The regional assessment report on BIODIVERSITY AND ECOSYSTEM SERVICES **FOR AFRICA**

THE IPBES REGIONAL ASSESSMENT REPORT ON BIODIVERSITY AND ECOSYSTEM SERVICES FOR AFRICA

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CHAPTER **2**

NATURE'S CONTRIBUTIONS TO PEOPLE AND QUALITY OF LIFE

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CHAPTER 2

NATURE'S CONTRIBUTIONS TO PEOPLE AND QUALITY OF LIFE

EXECUTIVE SUMMARY

Africa's natural assets and associated contributions to people are underutilised in some areas, but are generally in decline due to a range of natural and human activities *(well established).* Use and distribution of water resources are uneven among both water-scarce and water-rich regions, countries and communities, and remains, in certain areas, a source of conflict. Africa has abundant and diversified energy sources, including oil and gas and clean energy; but access remains uneven. Renewable energies could provide economically and environmentally attractive alternatives for many countries, while realisation of hydropower potential has remained limited. Despite the presence of a significant portion of the world's arable uncultivated lands, both food production and access experience patterns of constraint in certain areas. Furthermore, little value is added to agriculture, forest, agroforest, livestock and fishery products through industrialisation and processing {2.4.1, 2.4.2}.

Africa's waters are known for the abundance of their fishery resources, with the six Large Marine Ecosystems (LMEs) ranking within the first four most productive LMEs in the world *(inconclusive).* The fisheries of Africa provide a source of livelihood for 8 million active fishers and their families. If all catches were landed in Africa, African fisheries could contribute a landed value of $20 billion to national economies, with an additional 3.6 billion injected by the small-scale fishing sectors across the value chain. Despite regional differences, current trends in fisheries catch data from LMEs in Africa reaffirm a need for equitable and sustainable use. Overall catches increased from 2.1 million tons in 1950 to 16.7 million tons in 1988 and then decreased to 12.4 million tons in 2010. The artisanal sector, whose landed value reached $4 billion in 2010, is in decline since 2004 along with the industrial sector's catch, despite an increasing fishing effort {1.3.4.1.2, 1.3.4.1.3, 2.2.1}.

Non-Timber Forest Products (NTFPs) contribute significantly to maintain livelihoods of rural communities in Africa *(well-established).* There is a growing evidence that NTFPs are essential income source in the total household economy in African rural communities in Africa. For example, wild and plants fruit trees on common land make up to 15%, 10% and 27 of total income (subsistence and cash income) in Malawi, DRC, and Ethiopia respectively. Due to growing demand for conversion of land for cultivation purposes, growing populations in certain areas, the availability of NTFPs is threatened {2.2.1.2}.

Woodfuel plays an important role in energy provision in Africa (in particular sub-Saharan Africa) and serves as a critical resource for physical and socio-economic development in both rural and urban communities, a trend that is likely to continue *(well-established)*. Woodfuels account for >80% of primary energy supply in sub-Saharan Africa, where >90% of the population rely on firewood and charcoal for energy, especially for cooking. The demand for charcoal is growing and is expected to increase further, with likely negative effects on health, socio-economic activities and environmental health under business-as-usual scenarios. Despite woodfuel values and increase in demand, the topic tends to be under-represented in policy, with emphasis instead on the need to gaining access to 'modern energy' sources such as electricity and kerosene. Africa sees a clear need to promote and guarantee renewable energy security, availability, and reliability for human comfort {1.3.4, 2.2.1.2}.

Africa has a significant amount of undocumented indigenous local knowledge that would enhance our understanding of biodiversity and ecosystem services status and trends *(inconclusive).* Indigenous local knowledge of the status and trends of biodiversity may be particularly critical in Africa, due to the relative dearth of scientific biodiversity studies relative to other regions (Chapter 3). Indigenous and local knowledge is critical to the management and sustainable use of biodiversity and ecosystem services in Africa because of the strong but poorly understood links between biodiversity, ecosystem services, spirituality, culture, and identity. Africa's high cultural diversity with a multitude of unique ethnicities and social groups shows specificity with regards to resource use and management of selected material and non-material nature's contributions. This diversity also results in different perception of nature and interaction with natural ecosystems, thus building unique indigenous and local knowledge for the various countries and localities in the continent over millions of years of interaction between indigenous and local people and nature {2.2.3.3, 4.4.7}.

2.1 INTRODUCTION

The Millennium Ecosystem Assessment (MA) contextualized, in 2003, the linkages between nature and human well-being with the concept of Ecosystem Services (Beaumont *et al.*, 2007; Balvanera *et al.*, 2006; Akachuku, 2008; Nelson *et al.*, 2009). More recently, in 2015, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) conceptualised nature's benefits (ecosystem goods and services) to people, their contribution to good quality of life, including the drivers of change and the impacts they have on human well-being as the nature's contributions to people, arranged into three main categories **(Table 2.1; Figure 2.1)**: material contributions, non-material contributions and regulating contributions (Díaz *et al.*, 2015). Since the adoption of the 2011–2020 Strategic Plan for Biodiversity, the focus has been as to how to mainstream the concept of natural assets and ecosystem services into policies and decision-making processes. As indicated in Chapter 1, integrating ecosystem services into policy is critical for the African continent, as ecosystem services have not yet been regarded as a crucial element of the human systems.

Chapter 2 reflects on the IPBES conceptual framework boxes "Nature's contributions to people" and "Good quality of life", as well as the valuation of NCP and ecosystem services values when available. The chapter reflects Goal D of the Strategic Plan for Biodiversity, which is to enhance the benefits to all from biodiversity and ecosystem services. It further addresses issues related to the Aichi Biodiversity Targets, the Sustainable Development Goals (SDGs) and the Intergovernmental Platform for Climate Change (IPCC). It assesses the values and status of nature's contributions to people, including the interrelationship between biodiversity; ecosystem functions and society; the geographical differences between production and use of ecosystem services; and trends and future dynamics of ecosystem goods and services.

Overall, NCPs are particularly important in Africa since a large proportion of the population live in rural areas, and rely quasi-exclusively on material ecosystem services for their livelihoods and, to a significant extent, for their health. Nevertheless, quantity and quality of NCPs tend to decrease due to the overuse of resources, degradation of natural habitats and biodiversity, the increase of all kinds of pollution alongside with the current and future changes incurred by climate change (Chapters 1, 3, & 4). Valuation of ecosystem services is recent in Africa and limited to the provisioning services for food (fish), raw material (wood), medicinal uses (plants, etc.) and regulating ones (water). In this regard, limited monetary values have been produced for a limited number of services. Valuation of NCP has proven to be a useful method to define baselines as well as indicating changes in food, energy, livelihood and health security; and their linkages to biodiversity and ecosystem functions and services that are also critical to social relationships, spirituality and cultural identity.

The objective of this chapter is to present an assessment, at the scale of Africa, of two components of the IPBES conceptual framework: NCP in terms of goods and services and to a good quality of life. The Assessment focuses on NCP in the Africa continent in terms of their geographical differences, their values, status, trends and future dynamics, as well as their impact on human well-being. The approach is based on geographical setting according to the five subregions of Africa (North, South, West, East, and Central), and different units of analysis: tropical and subtropical dry and humid forests; Mediterranean forests, woodlands and shrubs; tundra and high mountain habitats; tropical and subtropical savannas and grasslands; dry lands and desserts; wetlands (peat lands, mires and bogs); urban and semi urban areas; cultivated areas; freshwater (brackish and marine); Inland surface waters and freshwater bodies; shelf ecosystems (neritic and intertidal/littoral zone); open ocean pelagic systems as well as deep sea and coastal areas. The review focuses on NCP in terms of their production and contribution, their use and non-use values by means of different valuation methodologies (biophysical, social, cultural, and economic); their impact on human well-being in relation to basic material for good life, health, livelihood security and on freedom. It further highlights status and trends of some of the continent`s representative NCP. Approaches pertaining to future dynamics of NCP involve reviewing some of the key projects that are undertaken in the region related to reforestation/afforestation; avoided deforestation; sustainable forest management; agroforestry and energy efficiency, amongst others.

The chapter is structured into 4 sections. In the first section, values and valuation of NCP for material and regulating contributions are presented. In the second section, the geographical differences in production and contribution of ES are reported, while in the following section, the status, trend and future dynamics of NCP are described. In the fourth section, the impacts of NCP changes on human well-being are introduced. The conclusion recalls the main elements of the Assessment review.

Figure 2 1 Examples of nature's contributions to people:

(A) Nature's material contributions: More than 400 million Africans rely on fish as a source of animal protein, and several hundred million people depend on fish as their main source of income. Better processing and marketing technologies can slash post-harvest losses by more than half, generating $350 million and ensuring that 350,000 tons of additional fish will reach the poor. The continent is projected to need an additional 1.6 million tons of fish a year by 2030 just to maintain current consumption. This demand will increase by a further 2.6 million tons a year by 2050.

(B) Nature's non-material contributions: Both land- and seascapes provide important areas for recreation, relaxation, healing, nature-based tourism and aesthetic enjoyment, religious and spiritual fulfilment, cognitive development, as well as the promotion of social cohesion and a sense of identity. Tourism is well developed and an important source of income in the northern, southern, and eastern parts of Africa, as well as the oceanic Islands. Many sites in Africa have been classified as protected or heritage sites for their non-material contributions. Many forest locations have been earmarked as sacred sites. In Tanzania, for example, more than 600 sacred groves exist in the North Pare Mountains.

(C) Regulating contributions: These contributions from nature are increasingly being appreciated and valued higher in national accounting systems. Highly valued services are mainly linked to agricultural production, including climate, air and water regulation, disease and pest control, and pollination. Other services include nesting, feeding and mating sites for birds and mammals, such as the Key Biodiversity Areas. Key Biodiversity Areas are more and more integrated in national protected systems (Figure SPM 7).

A) MATERIAL–COMMERCIAL VS LOCAL PROCESSING

B) NON MATERIAL–TOURISM

C) REGULATING–MANGROVES/WETLANDS/LAKES

Photos credits: Pierre Failler

Table 2 1 **The 18 categories of nature's contributions to people used in IPBES assessments with regional case studies of relevant key references that refer to these categories.**

Regulating contributions–Functional and structural aspects of organisms and ecosystems that modify environmental conditions experienced by people, and/or sustain and/or regulate the generation of material and non-material benefits. In many cases, these NCP are not experienced directly, for example, many people directly enjoy useful, beautiful or otherwise meaningful plants, soil organisms that are essential for the supply of nutrients that underpin growth and long-term survival of such plant species. Sometimes regulating contributions impact people's quality of life directly; for example, avalanches have a direct negative effect on people who live in avalanche-prone areas, and therefore their prevention or favouring by different kinds of vegetation directly affect people's quality of life.

CATEGORIES OF NCP	A BRIEF EXPLANATION AND SOME EXAMPLES	VALUES TYPE	STUDY REGION	SOURCE
Habitat creation and maintenance	The formation and continued production, by ecosystems or organisms within them, of ecological conditions necessary or favourable for organisms important to humans (e.g., nesting, feeding, and mating sites for birds and mammals, resting and overwintering areas for migratory mammals, birds, and butterflies, nurseries for juvenile stages of fish)	Instrumental	East Africa and adjacent islands and Southern Africa	Reynolds *et al.*, 2011; Wangai, *et al.*, 2017
Pollination and dispersal of seeds and other propagules	Facilitation by animals of movement of pollen among flowers, and dispersal of seeds, larvae or spores of organisms important to humans	Instrumental	Africa	Gemmill-Herren, 2014

Table 2 1

CATEGORIES OF NCP	A BRIEF EXPLANATION AND SOME EXAMPLES	VALUES TYPE	STUDY REGION	SOURCE
Regulation of air quality	Regulation (by impediment or facilitation) by ecosystems, of CO_2/O_2 balance, O_3 for Ultraviolet-B absorption, levels of sulphur oxide, nitrogen oxides, volatile organic compounds, particulates, and aerosols	Instrumental	Africa	Chianu *et al.*, 2011
	Filtration, fixation, degradation or storage of pollutants that directly affect human health or infrastructure			
Regulation of climate: Climate regulation by ecosystems (including regulation of global warming)	Positive or negative effects on emissions of greenhouse gases (e.g., biological carbon storage and sequestration; methane emissions from wetlands)	Instrumental	Mauritius	Munang *et al.*, 2013; Mbow *et al.*, 2014
	Positive or negative effects on biophysical feedbacks from vegetation cover to atmosphere, such as those involving albedo, surface roughness, long-wave radiation, evapotranspiration (including moisture-recycling)			
	Direct and indirect processes involving biogenic volatile organic compounds			
	Regulation of aerosols and aerosol precursors			
Regulation of ocean acidification	Regulating, by photosynthetic organisms (on land or in water), of atmospheric CO_2 concentrations and so seawater pH, which affects associated calcification processes by many marine organisms important to humans (such as corals)	Instrumental	Mauritius, Africa	Lloyd *et al.*, 2012
Regulation of freshwater quantity, flow, and timing	Regulation by ecosystems, of the quantity, location, and timing of the flow of surface and groundwater used for drinking, irrigation, transport, hydropower	Instrumental	Africa	Lévêque, 1997
	Regulation of flow to water-dependent natural habitats that in turn positively or negatively affect people downstream, including via flooding (wetlands including ponds, rivers, lakes, swamps)			
	Modifying groundwater levels, which can ameliorate dryland salinization in unirrigated landscapes			
Regulation of freshwater and coastal water quality	Regulation– through filtration of particles, pathogens, excess nutrients, and other chemicals–by ecosystems or particular organisms, of the quality of water used directly (e.g., drinking) or indirectly (e.g., aquatic foods, irrigated food and fibre crops, freshwater and coastal habitats of heritage value)	Instrumental	Kenya, Comoros Island, and Tanzania	Comte *et al.*, 2016
	Role of mangroves and seagrasses in this regulation process show in West Africa			
Formation, protection, and decontamination of soils and sediments	Sediment retention and erosion control, soil formation and maintenance of soil structure and processes (e.g., such as decomposition and nutrient cycling) that underlie the continued fertility of soils important to humans. Filtration, fixation, degradation or storage of chemical and biological pollutants (pathogens, toxics, excess nutrients) in soils and sediments that are important to humans	Instrumental	Africa	Symeonakis *et al.*, 2010
Regulation of hazards and extreme events	Amelioration, by ecosystems, of the impacts on humans or their infrastructure caused by e.g., floods, wind, storms, hurricanes, seawater intrusion, tidal waves, heat waves, tsunamis, high noise levels	Instrumental	Africa	Tall *et al.*, 2013
	Reduction, by ecosystems of hazards like landslides, avalanches			
Regulation of organisms detrimental to humans	Regulation, by ecosystems or organisms, of pests, pathogens, predators, competitors, etc. that affect humans, plants, and animals	Instrumental and intrinsic	Africa	Grzywacz *et al.*, 2014
	Regulation by predators or parasites of the population size of non-harmful important animals (e.g., large herbivore populations by wolves or lions)			
	Regulation (by impediment or facilitation) of the abundance or distribution of potentially harmful organisms (e.g., venomous, toxic, allergenic, predators, parasites, competitors, disease vectors, and reservoirs) over the landscape or seascape			
	Removal of animal carcasses and human corpses by scavengers (e.g., vultures in Zoroastrian and some Tibetan Buddhist traditions)			
	Regulation (by impediment or facilitation) of biological impairment and degradation of infrastructure (e.g., damage by pigeons, bats, termites, strangling figs to buildings)			

Table 2 1

Material contributions–Substances, objects or other material elements from nature that sustain people's physical existence and infrastructure. (The basic physical and organisational structures and facilities (e.g., buildings, roads, power supplies) needed for the operation of a society or enterprise). They are typically consumable, for example when organisms are transformed in food, energy, or materials for shelter or for some ornamental purposes.

