The Convention on Biological Diversity's Aichi Biodiversity Target 11, on protected areas, includes aspirations of reaching 17% protected area coverage of the world's terrestrial and inland waters and 10% of coastal and marine areas, by 2020 (Ervin *et al.*, 2010). By 2016, estimates of the chances of meeting these goals by the deadline, showed that terrestrial and inland waters is likely to be achieved

Figure 4 27 **Africa's Protected Area Connectedness Index (PARC-connectivity) in 2012. Source: GEO BON-CSIRO, The figure prepared by Task Group on Indicators and Knowledge and Data Technical Support Unit).**

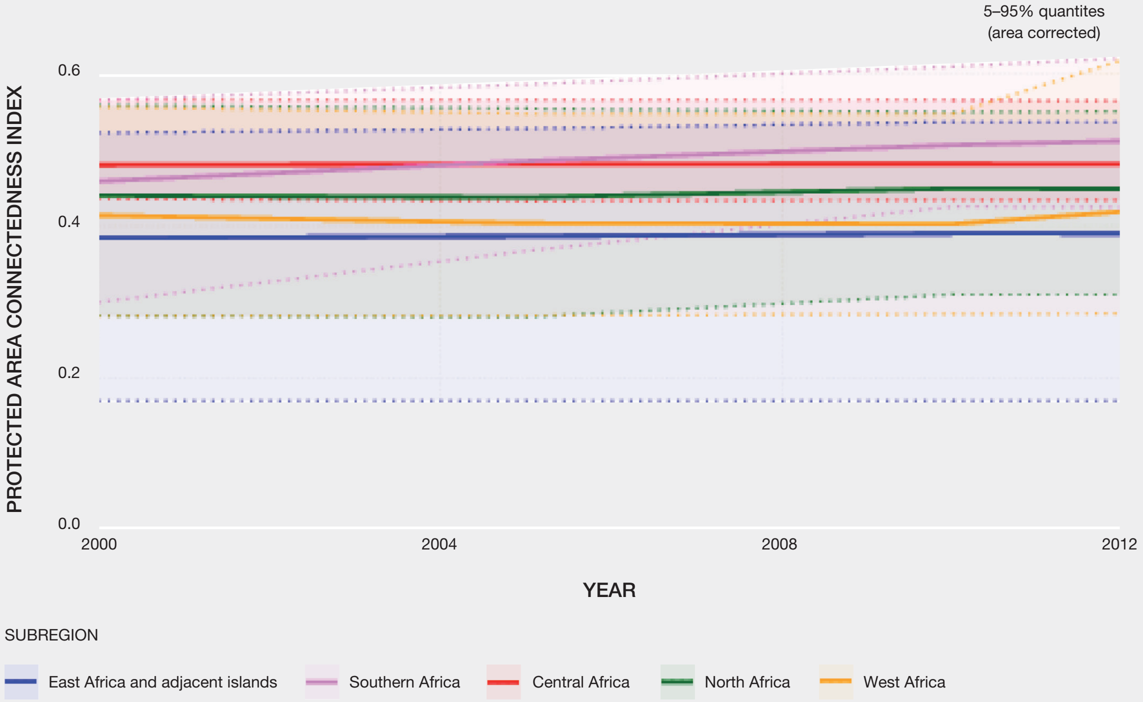
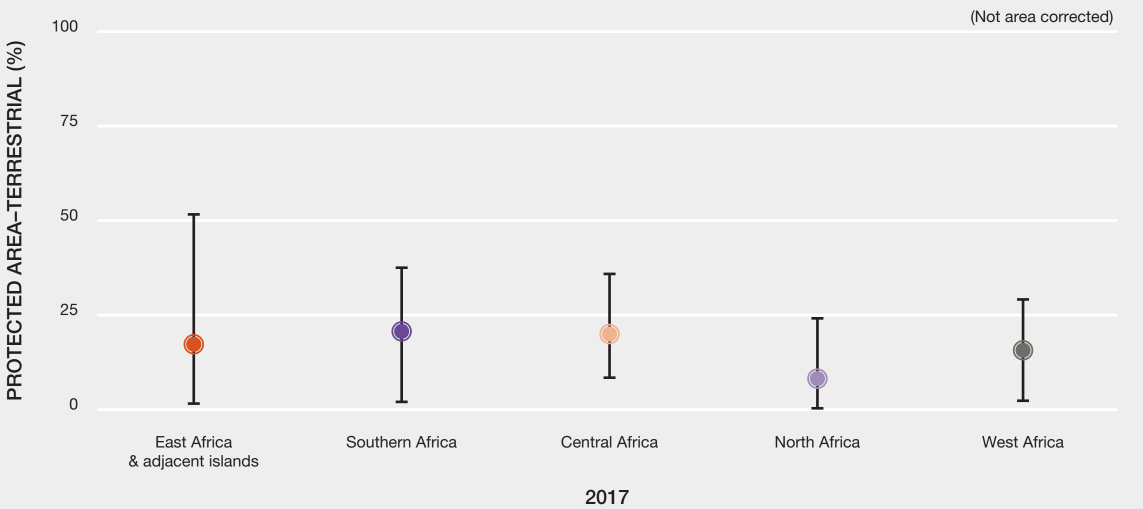