CATEGORIES OF NCP	A BRIEF EXPLANATION AND SOME EXAMPLES	VALUES TYPE	STUDY REGION	SOURCE
Energy	Production of biomass-based fuels, such as biofuel crops, animal waste, fuelwood, agricultural residue pellets	Instrumental	Mozambique	Batidzirai *et al.*, 2006; Wicke, *et al.*, 2011
Food and feed	Production of biomass-based fuels, such as biofuel crops, animal waste, fuelwood, agricultural residue pellets	Instrumental	Africa	IRENA, 2017
Materials and assistance	Production of materials derived from organisms in crops or wild ecosystems, for construction, clothing, printing, ornamental purposes (e.g., wood, fibres, waxes, paper, resins, dyes, pearls, shells, coral branches)	Instrumental	Africa	Griffis, 1998
	Direct use of living organisms for decoration (i.e., ornamental plants in parks and households, ornamental fish), company (i.e., pets), transport, and labour			
Medicinal, biochemical and genetic resources	Production of materials derived from organisms (plants, animals, fungi, microbes) used for medicinal and veterinary purposes	Instrumental and relational	Africa	Wollny, 2003
	Production of genes and genetic information used for plant and animal breeding and biotechnology			

Non-material contributions–Nature's contribution to people's subjective or psychological quality of life, individually and collectively. The sources of these intangible contributions can be physically consumed in the process (e.g., animals in recreational or ritual fishing or hunting) or not (individual trees or ecosystems as a source of inspiration).

CATEGORIES OF NCP	A BRIEF EXPLANATION AND SOME EXAMPLES	VALUES TYPE	STUDY REGION	SOURCE
Learning and inspiration	The provision, by landscapes, seascapes, habitats or organisms, of opportunities for the development of the capabilities that allow humans to prosper through education, acquisition of knowledge and development of skills for well-being, scientific information, and inspiration for art and technological design (e.g., biomimicry)	Relational	Niger, Tanzania	Moussa *et al.*, 2008
Physical and psychological experiences	Provision, by landscapes, seascapes, habitats or organisms, of opportunities for physically and psychologically beneficial activities, healing, relaxation, recreation, leisure, tourism and aesthetic enjoyment based on the close contact with nature. For example, hiking, recreational hunting, and fishing, birdwatching, snorkelling, gardening	Relational	Côte d'Ivoire, Cameroon	Feka *et al.*, 2008; Kouassi *et al.*, 2013
Supporting identities	Landscapes, seascapes, habitats or organisms being the basis for religious, spiritual, and social-cohesion experiences	Relational	South Africa, Zimbabwe	Radder *et al.*, 2008
	Provisioning of opportunities by nature for people to develop a sense of place, purpose, belonging, rootedness or connectedness, associated with different entities of the living world (e.g., cultural and heritage landscapes, sounds, scents and sights associated with childhood experiences, iconic animals, trees or flowers)			
	The basis for narratives and myths, rituals and celebrations provided			Byers *et al.*, 2001
	landscapes, seascapes, habitats, species or organisms (e.g., sacred groves, sacred trees, totem animals)			
	Source of satisfaction derived from knowing that a particular landscapes, seascape, habitat or species exist in the present			

Table 2 1

For all groups of nature's contributions to people	
Maintenance of options	The capacity of ecosystems, habitats, species or genotypes to **keep human options open** in order to support a later good quality of life. Examples include benefits (including those of future generations) associated with the continued **existence of a wide variety** of species, populations, and genotypes
	Future benefits (or threats) derived from keeping options open for **yet unknown discoveries and unanticipated uses** of particular organisms or ecosystems that already exist (e.g., new medicines or materials)
	Future benefits (or threats) that may be anticipated from **on-going biological evolution** (e.g., adaptation to a warmer climate, to emergent diseases, development of resistance to antibiotics and other control agents by pathogens and weeds)
	Ecosystems in Protected areas, and more particularly in marine protected areas have shown a higher resilience capacity than the ones not protected or well managed. Efficient protection measures contribute to the maintenance of options

2.2 VALUES AND VALUATION OF NATURE'S CONTRIBUTION TO PEOPLE

IPBES's conceptual framework identified three major inclusive elements of the interaction between human societies and the non-human world. These elements are nature, nature's contributions to people, and a good quality of life. This section focuses on the assessment of values attributed to nature's contributions to people in Africa. The values that are attributed to nature's contributions to people are both instrumental and relational and include material contributions such as the provision of food and feeds, regulating contributions such as climate regulation and pollination, and non-material contributions linked to physical and psychological experiences. **Figure 2.2** provides a summary representation of the relative proportion of material, non-material, and regulatory values attributed to nature's contribution to people in different sub regions of Africa from the papers considered for the synthesis of information on values of biodiversity in Africa.

In many parts of the world, including Africa, perceptions of the values of nature and its contributions to a good quality of life differ and often result in conflicting views depending on the cultural or institutional setting. This implies that various environmental decision-making efforts would have different implications in different settings, but in reality, independent values are seldom recognised or explicitly taken into account. It thus becomes important that in this assessment (and others), the diversity of perceived values from nature's contributions to people are clearly understood, and not simply ignored or misrepresented at regional and subregional level.

Accounting for the value of nature's contributions to people is challenging in part because nature's contributions to people are often not traded and in part because there are very few formal valuation studies of nature and its contributions to people on the continent of Africa. The extent and quantity of existing valuation studies in Africa is unfortunately limited in geographical scope and types of ecosystems covered (e.g., Turpie *et al.*, 1999; Naidoo *et al.*, 2005; Bignaut *et al.*, 2008; O'Farrell *et al.*, 2011; Egoh *et al.*, 2012; Failler *et al.*, 2012; Failler, 2016). This chapter summarises findings from major studies and assessments that have been carried out to date.

Along with the spatially explicit ecosystem service research in Africa, pragmatic approaches to ecosystem service valuation have been suggested by Failler *et al.* (2009) and O'Farrell *et al.* (2011), and in their guidelines for the estimation of coastal and marine ecosystem services valuation. O'Farrell *et al.* (2011) estimated grazing values in the Succulent Karoo of South Africa at a range of \$19 to \$114 million, tourism activities from \$2 to \$20 million; and services linked to water from \$300 to 3120 million. Failler *et al.* (2009) have estimated the total economic value of ecosystem services of marine protected areas in West Africa at \$30,000/km^2 (Section 2.4.2.1). More recently, Failler (2016; 2017a & b) has provided, for UNEP, an estimate of African coastal and marine ecosystem services values. These estimates are presented in **Figure 2.4** alongside with other ecosystem services values.

2.2.1 Material Contributions

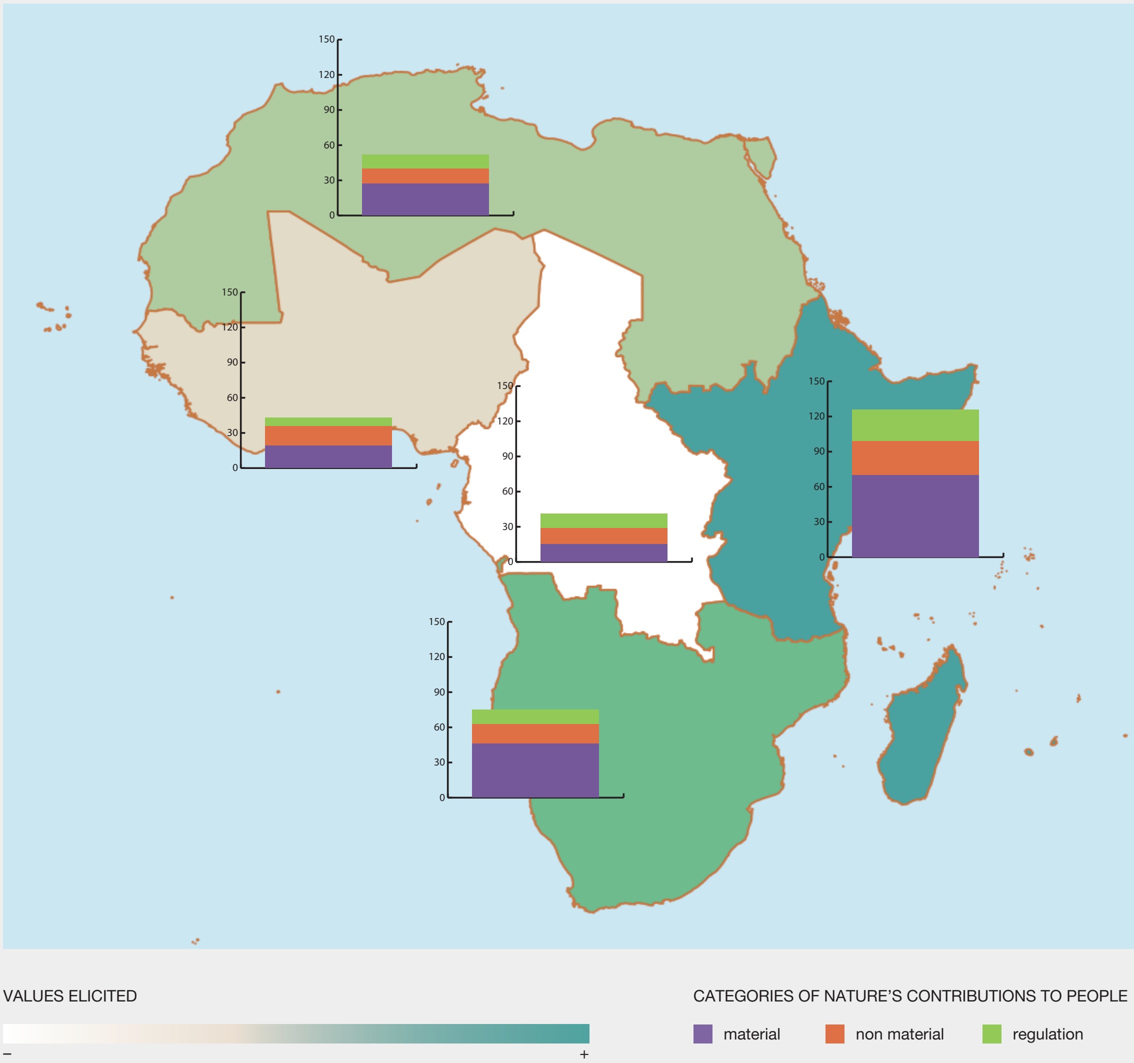
Material contributions are the provisioning services that describe the material or energy outputs from ecosystems. The materials considered in this section are food, energy, health, and water. As mentioned in Chapter 1, Africa is rich in biodiversity and draws on diverse forms of plants and fauna to meet its basic human needs (Chapter 3). Its people depend highly on these materials for daily sustenance, construction purposes, fuel, and health and cosmetic purposes, amongst other uses.

2.2.1.1 Food and feeds

Food production serves as an important material contribution of ecosystem services in terms of nature's contributions to people. Many communities in Africa depend on food provided by natural ecosystems such as forests, grasslands, wetland areas and water bodies sustaining fisheries (FAO, 2014) for their food security. The main food items that are sourced come from bushmeat (Olupot *et al.*, 2009; Golden *et al.*, 2011), insects, fresh fruits, nuts, seeds, tubers and green leafy vegetables (Kehlenbeck *et al.*, 2014), edible oils, drinks spices, condiments (Faye *et al.*, 2011), mushrooms, honey, sweeteners, wild tubers, and snails, amongst others.

Hunting bushmeat is a common practice, particularly in Central Africa (Chapters 3 & 4), where it provides high-quality animal protein. Target animals include mostly insects, rodents, birds, reptiles, as well as other primate species (Ajayi *et al.*, 2010; Salami *et al.*, 2011). Larger-bodied species are usually preferred, however, as they generate a greater return on effort invested in hunting (Wilkie *et al.*, 2016; Chapter 3). For example, in the Congo Basin countries, approximately 80% (maximum 98%) of the volume of meat eaten comes from wild animals and contributes between 30% and 80% of the daily fats and protein requirements (Nasi *et al.*, 2011). Bushmeat serves as a cheap and easily accessible resource especially for rural households, who, rely heavily on this resource during the "hungry season" and in situations of stress or emergency (Nlom, 2011; Chapters 3 & 4).

Figure 2 2 **Values representation per subregion and targeted nature's contributions to people. Source: see Appendix AfRA 2.1; Available at https://www.ipbes.net/sites/default/files/synthesis_of_information_on_ecological_and_socio-economic_benefits_of_bes_in_africa.xlsx.**



The rate at which urbanisation is growing in Africa, combined with an increasing demand, which is now surpassing supply, there has been a devastating impact on the biodiversity of the region (Kasisi, 2012; Chapters 3 & 4). **Figure 2.3** illustrates the rate of increase of bushmeat production in the Congo Basin countries between 1985 and 2005, and **Table 2.2** further demonstrates the increase in the volume of consumption in the Congo Basin in 2009.

Some regions show positive impacts on biodiversity, however. Fenced and unfenced community conservancies in Namibia and Kenya and private game ranches in South Africa, for example, have been generally (although

Figure 2 3 **Bushmeat production in selected countries within Congo Basin between 1980 and 2005. Source: Ziegler (2009).**

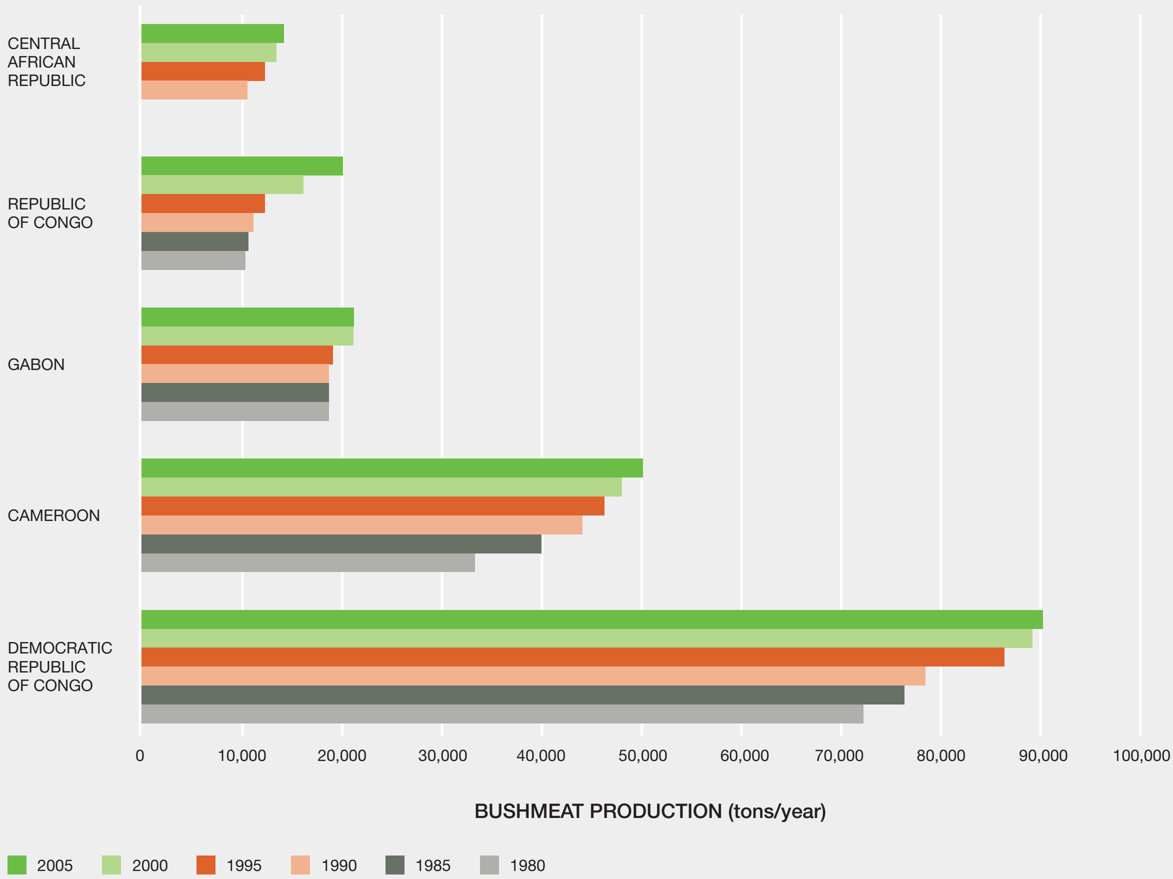


Table 2 2 **Bushmeat consumption in selected countries within the Congo Basin in 2009. Source: Nlom (2011).**

	Cameroon	Central African Republic	Congo	DRC	Equatorial Guinea	Gabon	TOTAL
Total consumption (tons/year)	78,077	12,977	16,325	1,067,873	9,763	11,381	1,196,396
Average harvest (kg/ km forest/year)	503	248	77	897	574	50	645
Average consumption (kg/person/year)	21	17	11	41	24	15	35
Bushmeat value ($/year)	195,193	32,443	40,813	2,669,683	24,408	28,453	2,990,990

not always) successful in conservation efforts by mixing wildlife and livestock production (Wilkie *et al.*, 2016). Mixed wildlife–livestock production can increase income for poor rural families when wildlife is sold by hunters as trophies or as meat to high-value tourist lodges and export markets.

Insects comprise another source of protein, minerals, and vitamins. About 250 edible species are listed in Africa, where the dominant 78% represent Lepidoptera (30%), Orthoptera (29%) and Coleoptera (19%), while the other 22% comprise Isoptera, Homoptera, Hymenoptera, Heteroptera, Diptera, and Odonota. Whether or not insects are eaten depends partly on taste and nutritional value, but also on customs, ethnic preferences and prohibitions. Because most insects are only available seasonally. Preservation by drying is often practiced (van Huis, 2003). Research in Bangui estimated that 29% of the total annual consumption of animal proteins was obtained from caterpillars and larvae, and that during the harvesting period, they accounted for over half of the population's protein consumption (N'Gasse, 2003). Bahuchet (1972) recorded that caterpillar consumption in a forest camp of the Aka Pygmies in the Central African Republic made up 75% of people's protein consumption during the caterpillar season. Many insects also provide commercially value added products, such as honey. Currently, Egypt is the dominant honey producer, with the highest value of honey in Africa at about €98/hectare (Croitoru, 2007).

Wild plants are also an excellent source of food and vitamins and in the absence of regular supply of animal protein and fat (i.e., dairy products and meat, plants are fundamental to nutritional security) (Maranz *et al.*, 2004; Teklehaimanot, 2004). According to Kronborg *et al.* (2014), the protein contents of the fermented product of *Parkia biglobosa* (soumbala/moutarde in local language), for instance, can surpass that of meat. In West Africa, there are three key species complementing daily rural diets: *Vitellaria paradoxa*, *Parkia biglobosa*, and *Adansonia digitata* (Augusseau *et al.*, 2006; Belem *et al.*, 2007; Heubach *et al.*, 2013), while in Sudan, a wide variety of wild plants are used in everyday meals, such as for salads, drinks (hot and cold), and everyday cooking (Salih *et al.*, 2014).

Plant products are mostly open-access resources (i.e., no financial investment is needed to produce or collect them) (Angelsen *et al.*, 2003). They are available in the dry season when fields are already harvested and are suitable for mid-term storage to provide a buffer during times of seasonal or financial stress (Arnold *et al*., 2001; Schreckenberg *et al.*, 2006). There are many examples of the nutritional values of Non Timber Forest Products (NTFPs) of plant origin across the continent, like Marula (*Sclerocarya birrea*), a source of nutrition and a dietary mainstay in South Africa, Botswana, and Namibia.

Besides bushmeat, insects, and plants, fisheries constitute another key source of food and income derived from nature. Despite regional differences (Belhabib *et al.*, 2016), some major trends can be revealed by analysing fisheries catch data. Data extracted from the Sea Around Us database show that overall catches increased from 2.1 million t in 1950 to 16.7 million t in 1988, and then decreased to 12.4 million t in 2010. The artisanal sector, whose landed value reached $4 billion in 2010, is in decline since 2004, along with the industrial sector's catch, despite an increasing fishing effort. Subsistence sectors, consumption driven fishing activities conducted operated almost exclusively by women, caught 411,000 tons in 2010. Overall, catches by this sector increased, showing high dependence upon fish. With the over-exploitation of fish stocks (Pauly *et al.*, 2015), costs of fishing increased (Teh *et al*., 2013), translating into a shift from subsistence to artisanal fishing (Belhabib *et al.*, 2014).

In sub-Saharan Africa, fish provide over one-fifth of protein intake by local communities. In West African coastal countries such as Ghana and Sierra Leone, the rate of protein uptake from fish is more than half. West African is considered one of the most economically important fishing zones in the world, with a production of 4.5 million tons of fish in 2000 (Belhabib *et al.*, 2014). Southern African countries also constitute exceptional fishing areas and export between 80% and 90% of their marine fish annually (Akpalu, 2013). Other countries such as Egypt, Morocco, Ghana, Kenya, Namibia, Nigeria, Senegal and Uganda, also produce large quantities of fish, which contribute significantly to food security and nutrition in those areas (FAO, 2016). Over 3,300 industrial vessels (20% foreign) and 54,000 artisanal and subsistence pirogues catch over 6.4 million tons of fish per year (Belhabib *et al.*, 2012; Belhabib *et al.*, 2015b), for a landed value of $10.6 billion (Belhabib *et al.*, 2015a). Catches peaked in the late 1990s and have been declining since then, despite or because of an increase in the fishing effort. However, as this region is also targeted by foreign fleets under agreement and illegal fleets, at least 15 of the 18 important coastal demersal stocks and pelagic resources (sardinellas, horse mackerel *Trachurus trachurus*, chub mackerel *Scomber colias*, anchovy, and bonga shad *Ethmalosa fimbriata*) are fully or over-exploited (CCLME, 2016). This raises serious concerns about food security and the sustainability of fishing access agreements with foreign countries (Belhabib *et al.*, 2015a).

The countries of Eastern and Southern Africa and others in the Indian Ocean (ESA-IO) region collectively produce almost 1.9 million metric tons of fish – or 23% of Africa's fish production every year. A special characteristic of the region's fish production is that the greatest proportion of the total catch is derived from diverse inland and fresh water fisheries, rather than marine fisheries (IOC, 2014). Despite this, per capita, fish consumption has stagnated in Africa and only accounts for a tiny share of global fish production, approximately 0.6% and shrinking (CAPMAS, 2014; Soliman *et al.*, 2016). In **Figure 2.4**, a summary of Africa's material and non-material contribution to people from fisheries is given.

Small-scale fisheries are the only source of animal protein to many rural populations and are economically significant in a number of areas in Africa (FAO, 2014). According to FAO (2016), the total fish supply was 11 million tons live weight equivalent or 10.5 kg/year per capita. It was estimated that with a total GDPA of \$288.4 billion, this sector contributes 6% of the GDPA for the whole of Africa. The highest

Figure 2 4 **Indicative lists of economic values of nature's contributions to people in Africa.**

Sample values of some ecosystem services in selected ecosystems (freshwater, marine and coastal areas and forests) in Africa. Apart from fishery and blue carbon values, data comes from various sources, with methodological differences, which means comparisons of values between subregions or ecosystems is not currently possible. (a) **North Africa:** Marine and Coastal fishery value added (FAO FISHSTAT, 2017); Carbon sequestration (Canu *et al.*, 2015); Inland waters (de Graaf *et al.*, 2014); Forest (Daly, 2016); (b) **West Africa:** Marine and Coastal (Failler, 2016); Wetlands (Failler *et al.*, 2012); Inland waters (Acharya *et al.*, 2000); (c) **Central Africa:** Marine and Coastal (Failler *et al.*, 2017a); Wetlands (Failler *et al.*, 2017b); Inland waters (de Graaf *et al.*, 2014); Forest (Yaron, 2001); (d) **South Africa:** Marine and Coastal (Mclean *et al.*, 2017; Klaus *et al.*, 2017); Inland waters (de Graaf *et al.*, 2014); Savanna (de Wit *et al.*, 2006); (e) **East Africa and adjacent islands:** Marine, Coastal and Wetlands (Mclean *et al.*, 2017); Inland waters (de Graaf *et al.*, 2014); Forest (Emerton *et al.*, 1999); Dryland and Desert (Barrow *et al.*, 2007); Savanna (Emerton, 1998).

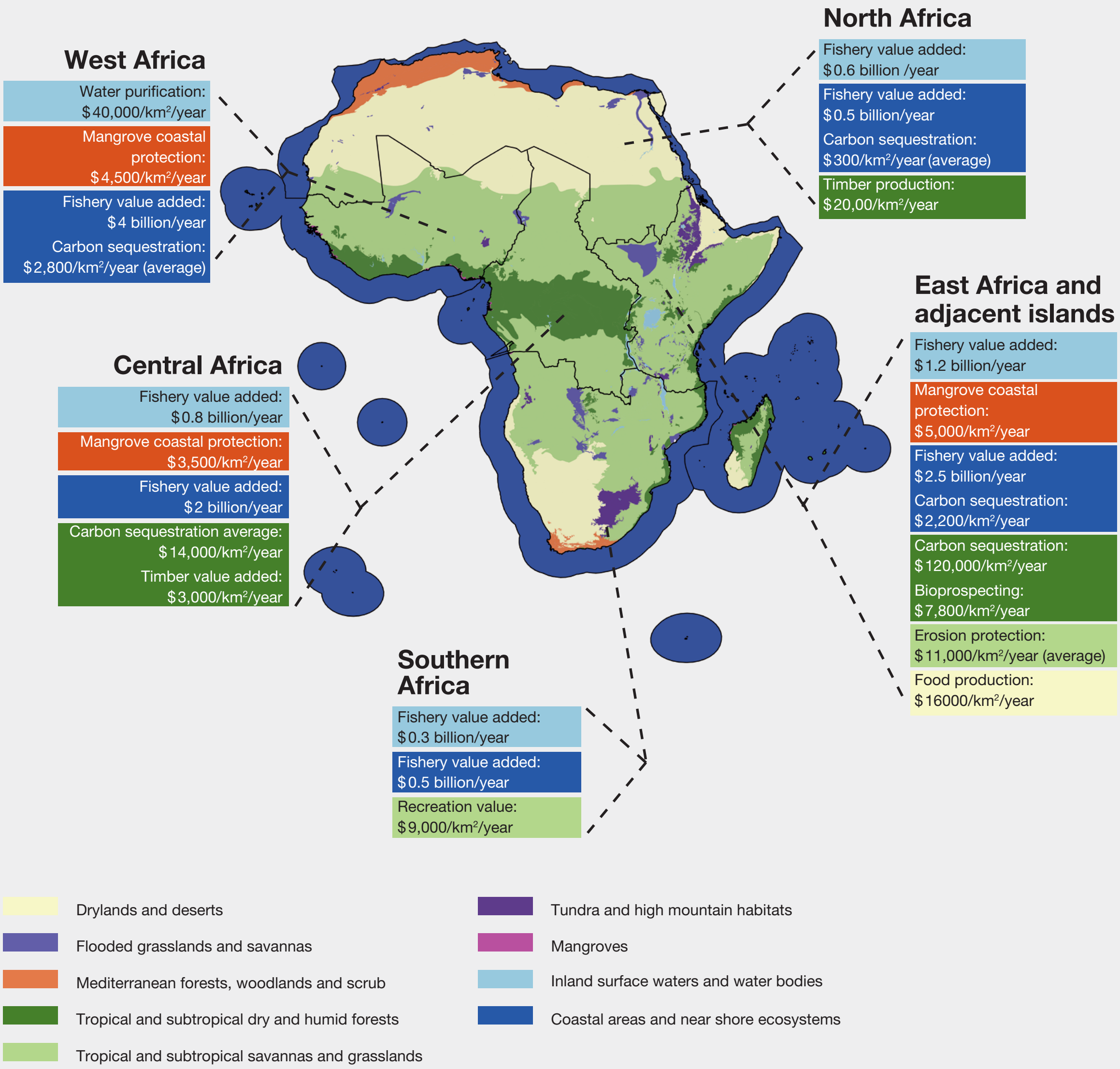
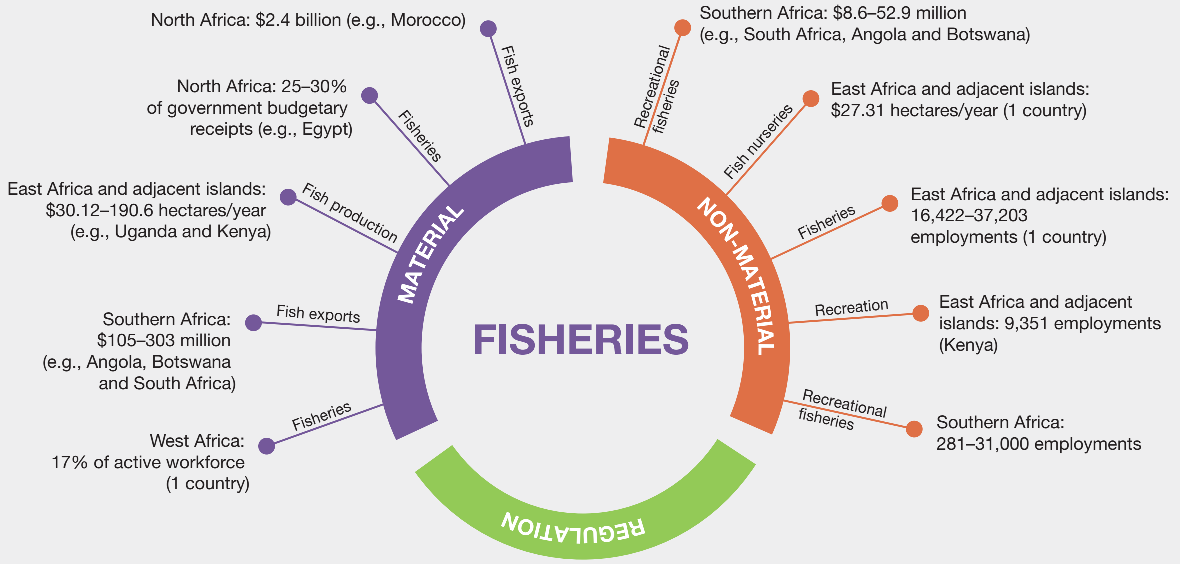


Figure 2 5 **Multiple values of fisheries based on their diverse contributions to people. Source: See Appendix AfRA 2.1; Available at https://www.ipbes.net/sites/default/files/synthesis_of_information_on_ecological_and_socio-economic_benefits_of_bes_in_africa.xlsx.**



contribution is from marine artisanal fishing contributing 1.82% of the total GDPA, whereas inland fishing and marine industrial fishing contribute 1.62% (FAO, 2014).

The successful management of fisheries has to consider the employment of fishers' ILK on the ecology and biology of local fish species. It has been found that the lack of sufficient scientific information on specific fish species was be complemented by the local fishers ILK (Gaspare *et al.*, 2015).

2.2.1.2 Timber and Non-Timber Forest Products (NTFPs) and livelihoods

Forests and woodlands provide valuable ecosystems services by provisioning timber and Non Timber Forest Products (NTFPs), which serve as a diverse source of jobs and livelihoods in Africa. For instance, in Tanzania, the estimated annual revenues generated from timber for domestic use are $10 million in terms of planks, and twice as much when processed into furniture (Schaafsma *et al.*, 2014b). Africa-wide, the annual consumption of wood is projected to grow by over 40% by 2030, and the region as a whole is slated to become a net importer of wood products for fuel and construction. According to Nlom (2011), the formal forestry sector in Congo Basin countries produces more than 10 million tons of timber a year, with production dominated by Gabon (3.96 million tons) and Cameroon (3.16 million tons). A large proportion of this timber is exported–around 50% overall, ranging from 15% in the Central African Republic to over 90% in the Democratic Republic of Congo. The current total annual value of these exports exceeds $2.5 billion, while the estimated market value of domestically-consumed timber and timber products is estimated to total almost $1 billion. The FAO (2013), quantified the total value of forests to rural people in Uganda at about $4.01 billion **(Table 2.3)**.