Figure 4 28 **Subregional status of terrestrial protected area coverage in Africa, 2017.**

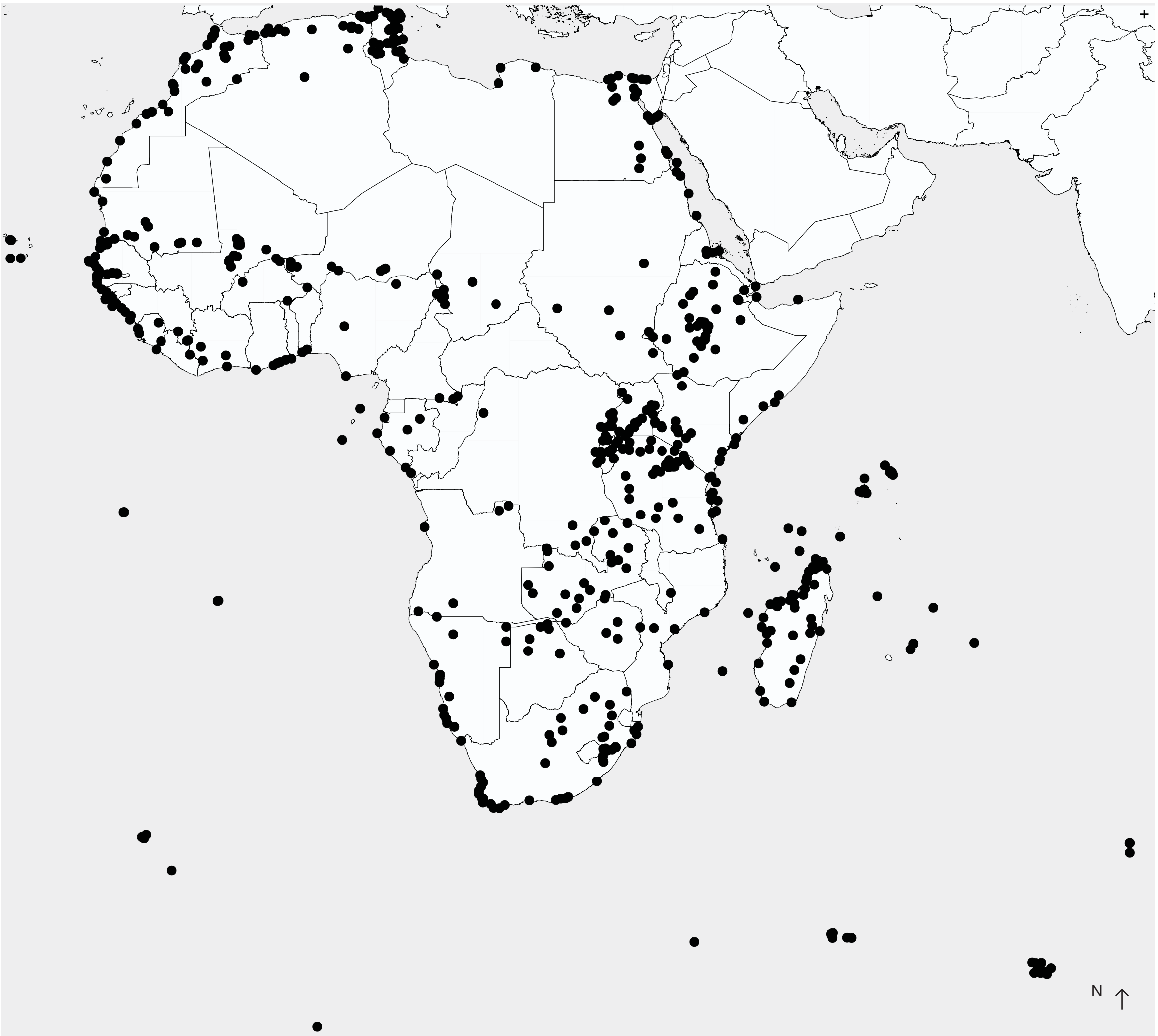
Note: circles represent mean and bars represent confidence intervals. Source: UNEP-WCMC *et al.* (2017). Figure prepared by the IPBES Task Group on Indicators and Knowledge and Data Technical Support Unit.