Domestic demand for timber in this region is growing, however, which is almost entirely supplied by the largely unregulated, inefficient and unsustainable informal sector, which makes the sector's real contribution to GDP and to local livelihoods challenging to measure (Cerbu, 2016). The region is well known for round wood and timber exports from large forest concessions, traditionally managed by foreign owned companies. Total recorded round-wood harvests for industrial timber are 7.5 million m^3, compared with 1.7 billion m^3 globally (Bromhead, 2012).

In the subregions of East Africa (Kenya, Malawi, Somalia, Sudan, Tanzania, Uganda, Zimbabwe), Teak is particularly valued, mainly for its durability and water resistance, and is used for boat building, exterior construction, veneer, furniture, carving, turnings, and other small wood projects (USDA, 2010). Its leaves are also edible and have medicinal properties (Farinola *et al.*, 2014).

On the African island of Madagascar, endemic species of rosewood is in great demand for veneer, musical instruments (guitar bodies and fingerboards), furniture, cabinetry, inlays, carving, turned objects, and other small specialty wood items. The essential oil can also be extracted from the wood and used for aromatherapy and perfume. The heartwood is traditionally used as medicine to treat malaria, bilharzias, and cysticercose (WHO, 2013).

The southern African region is characterised by the Miombo dry land forests, which cover 2.4 million hectares (twice the area of the Congo Basin rainforests) and span from Mozambique to Angola and including parts of southern Tanzania and southern DRC (Chapter 3). Miombo woodlands provide many services to rural populations, including late dry-season grazing for livestock from foliage, building materials, and a range of non-timber forest products such as honey, ingredients for cosmetics, Amarula (a cream liqueur), etc. (Chapters 1, 3, & 4). According to Kimaro *et al.* (2013), wild tree fruits and edible mushrooms are widely used by local people near Ngumburuni forest reserve in Tanzania.

Non-Timber Forest Products (NTFPs) contribute significantly to the subsistence, daily life, and welfare of people, and could become a major instrument of economic development for some rural communities (Mahaptara *et al.*, 2011; Lambini *et al.*, 2014; Maisharou *et al.*, 2015; **Table 2.4**). The average share of NTFPs income in total household income in rural Africa is 21.4% (Angelsen *et al.*, 2014; Heubach *et al.*, 2016), with varying figures across countries ranging from 20% in Tanzania (Schaafsma *et al.*, 2014a), to up to 44% in Zambia (Kalaba *et al.*, 2013). Amous (1999) estimated a per capita fuelwood consumption of 0.89 m^3/year and African fuelwood consumption by households is still the highest in the world (Arnold *et al.*, 2003; UN, 2018). Women and children are the main collectors and traders of NTFPs, and they form a substantial component of women's livelihoods in many rural areas (Arnold *et al.*, 2001; Pouliot *et al.*, 2013; Colfer *et al.*, 2015). However, as pointed out by Ambrose-Oji (2011), few countries have explicit laws that govern the harvesting of NTFPs Inventories of all species used and sold would be impossibly costly to undertake, and they recommend creating inventories of only the half dozen most important NTFPs sold in any location.

Table 2 3 **The total annual value of forest products to rural people in Uganda. Source: FAO (2013).**

FOREST PRODUCT CATEGORY	CASH VALUE		NON-CASH VALUE		THE TOTAL VALUE OF FOREST PRODUCTS	
	($million)	(%)	($million)	(%)	($million)	(%)
Fuel	406	10.1	1,186	29.5	1,592	39.6
Building materials	346	8.6	655	16.3	1,001	24.9
Forest Foods	241	6.0	510	12.7	752	18.7
Fibre (for ropes, baskets, matting, etc.)	68	1.7	257	6.4	326	8.1
Herbal medicines	44	1.1	145	3.6	189	4.7
Timber	32	0.8	129	3.2	161	4
Total	1,137	28.3	2,882	71.7	4,019	100

Table 2 4 **The value of NTFPs per country group (Euro/hectare, 2005 prices). Source: Croitoru (2007).**

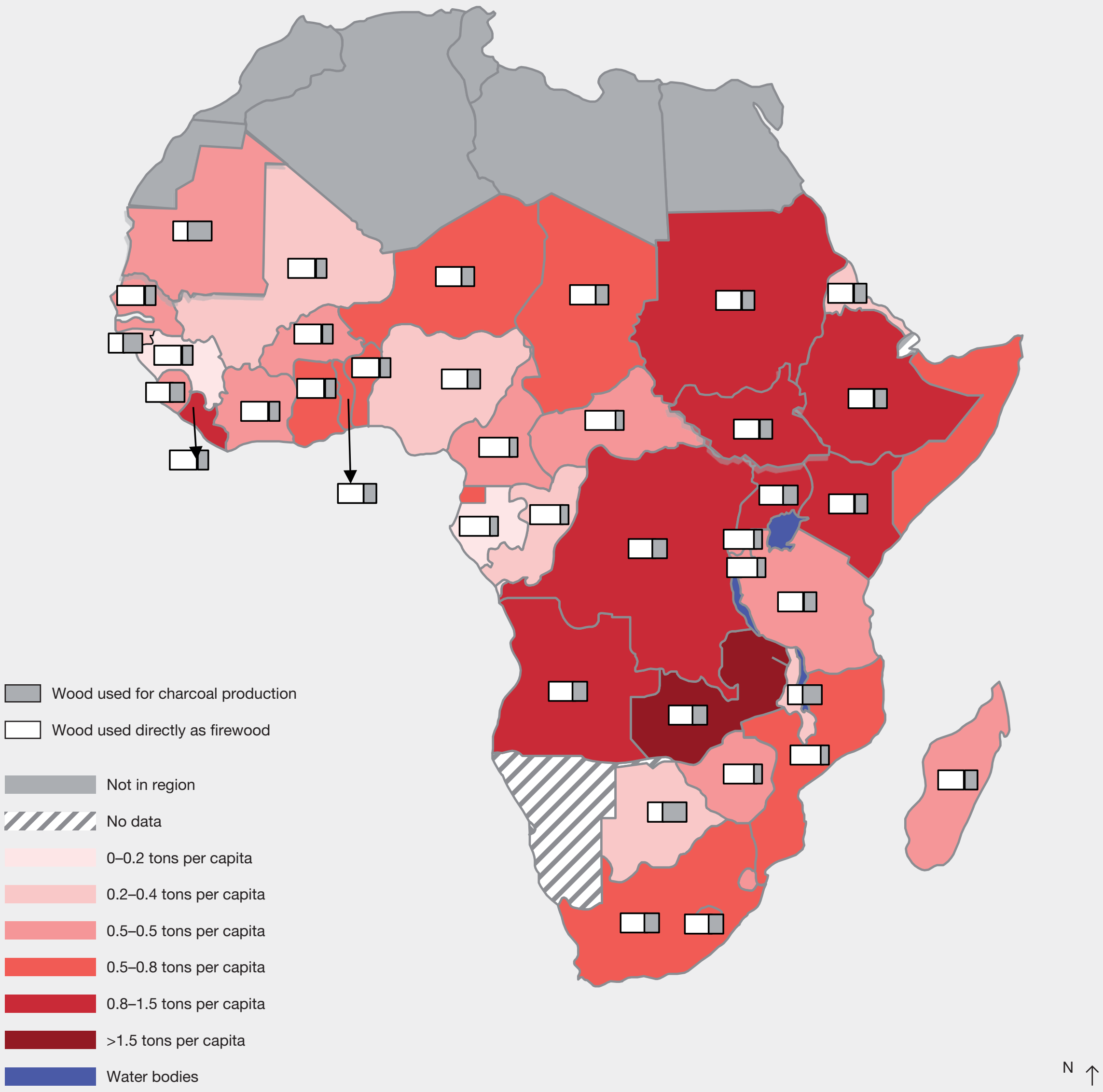
Firewood		Grazing	Cork	Mushrooms	Honey	Other NTFPs	TOTAL NTFPS
Morocco	17	31	1	1	4	1	54
Algeria	0	36	1	No data	0	0	38
Tunisia	3	81	11	0	2	12	109
Egypt	7	No data	No data	No data	97	No data	104
Average	11	35	2	1	3	1	54

2.2.1.3 Energy

Fuelwood is the dominant source of energy in Africa (World Bank data repository, 2017), with over 90% of energy needs in rural areas supported by fuel wood. Urban areas rely more on charcoal as a source of energy for cooking (Bailis *et al.*, 2005; **Figure 2.6**). For instance, in Tanzania, direct dependence fuelwood is high; 92% of rural households rely on it for cooking, whereas 50% of the urban population uses charcoal (National Bureau of Statistics Tanzania, 2011). In Central Africa, demand for household energy from rapidly growing urban centres (e.g., Kinshasa; Chapter 3) exerts massive pressure on forests (World Bank, 2013). Nlom (2011), identified fuelwood as the dominant energy source in the Congo Basin (mostly sourced from the natural forest). The annual consumption has been recorded at around 95 million m^3, mainly comprising firewood, with a total value of some $2.8 billion **(Table 2.5)**.

Figure 2 6 **"Current per-capita biomass production in sub-Saharan Africa.**

The colours show total wood fuel consumption, and the pie charts show the fraction of wood that is used for charcoal, based on multiple sources. FAO biomass estimates (including charcoal) were roughly consistent with IEA estimates and were used for all countries except Angola, Kenya, South Africa, Sudan, and Zambia (20% of the region's population). For these countries, FAO biomass estimates would have been too low to meet minimal household energy needs when considered with energy use from fossil fuels and other energy sources reported by IEA. In all of these countries except Kenya, IEA estimates were used; for Kenya, data from a detailed national household fuel consumption study were used." Bailis *et al.* (2005).



In East Africa and adjacent islands, 70–85% of urban households rely on charcoal, and between 2000 and 2010 the demand for charcoal grew at 3%/year, while firewood grew at 1%/year (World Agroforestry Centre, 2013; Chapter 3). Charcoal production constitutes an important source of income in rural Africa, but is, in certain areas, at the expense of forest cover (Chapters 1, 3 & 4). Currently wood fuel, i.e., firewood and charcoal accounts for around 10% of global energy supply, but dominates energy provision in many parts of the developing world (OCDE/IEA, 2014).

In sub-Saharan Africa, wood fuel accounts for > 80% of energy supply and over 90% of the population relies on these sources of energy (Bailis *et al.*, 2005), except in South Africa where levels of electricity supply are relatively high. For instance, it is estimated that four out of five people in the region are reliant on the traditional use of mainly fuelwood, for cooking (Bailis *et al.*, 2005). The expected increase in charcoal demand could significantly negatively impact on tree cover in dry forests and savannas, which supply much of the charcoal sold in the urban areas of sub-Saharan Africa (World Agroforestry Centre, 2013). In most sub-Saharan Africa countries, the wood-based biomass sector contributes significantly to employment, generally providing regular income to a large portion of people. This assumption is based on three studies (in Kenya, Malawi and Tanzania), extrapolated to sub-Saharan Africa to show that the charcoal industry in this region might have been worth more than $8 billion in 2007, with more than 7 million people dependent on the sector for their livelihoods (World Bank, 2012).

Sub-Saharan Africa is rich in energy resources but very poor in energy supply. Hydropower accounts for one-fifth of today's power supply, but less than 10% of the estimated technical potential has been utilised. In Central Africa, only 9% of the population in the DRC has access to electricity. This is an example where huge hydropower potential is surpassed by extreme energy poverty. In East Africa and adjacent islands, mainly in Kenya and Ethiopia, geothermal energy serves as the second-largest source of power supply. Coal production and use gradually extend beyond South Africa, but coal is surpassed by oil as the second-largest fuel in the sub-Saharan energy mix. Nigeria remains the region's largest gas consumer and producer, but significant offshore discoveries in Mozambique and Tanzania are also changing energy supply geography (OECD/IEA, 2014). **Figure 2.7** shows patterns of fossil fuel energy consumption at the sub regional level.

Figure 2 7 **Patterns of fossil fuel energy consumption in Africa at subregional level. Fossil fuel comprises coal, oil, petroleum, and natural gas products. Source: World Bank data repository (2017).**

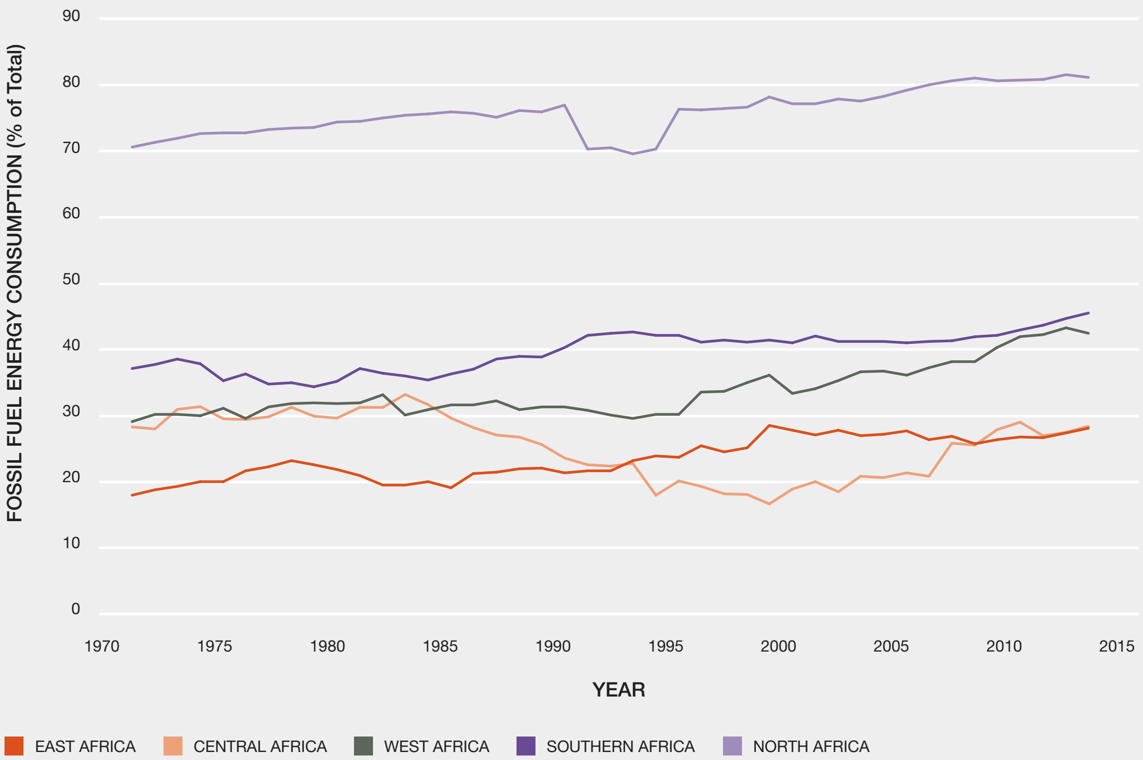


Table 2 5 **Value of fuelwood production in Congo Basin countries (2008). Source: Nlom (2011).**

	Cameroon	Central African Republic	Congo	DRC	Equatorial Guinea	Gabon	TOTAL
Firewood (m^3)	9,732.50	6,016.50	1,295.10	74,315.30	188.8	534.1	92,082.3
Charcoal (tons)	409.5	185.5	3.6	1,890.00	8.5	19.2	2,516.3
Fuelwood value ($)	304,260	186,060	38,961	2,286,159	5,919	16,599	2,837,958

According to IEA, (2009), bioenergy formed almost 50% of the Total Primary Energy Supply (TPES) for the African continent and over 60% of sub-Saharan TPES. Assessments carried out by Stecher *et al.* (2013), indicate that by the year 2020 potentials for bioenergy would rise for; crops (from 0 PJ/year to 13,900 PJ/year), and forestry biomass (from 0PJ/year to 5400 PJ/year). For residues and wastes, however, the potentials will rise from 10 PJ/year to 5,254 PJ/year. In South Africa, bioenergy potentials range from approximately 400 to 550 PJ/ year, where maize and wheat residues currently account for about 104 PJ of the sustainable bioenergy potentials (Batidzirai *et al.*, 2016). National Programmes in biogas production are being implemented in certain countries across the continent (Austin *et al.*, 2012).

Renewable energy markets (sun, water, biomass, and wind) are steadily growing on the continent, despite significant barriers facing implementation of energy projects in Africa, such as fluctuating exchange rates, political and institutional challenges, and falling international commodity prices, (Power Africa, 2016). Africa has significant potential for wind and solar energy; for example, Ethiopia has a capacity of 1,350 GW of energy from wind and annual total solar energy reserve of 2,199 million TWh/annum (Derbew, 2013). Africa's lengthy coastline provides significant potential for wind power production. South Africa, Morocco, Egypt, Ethiopia, and Kenya are currently the five most prominent countries in the wind energy market in Africa **(Table 2.6)**.

Solar power potential in Africa is significant (IRENA, 2016). The price of producing power from solar mini grids is expected to fall by approximately 60% in the next 20 years. According to IRENA (2016), up to 60 million Africans may already have access to renewable electricity.

Table 2 6 **The five biggest wind markets in Africa. Source: Tiyou (2016).**

s/N	Countries	Operational (MW)	Under construction (MW)
1	South Africa	I, 170	840
2	Morocco	870	50
3	Egypt	750	0
4	Ethiopia	320	0
5	Kenya	14	310
	TOTAL	**3,124**	**1200**

2.2.1.4 Medicinal, biochemical and genetic resources

According to WHO (2002), up to 80% of the population in Africa rely on traditional medicine to help meet their primary health care needs. Furthermore, numerous plant products are used in traditional African medicine (Moyo *et al.*, 2015; **Table 2.7**).

Traditional medicine, in particular, phytotherapy, is widespread throughout the African continent and extends to include practices for treatment of animals ailments and

Table 2 7 **Some medicinal plants used in treatments of some ailments in Africa.**

S/N	PLANT SPECIES	TREATMENTS/AILMENTS	SOURCE
1	*Xylopia aethiopica*	Ante natal care and child birth	Gbadamosi *et al.*, (2014)
2	*Garcinia Kola*	Anti-infection treatment, and sexual drive improvement	Gbadamosi *et al.*, (2014)
3	*Rauvolfia vomitora*	Purgative	Moyo *et al.*, (2015)
4	*Gmelina arborea*	Carminative in many ailments	El- Mahmood *et al.*, (2010)
5	*Tamarindus indica*	Constipation, obesity, etc.	Mohamed *et al.*, (2017)
6	*Prunus africanis*	Benign prostatic hypertrophy, also used in 19 other herbal preparation	Hoare, (2007).
7	*Khaya senegalensis*, and *Combretum Micranthum*	Anti- malaria	Lokossou *et al.*, (2012)
8	*Anthcleista nobilis*	Rheumatism	Lokossou *et al.*, (2012)
9	*Newbouldia laevis*	A cough, toothache, and conjunctivitis	Lokossou *et al.*, (2012)

general animals' health care (Halmy, 2016). Both women and men practice folk medicine, but women hold a substantial portion of the traditional knowledge (Pourchez, 2014). Overharvesting of medicinal materials for commercial trade, however, can severely threaten plant populations and, subsequently, the longevity of traditional medicine (Moyo *et al.*, 2015).

In Nigeria, for example, biodiversity supports the health needs of millions, and studies have revealed hundreds of different kinds of herbs with a range of medicinal uses throughout the country (Nigeria, 2015). Accordingly, trade in medicinal plants and animal parts have grown, and now form a major category of merchandise in village markets in rural and peri-urban settlements. Consequently, maintaining health standards for millions of Nigerians depends on the protection and sustainable management of biodiversity. Efforts are now being made in different parts of the country to domesticate certain medicinal plants. For example, one of the mandates of the National Agency for Genetic Resources and Biotechnology is to document and archive essential genetic biodiversity resources.

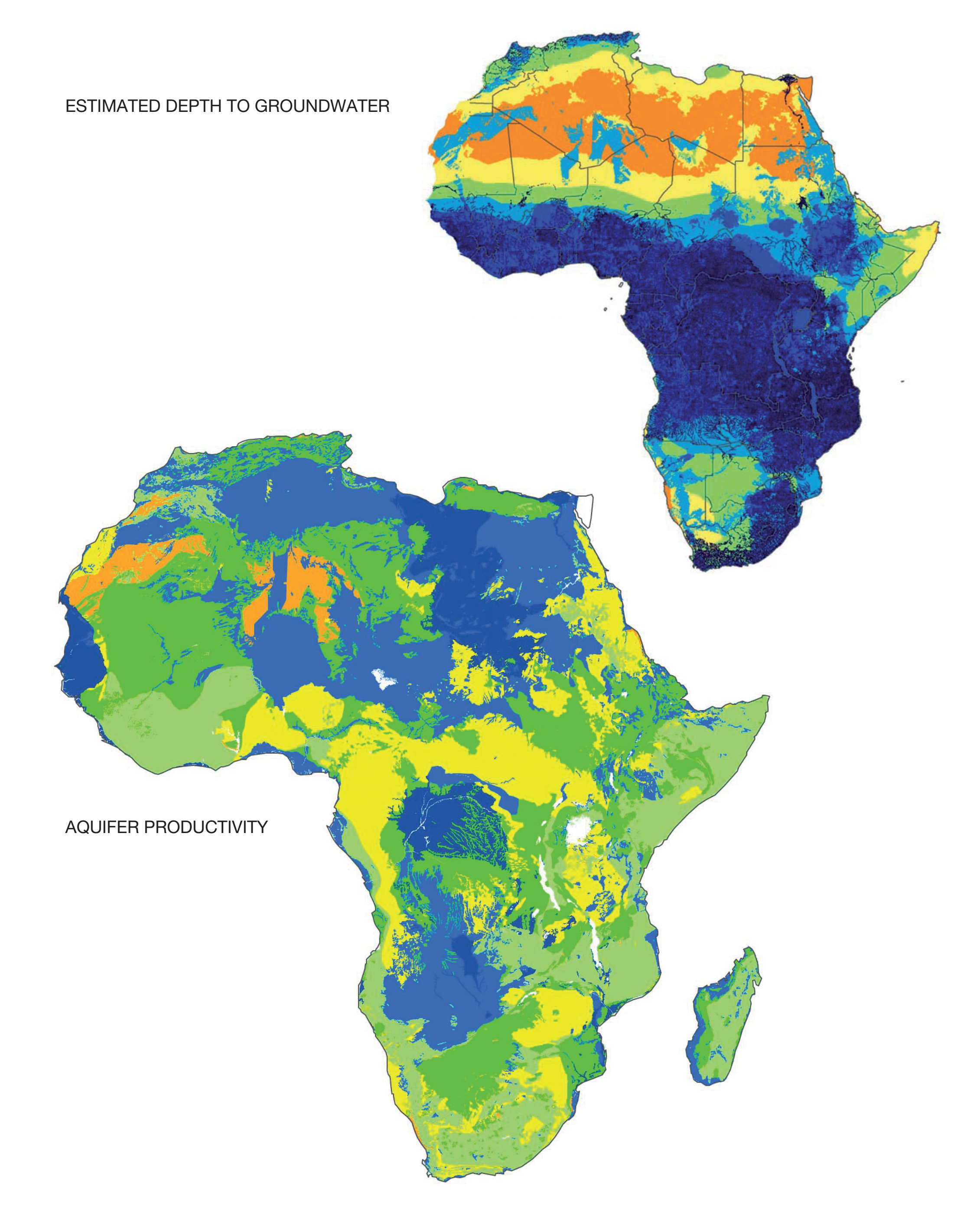
In Central Africa, among some of the most valuable non-timber forest products in international trade are medicinal plants, supplying the pharmaceutical and herbal industries. For example, export of medicinal plants is a major foreign exchange earner in Cameroon, with annual earnings of $2.9 million (FAO, 2002). A number of species are exported, but the majority of the trade is in the following four species: *Prunus africana*, *Pausinystalia johimbe* (native to the coastal forests of Central Africa), *Voacanga africana* and *Strophanthus gratus* (Hoare, 2007). *Prunus africana* provides the largest volume of any African medicinal plant in international trade. It is most commonly used for its anti-inflammatory and analgesic properties, and to treat malaria. It is mainly exported from Cameroon, DRC, and Equatorial Guinea to Europe ranges (between 3,200–4,900 tons), with a market value estimated at $150 million/year. The commercial value of the trade in 1999 from Cameroon alone was estimated to be $700,000 within the country.

2.2.1.5 Water supply

Water is an important ecosystem service, and major sources of water in Africa include streams and rivers, freshwater lakes, and groundwater sources. Water security in much of the continent is, however, under threat, and a number of freshwater ecosystems are currently undergoing degradation due to deforestation, pollution, invasive species as well as climate change (Niang *et al.*, 2014).

After Australia (and Antarctica), Africa is the world's third-driest continent. It constitutes 15% of the global population, but only has 9% of the global renewable water resources, of which only 15% is groundwater **(Figure 2.8)**, which supplies about 75% of its population. Water is also unevenly distributed, with Central Africa holding 50.66% of the continent's total internal water, and Northern Africa only 2.99% (Chapters 1 & 3). Thus, in all regions except Central Africa, water availability per person is lower than that of all of the world's other regions except Asia (the most populous continent) (UNEP, 2010). Since Africa's water

Figure 2 8 **Aquifer productivity for Africa showing the likely interquartile range for boreholes drilled and sited using appropriate techniques and expertise. The inset shows an approximate depth to groundwater. Source: Bonsor *et al.* (2011).**



AQUIFER PRODUCTIVITY (L/S)

Very High: >20 | High: 5–20 | Moderate: 1–5 | Low Moderate: 0.5–5 | Low: 0.1–0.5 | Very Low: < 0.1

ESTIMATED DEPTH TO GROUNDWATER (MBGL)

0–7 | 7–25 | 25–50 | 50–100 | 100–250 | > 250 resources are so vital to basic livelihoods and economic growth on the continent, an improved understanding of its availability, distribution and limitations is crucial for its better management (UNECA, 2006).

An analysis of data from 35 countries in sub-Saharan Africa (representing 84% of the region's population) shows significant differences in water access between the poorest and richest fifths of the population in both rural and urban areas. Over 90% of the richest quintile in urban areas use improved water sources, and over 60% have piped water on premises. In rural areas, piped-in water is not accessed in the poorest 40% of households, and less than half of the population use any form of improved source of water (UN, 2012; **Figure 2.9**). **Table 2.8** provides a more detailed breakdown of water availability in southern Africa.

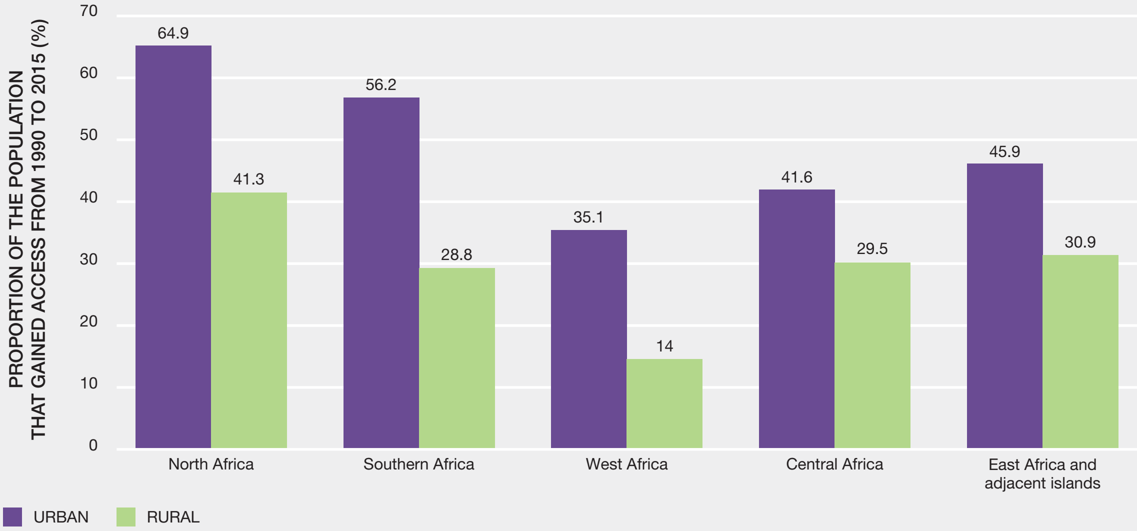
According to a survey of ecosystem services in seven African countries (Wong *et al.*, 2015), many regions in these countries are water stressed in terms of both supply and quality. The major causes of water degradation were cited as wetland degradation, agricultural, urban pollution, and deforestation. In the drier regions of Africa, oases play an important role in terms of both agricultural and water supply. Dates, cotton, olives, figs, citrus fruit, wheat and corn (maize) are common oasis crops. Amongst the world's most significant (and strategically important) supplies of groundwater exist beneath the Sahara Desert **(Figure 2.8)** for a relative amp of aquifer productivity in Africa) supporting about 90 major oases there. In certain areas, communities have traditionally planted trees such as palms around the perimeter of oases to protect against sand and wind erosion.

Table 2 8 **Water availability and use in Southern Africa, as compiled in the South African Facilities Management Association regional scale study. Source: van Jaarsveld *et al.* (2005).**

COUNTRY	Renewable water resources[1] (km^3/year)	Total water use (km^3/year)	Water per person[2] (m^3/person/year)	Access to improved water (% of total population)	Access to improved sanitation (% of total population)	Under-five mortality (per 1000 births)
Angola	184	0.34	13,620	38	44	260
Botswana	14.40	0.14	8,471	95	66	110
Burundi	3.60	0.23	519	78	88	190
Congo	832	0.04	26,8387	51	–	108
Dem. Rep. Congo	1,283	0.36	24,508	45	21	205
Equatorial Guinea	26	0.11	55,319	44	53	153
Gabon	164	0.13	130,159	86	53	90
Kenya	30.20	1.58	982	57	87	122
Lesotho	3.02	0.05	1,467	78	49	132
Malawi	17.28	0.11	1,641	57	76	183
Mozambique	216.11	0.64	11,960	57	43	197
Namibia	17.94	0.27	10,022	77	41	67
Rwanda	5.20	0.08	656	41	8	183
South Africa	50	15.31	1,156	86	87	71
Swaziland	4.51	0.83	4,215	48	44	149
Tanzania	91	2	2,642	68	90	165
Uganda	66	0.30	2,896	52	79	124
Zambia	105.20	1.74	10,233	64	78	202
Zimbabwe	20	2.61	1,560	83	62	123
Region		26.87[3]	11,390	61	63	155

1. Total surface and groundwater resources (corrected for partial overlap) within a country›s borders, plus or minus the natural flows entering and leaving the country, as well as flows secured through treaties and agreements with other countries. Aggregation cannot be done for the region as it would result in double counting of shared water resources.
2. Population-weighted means.
3. Weighted by total renewable resources of each country.