in advance, and has exceeded projection for coastal and marine protected areas within national jurisdiction (UNEP-WCMC, 2016). The African continent as a whole is on track to achieving this goal with the current 15.4% coverage. Two out of five subregions, namely Eastern Africa (20%) and Southern Africa (20.8%), have exceeded the 17% target **(Figure 4.28)**, while Central Africa at 16.6% is close to achieving this. Even though Northern Africa has less than 10% at the moment, if priority actions proposed in Morocco for 20 new protected areas and 30 Ramsar sites, will enable

Box 4 11 **Important Bird Areas and Wetlands of International Importance. Source: BirdLife International (2002).**

In Africa, over 1,250 sites have been identified as Important Bird Areas (IBAs) (see figure below), these are locations where networks have been formed for conservation of birds, other biodiversity and wider ecosystems and their services. IBAs have in many countries formed the basis of designation of wetlands of international importance, under the Ramsar convention. This is due to the recognition that the presence of significant numbers of waterbirds in a wetland is often an indicator of the importance of the site for many other features as well, including values and functions of great relevance for people (BirdLife International, 2002).



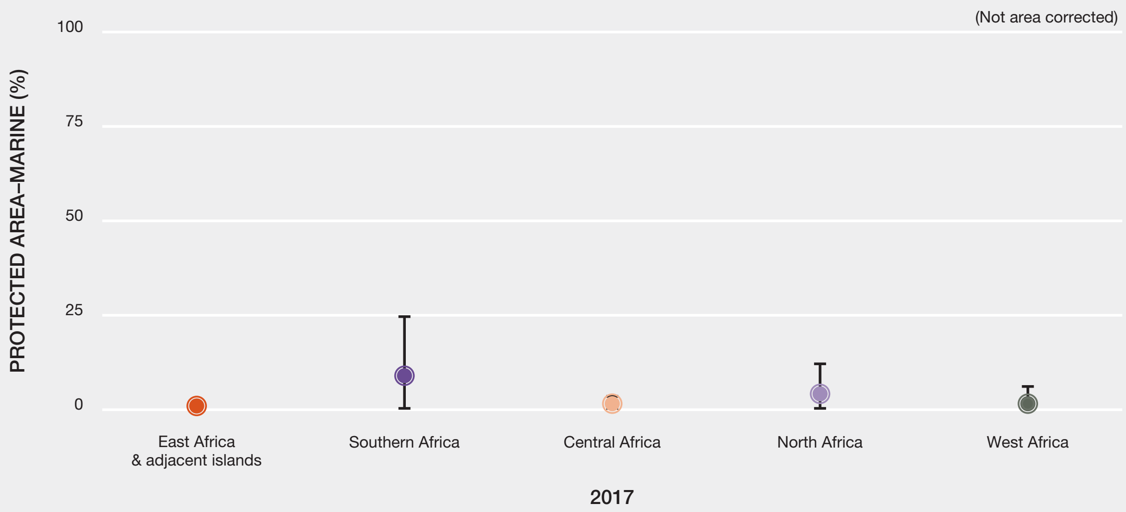
the subregion to remain on track. There are commitments to other conventions such as Ramsar showing a distribution of important bird areas and wetlands of international importance **(Box 4.4)** and the African Eurasian Waterbird Agreement between parties to the Convention for Migratory Species. The coverage of area by protected areas has been suggested to be a poor measure of progress, as also recognised by Aichi Target 11 (Barnes, 2015), and a more holistic approach of Key Biodiversity Areas has been proposed (Brooks *et al.*, 2016).