Figure 2 9 **Population of Africa that gained Access to clean water since 1990 at urban and rural areas. Data source: UNEP (2016).**



2.2.2 Regulating Contributions

2.2.2.1 Pollination, dispersal of seeds and other propagules

Pollination is an ecosystem service that is fundamental to plant reproduction, agricultural production and the maintenance of terrestrial biodiversity. Pollen is moved between flowers by wind, water, or animals as a precursor to fertilisation (IPBES, 2016). The majority of animal pollinators are insects, of which bees are the best known, but large animals such as birds, bats, and other mammals also frequently help pollinate large flowers. Pollination by hand has also been practiced for many years in, for example, the production of dates (*Phoenix dactylifera*) in the Middle East (Zaid *et al.*, 2002) and in the production of vanilla (Arditti, 1992; Fouche *et al.*, 1992).

African forest elephants (Chapter 3) are major seed dispersers. In Uganda, for example, elephants are responsible for spreading seeds a great distance from the parent trees. Asian elephants typically spread seeds from 1 km to 6 km, while Congo forest elephants are capable of spreading seeds as far as 57 km. *Myrianthus arboreus* are typical fruits targeted by large mammals and elephants in Congo (Campos-Arceiz *et al.*, 2011). Moreover, in the Congo Basin, *Baillonella toxisperma* (Sapotaceae), is species frequently exploited for a number of products, which relies on mammals and local populations for dispersal of the species (Duminil *et al.*, 2016). In Madagascar, insects, lemurs, birds, and bats play an important role in improving agricultural yield, pollination and forest regeneration (Oleksy *et al*., 2017).

2.2.2.2 Regulation of climate

Ecosystem services play a critical role in mitigation and adaptation strategies for climate change. Forest ecosystems, in particular, contribute to mitigation, due to their capacity to remove carbon from the atmosphere and to store it. Effective agricultural management can also enhance carbon sequestration through soil conservation, or by introducing trees into agroforestry systems (Uprety *et al.*, 2012a). Well-managed ecosystems can further support adaptation to climate variability and change by providing a range of ecosystem services (Doswald *et al.*, 2014).

In cities, ecosystem based adaptation requires a robust understanding of landscape ecology and the potential of green infrastructure to improve the well-being of vulnerable communities, as in the case of Durban, South Africa (Roberts *et al.*, 2012). While ecosystem services are part of the solution to climate change, they are also, themselves, affected by changing climatic conditions (Chapter 3 & 4; SPM sections B & D). As a result, the provision of ecosystem services and the well-being of people that rely on these services are under threat by climate change. Such modification is expected to increasingly impact, both positively and negatively, the provision and value of ecosystem services.

Much attention has recently been focused on the role of Congo Basin forests in carbon sequestration, and the impacts of deforestation and forest degradation on global carbon emissions. For example, estimates made in the 2008 State of the Forests Report (de Wasseige *et al.*, 2008; Nlom, 2011; Chapters 3 & 4) estimate the total stock of carbon in Congo Basin forests to be some 47 billion tons **(Table 2.9)**. In key coastal and marine areas around the continent, climate change is increasingly impacting coral reefs and mangroves (Niang *et al.*, 2014; Chapters 3 & 4).

2.2.2.2.1 Regulation of hazards and extreme events

Extreme climatic events, in particular droughts and heat waves, significantly impact on ecosystem carbon and water cycles and a range of related ecosystem services (Chapter 4, section 4.2.1.1). As indicated above, ecosystem services may help in regulation of hazards and extreme events.

For example, in terms of coastal resilience, mangrove forests provide protection and shelter against extreme weather events, such as storm winds and floods, as well as tsunamis. Mangroves absorb and disperse tidal surges associated with such events. As indicated by Hirashi *et al.* (2003), a mangrove stand of 30 trees per 0.01 hectares with a depth of 100 metres can reduce the destructive force of a tsunami by up to 90%. Recent research by The Nature Conservancy and Wetlands International proves that mangroves reduce wave height by as much as 66% over 100 metres of forest (McIvor, 2012).

Floods and fires are considered natural hazards – that is, natural processes or phenomena occurring in the biosphere that may become damaging for human as well as for natural systems. They are most strongly subject to feedback processes and most directly influenced by human activities such as urbanisation and environmental degradation (Chapter 4, sections 4.2.1.2 & 4.2.1.4). Deforestation, for example, has a direct effect on the incidence and magnitude of flood events (Schaeffer *et al*., 2013). Additionally, benefits from flooding may occur through the transport of sediments and nutrients to the coastal zone, although the consequences of this are often negative. Ecosystem conditions and their services can play a role in modulating both the event and the human systems that create conditions of vulnerability. This is also true for natural systems. The preservation of natural areas is important for flood attenuation. For example, some natural soils (not affected by human activities) have a large capacity to store water, facilitate the transfer of groundwater, and prevent or reduce flooding. The capacity to hold water is dependent

Table 2 9 **Stock of carbon in Congo Basin forests (million tons). Source: de Wasseige *et al.* (2008); Nlom (2011).**

	Cameroon	Central African Republic	Congo	DRC	Equatorial Guinea	Gabon	TOTAL
Humid forests	3,203	886	3,263	18,056	383	4,033	**29,824**
Mosaic forest/croplands	414	167	534	1,945	57	287	**3,404**
Mosaic forest/savanna	628	2,437	145	3,059	3	20	**6,292**
Closed deciduous forest	6	54	73	1,625	0	10	**1,768**
Deciduous woodland	684	1,658	6	1,812	1	2	**4,163**
Open deciduous woodland	108	258	199	760	0	31	**1,356**
TOTAL	**5,043**	**5,460**	**4,219**	**27,258**	**445**	**4,383**	**46,808**

Box 2 1 **Regulating contributions by tropical rain forests.**

Major terrestrial ecosystems in the tropics are tropical rainforests and tropical savannas, basically separated by soil type and by period of the year when evapotranspiration is lower, the precipitation being 9–10 months for forests and 6–8 months for savannas, which define substantial differences in vegetation physiognomies. In other words, tropical forests cover an area of 17 million km^2 with 340 x 109 tons of Carbon stored in the above and below ground biomass, and tropical savannas cover 15 million km^2, with 24 x109 tons of Carbon. Therefore, tropical systems account for a substantial portion of the carbon stored in the atmosphere, highlighting the importance of these systems in the global carbon balance (IPCC, 2007).

on soil texture (size of soil particles and spaces between them) and soil structure. Wetlands, floodplains, lakes, and reservoirs are the main providers of flood attenuation potential in the inland water system.

For food production, Smith *et al.* (2010) have identified agricultural adaptation options that could have a positive impact on the mitigation of greenhouse gases emissions, such as measures that reduce soil erosion or increase the diversity of crop rotations. In the Economics of adaptation to climate change studies, the World Bank also identifies as options irrigation, improvement in water storage capacity and research and development to discover, for example, more drought-resistant species.

In terms of fisheries, sustaining affordable access to fish in the context of climate change will necessitate the adoption of adaptive measures aimed at protecting particular fish species or relieving fishing pressure on specific species or areas (Cinner *et al.*, 2012). The survival of freshwater fish species, for example, can be aided by creating thermal refugia such as deep ponds or reducing freshwater abstraction from rivers, lakes, and ponds (Wilby *et al.*, 2010). A study by Merino *et al.* (2012) shows that the global population's demand for fish could be sustained through 2050 in a scenario of 2°C warming by that time, by increasing aquacultural production and supporting the sustainable management of marine fish stocks (Niang *et al*., 2014; Chapters 3 & 4).

For the energy access, increased frequency and intensity of droughts increased rainfall seasonality, and wet extremes, are projected to affect hydropower and thermo-electricity production. To mitigate the impacts of climate change on the energy sector, there is a need to simultaneously address both supply and demand. In terms of ensuring supply of energy, investment in renewable sources, which do not depend on hydropower and water-cooling systems–thereby avoiding exposure to climatic changes is necessary (Willmott *et al.*, 2011; Chapters 3 & 4).

2.2.2.3 Regulation of freshwater and coastal quality

Ecosystems influence the hydrological functioning of watersheds through their contribution to rainfall interception, evapotranspiration, water infiltration, and groundwater recharge. This influence can reduce the impacts of climate variation on downstream population. For example, ecosystems can preserve base flows during dry seasons if they facilitate groundwater recharge; they can also reduce peak flows or floods during rainfall events if they contribute to rainfall interception and infiltration. In addition, ecosystems can reduce soil erosion and landslide hazards, which are partially climate related (Locatelli, 2016). The function of the forest in regulating the flow of water is well known.

As described earlier, mangroves are coastal forests that lie on the crossroad where oceans, freshwater, and land realms meet; and are key in the regulation of freshwater and coastal quality (Chapters 3 & 4). They are among the most productive and complex ecosystems on the planet, thriving in salty and brackish conditions that would just kill ordinary plants very quickly. Their capacity to protect against storms and even sea level rise make them indispensable for coastal communities in their fight against climate change. African mangroves are home to very diverse fauna. Aquatic mammals include monkeys, antelopes, and manatees. Its roots and mud are home to molluscs, such as bivalves and oysters, and crustaceans. Live and decaying mangrove leaves and roots provide nutrients that nourish plankton, which in turn are food for many of these species. With this abundance of food, mangroves function as nurseries for many fish species; many of commercially caught fish have spent part of their lives in mangroves. Mangroves are also home to terrestrial fauna, including mammals, reptiles, and avian species; especially waterbirds (McIvor, 2012).

Mangroves also play a vital role in climate change mitigation and adaptation, as mentioned previously (Chapter 4, section 4.2.2.2). Ecosystems services related to climate change mitigation and adaptation include carbon sequestration at rates higher than terrestrial forest systems, a buffer against shoreline erosion, protection against extreme weather events through absorption and dispersion of tidal surges, and groundwater recharge. While estimates vary, many scientific studies have indicated that mangroves are among the most intense carbon sinks on the planet and that they sequester higher amounts of carbon than terrestrial forest ecosystems (Hutchinson *et al.*, 2014). Given the amount of carbon that mangroves sequester and the important socio-economic benefits derived from mangroves, Reduced Emissions from Deforestation and Forest Degradation activities-including conservation, sustainable management, and the enhancement of carbon stocks-have great potential to contribute to climate change mitigation efforts while providing economic development opportunities to the region.

In term of species, certain tree species could contribute indirectly to water regulation, in controlling pollution, for example. As an example, for water pollution control, suspension of the ground seed of *Moringa oleifera*, the benzolive tree, is used as a primary coagulant. It can clarify water of any degree of visible turbidity (ISO, 2016).

2.2.2.4 Soil amelioration

Soils play a pivotal role in major global biogeochemical cycles (carbon, nutrient, and water) while hosting the largest diversity of organisms on land. As a result, soils deliver fundamental ecosystem services. A soil process in support of one ecosystem service can either provide co-benefits to other services or result in trade-offs. The ability of soils to provide services is principally conferred by two attributes: the range of biogeochemical processes that occur in the soil, and the functionality of soil biodiversity (Smith *et al.*, 2015). As mentioned earlier, carbon storage is an important ecosystem function of soils that has gained increasing attention in recent years. Changes in soil carbon impacts on, and feedback to, the Earth's climate system through emissions of CO_2 and CH_4, as well as storage of carbon removed from the atmosphere during photosynthesis (climate regulation). Soil organic matter itself also confers multiple benefits, such as enhancing water purification and water holding capacity, protecting against erosion risk, and enhancing food and fibre provision through improved soil fertility (Pan *et al.*, 2013, 2014). Moreover, soil is an important carbon reservoir that contains more carbon (at least 1,500–2,400 PgC) than the atmosphere (590 PgC) and terrestrial vegetation (350–550 PgC) combined (Ciais *et al.*, 2013; Schlesinger *et al.*, 2013) and an increase in soil carbon storage can reduce atmospheric CO_2 concentrations (Whitmore *et al.*, 2014). After carbon, nitrogen is the most abundant nutrient in all forms of life, since it is contained in proteins, nucleic acids, and other compounds (Galloway *et al.*, 2008). Organisms ultimately acquire Nitrogen from plants, which on land is mostly taken up in mineral form (i.e., NH_{4^+} and NO_3) from the soil. Soils further provide important ecosystem services through their influence on the water cycle. These services include provisioning services of food and water security, regulating services associated with moderation, and purification of water flows, and they contribute to the cultural services of landscapes/water bodies that support recreation and aesthetic values (Dymond, 2014). Furthermore, soils represent a physically and chemically complex and heterogeneous habitat supporting a high diversity of microbial and faunal taxa. These complex communities of organisms play critical roles in sustaining soil and wider ecosystem functioning, thus conferring a multitude of benefits to global cycles and human sustainability. Specifically, soil biodiversity contributes to food and fibre production and is an important regulator of other soil services, including greenhouse gas emissions, water purification (Bodelier, 2011).

Forest soils support the diversification of livelihoods and their role in providing ecosystem services which underpin the agricultural production system–through soil formation, nutrient cycling and provision of green manure and microclimate regulation; further enhancing synergies between the forest-tree landscape and the wider food production system (MA, 2005). Land clearing and slash-and-burn practices pose a particular threat to forests, mostly in the Eastern and Southern subregions (Chapters 3 & 4).

2.2.3 Non-material Contributions

Nature's non-material contributions are highly significant, even though their sources are intangible and based on cultural context. This section provides an overview of nature's non-material contributions in Africa, through highlighting the links between biodiversity, ecosystem services, spiritual, religious significance, and other immaterial services. The section further shows relevant cases of such contributions and the interrelations between these dimensions.

2.2.3.1 Supporting identities

Africa's cultural landscapes and habitats support religious and social experiences, according to Opoku (1978). Thus, the unseen is as much a part of reality as that which is seen. There is a complementary relationship between the two, with the spiritual seen as, in certain circumstances, more powerful than the material. A number of traditions and belief systems recognise linkages between health, diet, properties of different foods and medicinal plants, and horticultural/natural resource management practices–all within a highly articulated cosmological/social context (Edwards *et al.*, 1997). **Table 2.10** below describes certain examples of supporting identities based on landscapes with religious, spiritual and social cohesion experiences in selected African countries.

2.2.3.2 Physical and physiological experiences

Natural ecosystems in Africa provide significant opportunities for tourism, healing, relaxation, leisure, recreation, aesthetic appreciation, inspiration and education (e.g., hiking, recreational hunting, and fishing, birdwatching, snorkelling, gardening). Such services can improve mental and physical health; enhance a subjective sense of culture or place; and also enrich objective knowledge of natural and social sciences. Recently, Africa has been considered as one of the fastest growing tourism regions in the world. The continent holds more than a 5% share in tourism arrivals, and a 3.5% share of tourism receipts globally (UNWTO, 2017). 'Wildlife Watching Tourism' is considered a highly significant tourism segment in Africa. These activities can provide job opportunities for the local population through providing services to visitors, working as tour guides, staff, and cultural performers.

Ecotourism effectively managed by indigenous and local communities can promote biodiversity conservation and improve community development. Such positive outcomes are contingent, amongst others, upon improving the management and marketing skills of the local communities

Table 2 10 **Selected case studies of landscapes being the basis for religious and spiritual and social cohesion in Africa.**

LANDSCAPES/SEASCAPES, HABITATS OR ORGANISMS	RELIGIOUS AND SPIRITUAL LINKAGES	SOCIAL COHESION LINKAGES
Kagore Shona people in Zimbabwe use burial grounds as sacred sites	Spiritual significance 'deeply embedded' in the cultural landscape (Matowanyika, 1997)	–
Loita Maasai's 'forest of the lost child' in Kenya	Spiritual forest among the Maasai	Direct expression of the relationship between communities and their habitats (Poole, 1993; Kakonge, 1995).
Wildlife products from Dryland areas in Nigeria (Adeola, 1992)	Wildlife products play important roles in the performance of spiritual rites (e.g., invoking and appeasing traditional gods and witches), and as constituents in traditional medicines or for aphrodisiac, fertility or potency purposes	Wildlife products play important roles in community ceremonies (e.g., funerals and installation of rulers)
Great Fish River Wetland in the AmaXhosa communities	Performance of spiritual rituals in wetlands sites to maintain a spiritual relationship with ancestors (Biggs *et al.*, 2004)	Wetland sites shape community's cultural identity
Wetlands in Niger Delta (James *et al.*, 2013) and in Cameroon (Feka *et al.*, 2008)	Deeply held spiritual values linked to wetlands in Nigeria and protected mangroves in Cameroon	–
Mountainous forest Mafa- Bécédi-brignan in Ivory Coast. (Kouassi *et al*., 2008)	The sacred forest is seen as an ancestral heritage for the Akyé people and the site has a spiritual and religious significance to the people	The forest is used as a site for community festivals such as the generation day ("Fankwé") and the feast of yams (the "Yabe")

(Coria *et al.*, 2012). Botswana and Namibia provide (in certain sites) successful examples of how government policies that have banned commercial hunting and promoted community-based ecotourism have contributed to the conservation of wildlife and development of the local communities (Naidoo *et al.*, 2016).

2.2.3.3 Social relationships, spirituality and cultural identity

Natural ecosystems play a central role in cultural and spiritual practices for many indigenous and local communities in Africa, as indicated earlier. For example, Laikipia Maasai communities in Kenya are dependent on livestock for livelihoods and food security, which is dependent on the sustainability of a healthy environment. Spiritual leaders help the communities in interpreting variation in natural ecosystems, and advising in terms of response, including preparation for migration or shifting to new locations. Spiritual chiefs lead rituals and ceremonies to help the community connect with nature and remember the role of nature in the sustenance of life (Kaunga, 2016). These spiritual rituals involve, in many cases, the use of specific trees or species for their spiritual value. Many seeds and/or crops are critical during rituals and ceremonies (Kaunga, 2016; Mburu *et al.*, 2016).

As a further example, shellfish have an important patrimonial and symbolic value in Bijagos communities' culture, located in the island of Orango Grande, off the coast of Guinea, west of Africa. Shellfish are included in their religious ceremonies, as well as in other aspects of their life. For example, shellfish, along with other products such as tobacco, rice, or palm wine, is offered by the youngest to the oldest as a form of 'paying respect to the greatness of wisdom. Honey is also connected to the social life of these communities (Cormier-Salem *et al.*, 2010).

Studies have demonstrated relationships between biodiversity, human cultural, and linguistic diversity in Africa (Moore *et al.*, 2002). Aspects of cultural diversity include language, customs, habits, beliefs, local knowledge and practices used in the management of natural resources (Shemdoe, 2017). By being the sites of approximately 30% of the world languages, Africa is considered the richest worldwide in linguistic diversity, with more than 2,500 spoken languages (Batibo, 2006). Studies indicate, however, a decline in the African cultural and linguistic diversity (Batibo, 2006; Yankuzo, 2014). Effective management of natural resources and conservation of biodiversity of any cultural landscape require a better understanding of associated cultures, including linguistic diversity.

There is, thus, a growing recognition of the importance of protection of the different aspects of cultural diversity, including documentation of ILK of the respective local communities and the vernacular names bestowed on the species existing in the endangered cultural landscape (Yankuzo, 2014; Shemdoe, 2017; SPM sections A, B, & D). For example, efforts were made to record the cultural heritage of the Luhya people of the Kakamega region in Kenya to document vernacular bird names to improve conservation efforts of rare bird species (Sagita *et al.*, 1998).

2.2.3.4 Learning and inspiration

Nature on the African continent provides opportunities for gaining of knowledge and development of practices and skills for human well-being. One example here would be the development of 'sensory ecology' as a new scientific field in the 1940s by Felix Santschi, through his research studies on desert ants' navigation in the Tunisian desert (Wehner, 1990).

As described previously, African indigenous and local communities have developed knowledge, practices, and experiences through their interactions with their biophysical environment, observing changes and dynamics of natural ecosystems; which have allowed them to respond to environmental changes and disturbances over time and space. Validation and integration of ILK have, to some extent, taken place in the pharmaceuticals sector through evaluation of the medicinal effectiveness of many plants used in folk medicine. This has led to the discovery and extraction of many bioactive secondary metabolites, many of which have been used for the production of effective drugs (Dias *et al.*, 2012; Mahomoodally, 2013).

There is a growing scientific recognition of the importance and merit of integration of ILK with conventional forms of knowledge to develop new knowledge systems for facing future challenges and coping with environmental changes, especially for the design of adaptation and mitigation strategies (Dias *et al.*, 2012; Gómez-Baggethun *et al.*, 2013; Chapter 1, section 1.3.2; SPM section A). There is significant potential for integration of ILK in sustainable agriculture practices, ecological restoration, land conservation and adaptive management of natural resource (Dias *et al.*, 2012). The incorporation of the ILK in the rehabilitation activities of degraded lands due to mechanised rain-fed agriculture in the southern Gadarif region in Sudan, for example, should successfully support improved rehabilitation (Sulieman *et al.*, 2012).

The agroforestry parkland system approach is one of several techniques for management of soil fertility adopted widely by local communities in Africa (Lesueur *et al.*, 1995). It is a dominant farming system that covers the majority of the cultivated area in the Sahelian countries in Africa. In this system, farmers grow their crops in combination with wild multipurpose trees. This system has supported farmers' livelihoods for centuries. Farmers select and protect useful multipurpose species on their farmlands. The local farmers' strategy is to simultaneously gain the advantage of collecting from wild plants resources while growing different crops, and benefiting from the enhancing effect that wild plants have on soil (Nikiema, 2005).

Proper selection of species to be used in ecological restoration activities is critical for successful restoration. Integration of ILK with scientific knowledge could facilitate selection of species with both ecological importance and traditional value, thus ensuring the effectiveness of the restoration activities (Higgs, 2005; Uprety *et al.*, 2012a).

For crop selection, indigenous and local communities have developed land management approaches that depend on monitoring changes in wild plant species composition, particularly indicators of good soil quality. Farmers also use many species as indicators of poor soil condition, and as signs of land degradation. For example, local communities of Gadarif region in Sudan use the occurrence of species such as *Striga hermonthica*, *Veronica sp.*, *Evolvulus alsinoides*, *Desmodium dichotomum*, *Sonchus cornutus*, *Sorghum arundinaceum*, *Ocimum basilicum* and *Schizachyrium* in the agricultural land as indicators of land degradation (Sulieman *et al.*, 2012). In Niger, the presence of certain grasses such as the kounkoumbara (*Jacquemontia ovalifolius*), and the Tsintya (*Schoenfeldia gracilis*) is considered a sign of poor soil condition (Moussa *et al.*, 2008).

As a further example, farmers in Mpwapwa district of Tanzania rely on their traditional knowledge to determine soil quality, using a range of indicators such as soil colour and types of plants inhabiting the region. For example, the occurrence of Mahata (*Tragus berteronianus*) in a specific area is an indicator of soil suitability for growing maize, while the presence of Mphangalile (*Bidens lineoriloba*) is an indicator that the soil is suitable for growing groundnuts (Shemdoe, 2017). Certain native plants in deserts are also used as indicators of soil fertility. Local inhabitants in northern Sinai in Egypt, for example, consider the occurrence of the grass *Panicum turgidum* a sign of the fertility of the soil and they prefer to grow crops where the species occur (Halmy, 2016). In Niger, soils harbouring a high diversity of woody and grass species such as the *Guiera senegalensis*, *Piliostigma reticulatum*, *Andropogon gayanus*, *Cenchrus biflorus*, is considered as fertile soil (Moussa *et al.*, 2008).

For proper integration and dissemination of the ILK and traditional practices, comprehensive documentation of this body of knowledge is necessary (Bidak *et al.*, 2015; Halmy, 2016; Shemdoe, 2017). It is also important to translate the documented practices into national languages to make it accessible to researchers and decision-makers (Uprety *et al.*, 2012b; Shemdoe, 2017).

2.3 GEOGRAPHICAL DIFFERENCES IN PRODUCTION AND CONTRIBUTION OF ECOSYSTEM SERVICES

The particular location of Africa has contributed to the environmental conditions shaping the geographic distribution and the high diversity of its habitats and biomes (Chapters 1 & 4; SPM sections A & B). Chapter 3 to follow provides particular details in this regard.

2.3.1 Regulating contributions according to subregions and units of analysis

There are significant spatial differences with regard to regulating contributions of units of analysis **(Table 2.10)**. Observed differences are closely linked to differences in spatial distribution of those ecosystems across African regions (MA, 2005; Chapter 3). The highest contribution of tropical and subtropical dry and humid forests to regulating nature's contributions to people is in West and Central Africa. East Africa and adjacent islands and Southern Africa share comparable regulating nature's contributions to people when we consider Mediterranean forests, woodlands, and shrubs (Chapter 3). The highest regulating nature's contributions to people of mountainous regions are derived mainly from the highest mountainous areas in Africa, namely East Africa and, to some extent, West Africa (Chapter 3). Regulating nature's contributions to people of tropical and subtropical savannas and grasslands is the highest in Southern Africa **(Table 2.10)**. Their contribution to regulating nature's contributions to people in Central and North Africa is comparably low. Overall, most of Africa's subregions have some contribution to the regulating nature's contributions to people, irrespective of the unit of analysis, with the exception of North Africa for tropical and subtropical dry and humid forests **(Table 2.11)**.

Across the five subregions in Africa (North, West, Central, East and South), human influenced areas have no significant regulating contributions. Urban and semi-urban areas, and cultivated areas (mainly intensive agriculture and livestock– see Chapter 3) have generally negative effects on climate and ecosystems through their contribution to the soil, air and water pollution and greenhouse gases emission. However, as mentioned earlier, carbon sequestration on agricultural lands is possible through a range of soil management strategies (Kane *et al.*, 2015).

Wetlands, including peat lands, mires, and bogs have good regulating contributions (flood moderation, climate regulation) respectively in Central Africa and East Africa (including the Great Lakes Region–see Chapter 3, and example in **Box 2.2**). Regulating contribution is moderate for West Africa wetlands, weak for Southern Africa and very weak for North Africa. Drylands and deserts, covering about 40% of the land of Northern Africa (MA, 2005), have a good contribution to carbon cycling and climate regulation while contributing moderately in West Africa, East Africa, and Southern Africa. Drylands store carbon at about the same rate as evergreen forests (Jaramillo *et al.*, 2003). In addition, deserts provide genetic resources in the form of many species adapted to aridity, excessive temperature, high salinity and other harsh condition.

Freshwater, Inland surface, Shelf ecosystems, Open ocean, Deep sea and Coastal areas are among instrumental ecosystems in Africa, with strong spatial variation regarding their regulating, material contributions and non-material contributions (Brown *et al.*, 2008, UNEP 2016). Because of their relatively wide distribution in East Africa and adjacent islands, wetlands (Chapter 3) and inland surface waters

Box 2 2 **Water purification through wetlands: Nakivubo Swamps, Uganda.**

The Nakivubo swamps are adjacent to Uganda's capital city, Kampala. The local government had proposed draining the swamps to make way for agriculture, but when a study revealed that this ecosystem was providing a valuable service by filtering organic waste and other effluent derived from Kampala, the proposal was discarded. The study indicated that a water-purification facility capable of performing the same service would cost several million US dollars to construct, and $2 million/year to maintain. In this case, the value of converting land for agriculture would be offset by the cost of lost sewage-treatment capacity. Direct investment to maintain the wetland was a cost-effective measure to uphold the purification service. This example demonstrates how detailed information and cost estimates can better inform planning decisions.

Table 2 11 **Regulating nature's contributions to people according to subregions and ecosystem units of analysis.**

	ECOSYSTEM UNIT OF ANALYSIS	Regulating nature's contributions to people (water purification, climate regulation, or soil erosion regulation, etc.) — Subregions of Africa (from IPBES Africa regional assessment scoping document)				
		East Africa and adjacent islands	Southern Africa	Central Africa	North Africa	West Africa
		Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Mauritius, Mayotte, Reunion, Rwanda, Seychelles, Somalia, South Sudan, Uganda and United Republic of Tanzania	Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe	Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon and Sao Tome and Principe	Algeria, Egypt, Libya, Mauritania, Morocco, Sudan, Tunisia and Western Sahara	Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo
TERRESTRIAL	Tropical and subtropical dry and humid forests	Weak contribution	Moderate contribution	Excellent contribution	NA	Good contribution
	Mediterranean forests, woodlands and shrub	Excellent contribution	Excellent contribution	Moderate contribution	Excellent contribution	Good contribution
	Tundra and High Mountain habitats	Excellent contribution	Moderate contribution	Weak contribution	Very weak contribution	Weak contribution
	Tropical and subtropical savannas and grasslands	Good contribution	Excellent contribution	Very weak contribution	Very weak contribution	Good contribution
	Drylands and Deserts	Moderate contribution	Moderate contribution	NA	Good contribution	Moderate contribution
	Wetlands – peatlands, mires, bogs	Good contribution	Weak contribution	Excellent contribution	Very weak contribution	Moderate contribution
	Urban/Semi-urban areas	Very weak contribution	Very weak contribution	Very weak contribution	Very weak contribution	Very weak contribution
	Cultivated areas (including cropping, intensive livestock farming, etc.)	Weak contribution	Weak contribution	Weak contribution	Weak contribution	Weak contribution
AQUATIC	freshwater, brackish and marine	Excellent contribution	Weak contribution	Moderate contribution	Very weak contribution	Moderate contribution
	Inland surface waters and water bodies/freshwater	Excellent contribution	Weak contribution	Moderate contribution	Very weak contribution	Moderate contribution
	Shelf ecosystems (neritic and intertidal/littoral zone)	Weak contribution	Weak contribution	Weak contribution	Weak contribution	Weak contribution
	Open ocean pelagic systems	Good contribution	Good contribution	Moderate contribution	Moderate contribution	Good contribution
	Deep-Sea	Excellent contribution	Excellent contribution	Moderate contribution	Moderate contribution	Excellent contribution
	Coastal areas intensively and multiply used by human	Very weak contribution	Very weak contribution	Very weak contribution	Very weak contribution	Very weak contribution

FORESTS- WOODLANDS – SAVANNAS – GRASSLANDS

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

and water bodies/freshwater and shelf ecosystems (neritic and intertidal/littoral zone) provides excellent regulating contributions there, while moderate to weak contribution are observed in the other regions.

Deep sea areas of oceans constitute the so-called blue lungs of the planet, due to their highlighted role as global warming 'regulator'. East Africa and adjacent islands, Southern Africa and West Africa are regions where this is mainly a factor. These regions contribute strongly to regulating contributions, as compared to the two other regions.

2.3.2 Material contributions according to subregions and units of analysis

The material contribution is the highest for West, East Africa and adjacent islands, when tropical and subtropical dry and humid forests are taken into account (MA, 2005; **Box 2.3**; Chapter 3). This is further observed for woodlands, shrubs and Tropical and subtropical savannas and grasslands. However, a moderate and low contribution is noticed for these four major ecosystems when we consider tundra and high mountain habitats **(Table 2.12)**. North Africa shows globally the same tendency for all units of analysis, and has a relatively low contribution to material services.

Regardless of the region, urban and semi-urban areas have very weak to no material contribution in term of provisioning ecosystem services (Chapter 3). For West, East, and Southern regions of Africa, cultivated areas have good material contribution through provisioning of biofuel crops, animal waste, fuel wood, agricultural residue pellets, and food from domesticated organisms, amongst others. In regions of African Great Lake (East Africa and adjacent islands and Central Africa) and in West Africa, wetlands, peatlands, mires, and bogs have excellent contribution through provisioning of drinking water, irrigation water, hydro-power, fishes, minerals, and fuels (Upton *et al.*, 2013). Drylands and desert have a low material contribution in West, East, and Southern Africa while having moderate material contribution through provisioning food, fibre, forage, medicinal plants, wood fuel and biochemical; fresh water; hydrocarbons (oil and gas); metals and metallic minerals; precious minerals etc.