4.5.1.2 Coastal and Marine protected areas

Africa's Marine Protected Area (MPA) coverage is relatively low compared to Western European and Others Group where larger MPA networks exist. At subregional level Northern Africa has the largest coverage (9.1%), followed by Central, Southern, Western and Eastern Africa. At national level, DRC, Namibia and Mauritania, South Africa has the most area protected **(Figure 4.29)**.

Figure 4 29 **Subregional status of marine protected areas in Africa, 2017.**

Note: circles represent mean and bars represent confidence intervals. Source: UNEP-WCMC *et al.* (2017). Figure prepared by the IPBES Task Group on Indicators and Knowledge and Data Technical Support Unit.



4.5.2 Multilateral Environmental Agreements

The major environmental concerns or issues in Africa include: climate change, land, freshwater, oceans and seas and biodiversity (UNEP, 1997; UNEP, 2012). These concerns have to a large extent guided the continent's engagement with Multilateral Environment Agreements (MEAs), whereby the ratification of an MEA often reflects the importance that individual countries place on the issues it address. United Nations Convention to Combat Desertification, for example, is one of the most important environmental MEA processes for Africa. The special emphasis on the situation in Africa in the convention text has resulted in its receiving a high degree of political commitment and extensive support; in fact all African states are parties to the convention.

The United Nations Framework Convention on Climate Change (UNFCCC) is also of high priority in Africa. The Paris Agreement on climate change adopted in December 2015 further reinforced global commitments for the environment. UNFCCC parties agreed to hold the rise in average temperature to well below 2°C above pre-industrial levels – and to try to limit it to 1.5°C – while embracing the target of zero net emissions of greenhouse gases in the second half of this century. Nineteen nations have endorsed the Africa Clean Energy Corridor, which could increase the development of renewable energy projects from their present 12% of the East and Southern Africa Power Pool to at least 40% by 2030. The Convention on Biological Diversity has led to the formulation of biodiversity plans and strategies, especially in countries where the depletion of tropical rain forests and the rapid disappearance of biodiversity has attracted national and international attention. Convention on International Trade in Endangered Species of Wild Fauna and Flora closely related to the Convention on Biological Diversity, has seen the development of national programs in much of Africa to help in the sustainable utilization and trade in wildlife (UNEP, 1997).

The Ramsar Convention on wetlands of international importance has 28 contracting parties in Africa.
The Convention requires that parties designate at least one national wetland for inclusion in the List of Wetlands of International Importance. The floodplains of the Zambezi River and the Okavango Delta are among Southern Africa's major wetlands, providing a wide range of functions such as water and nutrient retention and flood control. They are also important for tourism. Other notable sites include the coral reefs of Tongaland and the St Lucia System (South Africa); the Kafue Flats and Bangweulu Swamps (Zambia); and in East Africa, the Lake George ecosystem in western Uganda and Lake Nakuru in Kenya (UNEP, 1997).

4.5.2.1 African Union Agenda 2063

In May 2013, African leaders met in Addis Ababa, Ethiopia to celebrate milestones and make development commitments for the next 50 years, producing the Agenda 2063. This agenda is a strategic framework for the socio-economic transformation of the continent building on existing growth and development initiatives. The Agenda aims at ensuring Africa remains focused and on track in its socio-economic development ideas within a rapidly changing world. These ideas are summarised under seven aspirations themed, the "Africa We Want". The adoption of the 2030 Agenda for Sustainable Development and its associated Sustainable Development Goals, two and a half years later (in January 2016), ushered in a new era of global partnerships for sustainable development. This new development was perceived by Africa as an opportunity to consolidate its priorities and concerns. The Agenda 2030 is indeed reflective of the aspirations of Agenda 2063. In the environment pillar of sustainable development, for instance, goal seven of Agenda 2063, which focuses on environmentally sustainable and climate resilient economies and communities, is aligned with the implementation of several Sustainable Development Goals on biodiversity, forests, oceans, and climate action among others (AU, 2015).

4.5.3 Sustainable land management

Sustainable land management (SLM) is defined as a knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fibre demands while sustaining ecosystem services and livelihoods. Sustainable land management is seen as the response mechanism to counter degradation of biodiversity and the provisioning of environmental services. It should be viewed as the driver of enhanced biodiversity in ecosystem service flows and is necessary to meet the requirements of a growing population. Improper land management can lead to land degradation and a significant reduction in the productive and service (biodiversity niches, hydrology, carbon sequestration) functions of watersheds and landscapes. (World Bank, 2008). In effect Sustainable land management is a positive driver to prevent or reverse degradation and to ensure communities can continue to reap sustainable flows of ecosystem services from the land. According to the World Bank (2008), SLM should:

- Foster an enabling environment for broad-based and sustainable rural growth;
- Promote agricultural productivity and competitiveness;
- Encourage nonfarm economic growth;
- Improve social well-being, manage and mitigate risk, and reduce vulnerability; and,
- Enhance sustainability of natural resource management.

Sustainable land management can and should be operating at a number of different spatial scales ranging from individual agricultural fields to entire catchments or countries. As such it is applicable to dryland crop agriculture, irrigation, and rangeland and forest management. The tools and methods used as well as the actors involved will change between scales, though in all cases the actual land-users would be key roll-players, with or without support from external agencies. There is a growing interest in using landscape level approaches that consider planning at a landscape of catchment level and that integrate across a number of land-use activities (e.g., cropping, animal husbandry, rangeland management, forestry and water management). Ensuring optimal trade-offs between different land-uses (often referred to as the land-use nexus) is also important and would consider aspects such as maintaining biodiversity, food, fibre fodder and fuel provision.

The United Nations Conference on Sustainable Development (Rio+20) adopted the document "the future we want", which recognised in paragraph 206 *the need for urgent* action to reverse land degradation. In view of this we will strive to achieve a land-degradation neutral world …" (UNCCD, 2012). In response the UNCCD has set an ambitious target for zero net land degradation by 2030 (UNCCD, 2012). Signatories to the convention would be expected to aim for this target. This would be achieved by either reducing degradation before it occurs or by reclaiming already degraded land. In essence zero net land degradation means that rates of restoration need to equal or exceed rates of land degradation. Defining and measuring net zero degradation is, however, contentious (Kaphengst, 2014; Stavi *et al*., 2014; Chasek *et al.*, 2015). Monitoring the degradation status of land, particularly at the global level, remains a key challenge (Cherlet, 2012). Operational aspects of implementing programmes to halt degradation, or restore degraded land, are also challenging and require political will as well as financial and technical resources(Stavi *et al*., 2014; Chasek *et al.*, 2015).

The World Overview of Conservation Approaches and Technologies (Liniger *et al*., 2007) is a global initiative that collects and documents information on sustainable land management practices so that these can be easily shared. A number of additional resources are available in support of sustainable land management including from the World Bank and TerraAfrica (Liniger *et al.*, 2011). The TerraAfrica program of the Global Environmental Facility was the major Global Environmental Facility funding stream in support of Sustainable land management in Africa.

Africa, as the least developed continent, has a huge need to achieve economic development. This places a tension between development and environmental issues. It is inevitable that large amounts of large-scale land transformation are going to take place. The objective of Sustainable land management is to ensure that the exploitation of natural resources is done in such a way as to sustainably achieve both objectives. Many Sustainable land management practices can simultaneously enhance crop and livestock yields whilst reducing the level of degradation. This would be through practices such as rainwater harvesting, conservation agriculture, small-scale irrigation management, integrated soil fertility management and agroforestry (to name but a few) (Liniger *et al.*, 2011).

4.6 CONCLUSION

Habitat conversion and loss pose a considerable ecological problem in Africa. Conversion of forest and rangelands for agriculture, mining and urban development has led to habitat loss, degradation of catchment areas and soil erosion leading to loss of biodiversity and livelihoods. The fragmentation that results from various land-uses contributes to biodiversity loss because many wildlife species are migratory and conservation areas do not provide sufficient habitat. This is leading to loss of biodiversity, especially of vulnerable species with narrow ecological niches, as natural habitat is partially or completely lost. Overharvesting of wild species despite their endemism and conservation status represents a serious threat to Nature's Contributions to People in Africa. Global markets and demand for wildlife products have severely challenged national policies because of the prevailing poverty, illicit trade and the high value of these products in the global markets. Illicit trade in wildlife is linked with international criminal gangs and terrorist organisations.

The spread of invasive alien species in terrestrial and aquatic ecosystems is rapidly increasing in Africa with impacts on native species, rural production and livelihoods. Invasive alien species have become a major ecological, social and economic problem despite the existence of legal measures and substantial funding to control them. The magnitude of the problem varies from ecosystem to ecosystem, and from country to country. Increased mobility and human interaction have been key drivers in the spread of invasive alien species. Pollution also contributes to loss of nature's contributions to people in Africa especially in freshwater ecosystems. Population growth is associated with an increased use of a large number of chemicals and pollutants including prohibited Persistent Organic Pollutants such as DDT under intensive crop production systems. Most of these agrochemicals find their way into water bodies, air and soil, causing unacceptable loss of pollinators, and freshwater flora and fauna including soil enriching microbes.

Africa is warming faster than the global average and it is likely to warm by an average of 1.5° to 3°C this century. There is likelihood of profound impacts on species distribution within the terrestrial environment, partial loss of the vast African savanna with its iconic fauna and flora, and collapse of coral systems. Climate change will impact human health by increasing range and seasonal duration of malaria, neglected tropical diseases, and incidences of zoonotic transmission of communicable diseases, for example, Ebola. It is also a cause of emerging infectious diseases for livestock and wildlife such as the rift valley fever, Anthrax and Canine Distemper; and for plants. Projections based on a continuation of current policies and practices indicate that climate change is expanding the habitat ranges of several these disease vectors. Fire consumes significant amounts of biomass across Africa every year and plays a positive role in shaping the structure and composition of various fire driven ecosystems. Fire suppression has negative effects on biodiversity in such ecosystems. Fire, coupled with browsing, can be used as a tool to suppress increases in woody plant encroachment. Protected areas make an important contribution to conservation of wild species and Nature's Contributions to People in Africa. In Southern Africa, the main drivers of development are shifting from extractive industries such as mining and exploitation of natural resources to sustainable ecotourism, resulting in improved land-use management due to a prevailing conservation ethic and associated economic benefits. Agreements for transboundary natural resource management such as with parks and water management (dam construction for cross-boundary water and energy supply) and others may also a result from this shift, e.g., Transfrontier Parks.

Urban migration is leading to increased demand for services and infrastructure development with communities requiring improved water supply, pollution control and waste management as well as energy supply for households and for industrial development. Demand for food, water and energy in urban areas has increased with urbanisation. The economic dynamics, social links and environmental synergies occurring across the urban-rural continuum underpins their interdependencies; with the flows and functions being asserted through access to food, ecosystem services, social services, transport, employment and markets. Urban communities are producing large quantities of solid and other wastes that are leading to environmental pollution. Africa's development trajectories are leading to improvement in quality of life, driven by growing investment in infrastructure development and expansion of modern urban human settlements, sanitation and energy supply. However, this is also putting enormous pressure on nature and nature's contributions to people. Higher economic growth among many African countries (>5% per annum) and growth in per capita income is driving demand for goods and services provided by nature. At national level, there are major investments in large investments in big infrastructure ports, roads, rails, telecommunications, high voltage electric power transmission lines, water distribution and sanitation, and planned petroleum pipelines across the region. The development of infrastructure puts enormous pressure on nature as land is cleared and resources are overutilized.

Changes in land ownership and an increase in land acquisition (land grabs) to meet local, national and global food and renewable energy demand are driving changes in nature and nature's contributions to people. Land ownership is shifting from small-holder farmers to large-scale commercial farming and land-use (or the focus of production systems) is shifting from subsistence agriculture to supply a growing international biofuels industry, influenced by policies in rich nations. This is contributing to land conversion as critical ecosystems including wetlands, rangelands and forests are being converted into agricultural land for food or energy markets. There are also trade-offs in the use of land for the production and supply of food, water, energy and other land-uses such as mining and development of human settlements (food, water, energy nexus). Sustainable development thrives best in an environment of good governance, peace and security whereas armed conflict has substantial costs in human and material terms, hinders production, damages infrastructure, prevents the reliable delivery of social services to communities. Organised criminal networks carry out environmental crimes (poaching, illegal wildlife trade, illegal trade of timber and non-timber forest products) across borders and affect national economies, security and threaten sovereignty of some countries. Environmental crimes undermine the livelihoods of natural resource dependent communities, damage the health of the ecosystems they depend on, and restrict potential investment in development of affected areas. Terrorist and rebel groups participate in environmental crimes in order to fund their illegal activities. The insecurity that results from their illegal activities leads to localized biodiversity loss, especially diversity of wild fauna and, undermines Africa's conservation legacy and livelihoods of resource-dependent communities.

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