Freshwater, brackish and marine contributions are well distributed in East Africa and adjacent islands (http://www.zonu.com/fullsize-en/2009-11-07-10918/African-Wetlands.html; Chapter 3), where they strongly contribute to material contributions. In Central Africa and West Africa, their contribution is moderate, while weak in Southern Africa and North Africa, with the exception of the contributions from the Nile River to the livelihood of the people in Egypt and Sudan. Similar patterns are observed for inland surface waters and water bodies/freshwater contributions.

2.3.3 Non-material nature's contributions to people according to subregions and units of analysis

Non-material contributions refer to contribution to people's subjective or psychological quality of life, individually and collectively as defined in the update on the classification of nature's contributions to people by the IPBES (IPBES/5/INF/24). West and Central Africa show the highest value for non-material contributions, especially for tropical and subtropical dry and humid forests. For North Africa, this does not apply for most biomes, except for Mediterranean forests, woodlands, and shrub. Eastern, Southern, and Central Africa, on the other hand, show high contribution for non-material services as regards tropical and subtropical savannas and grasslands **(Table 2.12)**. Importance of non-material provisions in sustaining remaining forests has been reported (UNEP, 2016). Neglecting cultural values and services in the design of interventions can produce dire unintended consequences and can impede the achievement of program goals. For example, West (2006) documented how marketing cultural forest goods in Papua New Guinea, an economic-development strategy to offset the consequences of conservation interventions, overlooked the numerous ways in which local peoples used the land and how wildlife contributed to their sociocultural system (Chan *et al.*, 2012).

Box 2 3 Case study of material contribution in Miombo and Mopane (Malawi).

Miombo and Mopane woodlands are the dominant land cover in southern Africa. Nature's contributions to people from these woodlands support the livelihoods of 100 million rural people and 50 million urban dwellers, and others beyond the region. Material contributions to rural livelihoods are estimated to $9 ± 2 billion/year; 76% of energy used in the region is derived from woodlands; and traded woodfuels have an annual value of $780 million. Woodlands harbour a unique and diverse flora and fauna that provides spiritual succour and attracts tourists (Ryan *et al.*, 2016).

Table 2 12 **Material nature's contributions to people according to subregions and ecosystem units of analysis.**

	ECOSYSTEM UNIT OF ANALYSIS	Regulating nature's contributions to people (Functional and structural aspects of organisms and ecosystems that modify environmental conditions experienced by people, and/or sustain and/or regulate the generation of material and non-material benefits, such as soil formation, pollination, seed dispersal, fresh water regulation, air quality regulation, etc.)				
		Subregions of Africa (from IPBES Africa regional assessment scoping document)				
		East Africa and adjacent islands	Southern Africa	Central Africa	North Africa	West Africa
		Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Mauritius, Mayotte, Reunion, Rwanda, Seychelles, Somalia, South Sudan, Uganda and United Republic of Tanzania	Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe	Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon and Sao Tome and Principe	Algeria, Egypt, Libya, Mauritania, Morocco, Sudan, Tunisia and Western Sahara	Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo
TERRESTRIAL	Tropical and subtropical dry and humid forests				NA	
	Mediterranean forests, woodlands and shrub					
	Tundra and High Mountain habitats					
	Tropical and subtropical savannas and grasslands					
	Drylands and Deserts					
	Wetlands – peatlands, mires, bogs					
	Urban/Semi-urban areas					
	Cultivated areas (including cropping, intensive livestock farming, etc.)					
AQUATIC	freshwater, brackish and marine					
	Inland surface waters and water bodies/freshwater					
	Shelf ecosystems (neritic and intertidal/littoral zone)					
	Open ocean pelagic systems					
	Deep-Sea					
	Coastal areas intensively and multiply used by human					

FORESTS- WOODLANDS – SAVANNAS – GRASSLANDS

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

Table 2 13 Non-material nature's contributions to people according to subregions and ecosystem units of analysis.

	ECOSYSTEM UNIT OF ANALYSIS	Non-material nature's contributions to people –Many cultural ecosystem services as defined in the Millennium Ecosystem Assessment.				
		Subregions of Africa (from IPBES Africa regional assessment scoping document)				
		East Africa and adjacent islands	Southern Africa	Central Africa	North Africa	West Africa
		Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Mauritius, Mayotte, Reunion, Rwanda, Seychelles, Somalia, South Sudan, Uganda and United Republic of Tanzania	Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe	Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon and Sao Tome and Principe	Algeria, Egypt, Libya, Mauritania, Morocco, Sudan, Tunisia and Western Sahara	Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo
TERRESTRIAL	Tropical and subtropical dry and humid forests	Weak contribution	Weak contribution	Excellent contribution	Very weak contribution	Excellent contribution
TERRESTRIAL	Mediterranean forests, woodlands and shrub	Very weak contribution	Very weak contribution	Moderate contribution	Moderate contribution	Weak contribution
TERRESTRIAL	Tundra and High Mountain habitats	Excellent contribution	Good contribution	Very weak contribution	Very weak contribution	Very weak contribution
TERRESTRIAL	Tropical and subtropical savannas and grasslands	Good contribution	Excellent contribution	Excellent contribution	Very weak contribution	Moderate contribution
TERRESTRIAL	Drylands and Deserts	Weak contribution	Weak contribution	Weak contribution	Excellent contribution	Weak contribution
TERRESTRIAL	Wetlands – peatlands, mires, bogs	Excellent contribution	Excellent contribution	Good contribution	Weak contribution	Excellent contribution
TERRESTRIAL	Urban/Semi-urban areas	Very weak contribution	Very weak contribution	Very weak contribution	Very weak contribution	Very weak contribution
TERRESTRIAL	Cultivated areas (including cropping, intensive livestock farming, etc.)	Moderate contribution	Moderate contribution	Moderate contribution	Moderate contribution	Moderate contribution
AQUATIC	freshwater, brackish and marine	Very weak contribution	Very weak contribution	Very weak contribution	?	Very weak contribution
AQUATIC	Inland surface waters and water bodies/freshwater	Moderate contribution	Moderate contribution	Good contribution	Moderate contribution	Good contribution
AQUATIC	Shelf ecosystems (neritic and intertidal/littoral zone)	Weak contribution	Weak contribution	Weak contribution	Weak contribution	Weak contribution
AQUATIC	Open ocean pelagic systems	Very weak contribution	Very weak contribution	Very weak contribution	Very weak contribution	Very weak contribution
AQUATIC	Deep-Sea	NA	NA	NA	NA	NA
AQUATIC	Coastal areas intensively and multiply used by human	Good contribution	Good contribution	Good contribution	Good contribution	Good contribution

FORESTS- WOODLANDS – SAVANNAS – GRASSLANDS

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

Excellent contribution | Good contribution | Moderate contribution | Weak contribution | Very weak contribution | Non applicable

For all regions of Africa, urban and semi-urban could have a very low contribution in term of non-material services (Chapter 3). With regards to cultivated areas, they have a moderate non-material contribution. These areas are also of high interest to researchers. In terms of wetlands, peatlands, mires, and bogs, good non material contribution is evident, especially in West Africa, Southern Africa, Central Africa and East Africa and adjacent islands, where they represent important sites for cultural activities (Adams, 1993; Verschuuren, 2010), for eco-tourism (Crisman *et al.*, 2001) and for research.

Apart from North Africa, where drylands and deserts are culturally integrated (Davis, 2004), these biomes have a low non material contribution in the other regions of Africa. Certain communities, particularly in North Africa, have lived in deserts for millennia. These communities ranged in their activities from hunter-gatherers, agriculture, and pastoralism. In Africa, deserts have contributed extensively to global culture, traditions and the body of scientific knowledge (Ezcurra, 2006). Deserts provide opportunities for spiritual and recreational contributions.

2.4 STATUS, TREND, FUTURE DYNAMICS OF NATURE'S CONTRIBUTIONS PEOPLE (NCP)

2.4.1 Status of NCP

The status, trends and future dynamics of contributions of nature to people in Africa are diverse but also depend on the underlying drivers and subregional/national level understanding, interpretation and integration of NCP into land-use and nature conservation (Chapters 3 & 4). The underlying drivers of status, trends and future dynamics of NCP include natural direct drivers relating to non-human processes and activities, whose occurrences are beyond human influence including natural climate and weather patterns, as well as extreme events such as prolonged drought or cold periods, tropical cyclones and floods, glacial lake outburst floods, earthquakes, volcanic eruptions and tsunamis (Chapter 4, sections 4.2.1.1 & 4.2.2.2). Anthropogenic direct drivers are those which result from human decisions and actions, such as institutions and governance systems, and other indirect drivers including degradation, exclusion and restoration of terrestrial and aquatic habitats, intensification or abandonment, harvesting of wild populations, climate changes produced by urbanisation and industrial emissions, pollutions of soil, water or air due to population pressures and species introductions (Chapter 4).

These underlying factors affect contributions of nature to people in different aspects, including climate regulation, disturbance regulation, water regulation, water supply, erosion control and sedimentation retention, soil formation, nutrient cycling, waste treatment, biological control, food production, raw materials, genetic resources, recreation and cultural heritage (Chapter 4). This Assessment uses the African subregions including North Africa, West Africa, Central East Africa and adjacent islands, and Southern Africa as ecosystem units of analysis. Such an approach is due to the level of understanding and interpretation of how NCP in public policy at the national, subregional and regional level play a significant role in biological diversity and ecosystem services. The methodology adopted in this section was to use the IPBES' categories of NCPs, and identify specific indicators as representations in the African subregions.

2.4.1.1 Habitat creation and maintenance

Protected areas are specifically earmarked and devoted areas of land or sea for the conservation and maintenance of biodiversity including natural and associated cultural resources, often governed through legally established systems. Chapters 3, 4 and 6 provide substantively more detail in this regard (Chapter 1; SPM sections B, D, & E).

2.4.1.2 Dispersal of threat potentials

The relationships among invasive alien species, terrestrial, freshwater and marine environments play significant roles in the status of nature's contributions to people. The introduction of invasive alien species causes changes to water regulation, waste treatment, weed control, water supply, erosion control and sedimentation retention, food production, recreation, and genetic resources (United Republic of Tanzania, 2014; Chapter 4, section 4.2.2.4). The status of nature's contributions to people is also affected by utilisation of biodiversity. Further details on this are provided in Chapter 4. Common challenges on the continent are over-fishing/harvesting and hunting inhibiting food production, biological control, genetic resources and availability of raw materials (Chapters 3 & 4).

A range of policies and strategies have been developed to support forests on the continent to be able to contribute to the regulation of hazards and extreme events (Fasona *et al.*, 2015, 2016; Chapter 6). Despite the progress in developing climate change policies in many African countries, a number have not reached the implementation stage, let alone made clear progress on mainstreaming (Chapter 6; SPM section E).

2.4.2 Trends of nature's contributions to people

2.4.2.1 Habitat Creation and Maintenance

In sub-Saharan Africa, both national and international (as well as regional) initiatives have resulted in the growth of protected areas (Chapter 4, section 4.5.1; SPM sections B, D, & E). For example, in 1998, Equatorial Guinea developed their protected area extension network from 3,196 to 5,081 km^2, representing about 18.1% of the national land area (Machado, 1998).

Despite challenges to protected area creation and management (Chapters 4 & 6), the establishment of protected areas can procure a net benefit in terms of total economic value **(Table 2.14)**. For instance, in West Africa, the comparison of the total economic value of ecosystem services within marine protected areas and ecosystem services located in non-protected zones (comparative area) shows that, while the direct use value (associated with fish and wood production mainly) is higher in a non-managed area, since there is no limitation on extractive activities, the indirect use value associated with carbon sequestration, fish biomass production, water purification and coastal protection against erosion is higher in marine protected areas than in the comparative area indicating a better quality and quantity of ecosystem services. This benefit is largely due to the better health status of ecosystems in marine protected areas that can be assimilated to a better resilience capacity in face of global changes (Bonin, *et al.*, 2016).

2.4.2.2 Materials and assistance

Chapters 3 and 4 provide detail on status and trends in deforestation, land transformation and losses due to, for example, poaching and unsustainable offtake (SPM section B). For example, in Southern Africa, the main concern over ivory poaching is in Mozambique, where the combined elephant population in the Selous-Niassa Ecosystem lost an estimated 7,000 elephants in the period between the 2009 and 2011 surveys (European Union, 2016).

2.4.2.3 Regulation of threat potentials

As described previously, and in more detail in Chapters 3 and, most particularly, 4; Africa is expected to be particularly severely impacted by climate change (SPM section B). Impacts on ecosystem services are already evident, with, in certain cases, future impacts likely to be severe (Niang *et al.*, 2014; Chapters 3 & 4; SPM section B). Impacts of invasive alien species (IAS) have already been referred to in Chapter 1, and are covered in detail in Chapter 4 (Chapter 4, section 4.2.2.4.3; SPM sections B & D). IAS are currently already impacting nature's contributions to people and ecosystem services, a trend that is likely, in certain areas, to worsen in the future (Chapter 4, section 4.2.2.4.3; SPM sections B & D).

2.4.3 Future Dynamics of nature's contributions to people

A range of international frameworks (Chapters 3, 4, & 6; SPM sections C, D, & E) have highlighted the importance of identifying, designating and managing protected areas as fundamental to biodiversity and ecosystem in relation to nature's contributions to people. Important indicators include the proportion of protected areas in relation to total land area and by type of ecosystems, as well as progress made by regions/subregions/countries with regards to implementation of international policies on natural resource use, protection and monitoring (Chapters 5 & 6; SPM sections C, D, & E). The future dynamics of nature's contributions to people in Africa could be influenced by both direct and indirect activities in the proportion of protected areas relative to the total land area and by type of ecosystems, progress made by regions/subregions/countries with regards

Table 2 14 **Benefits of ecosystem protection; an example of marine protected areas in West Africa. Source: Failler *et al.* (2012).**

	Marine protected areas*($ million)	Comparative areas*	Benefits
Direct use value	11.2	20.4	-9.1
Indirect use value	39.5	28.8	10.6
Non-use value	0.5	0.6	-0.1
TOTAL	**51.1**	**49.8**	**1.3**

*based on the same surface (MPA surface as reference) to implementation of international policies on natural resource use, protection and monitoring (Chapter 4, sections 3.5.2 & 3.5.3).

The future dynamics of protected areas in Africa are likely to depend on the following strategies (Chapters 4, 5 & 6):

- **Economic and land tenure reform strategies:** Progress in privatisation and commercialisation of protected areas will be improved by land ownership and tenure security which guarantees long-term investments and productivity. It should also create an inclusive financial environment that is accessible to all. Efforts to strengthen national and regional land governance towards protected areas is an imperative (Chapter 6).

- **Landscape-wide conservation planning:** a broad-based picture of conservation strategies which integrate protected areas into development goals covering all biomes, sectors, and subregions will be more useful in achieving development goals.

- **Resolving conflict:** Policy and legislation should address competition from other land-uses and between local communities and nature conservation programmes by exploring and emphasising co-dependence rather than competition. It should also build and nurture regional groups, transboundary arrangements, and collaborations among neighbouring protected areas (Chapter 6; SPM section E).

- **Community-Based Natural Resource Management:** (Chapters 1 & 6; SPM section E).

- **Strengthening the governance capacity of protected area institutions** to address the complex interactions between natural resources and local communities focusing on site-based planning and management of protected areas as well as promoting equity and benefit-sharing. This should also include measures to prevent and mitigate potential negative impacts and threats (Chapter 6; SPM sections D & E).

2.5 IMPACT OF NATURE'S CONTRIBUTIONS TO PEOPLE CHANGES ON HUMAN WELL-BEING

As shown in this and other assessments, human driven activity is altering the structure and functions of landscapes, water bodies and climate, and biogeochemical cycles, with some of the worst case scenarios in the tropics (Foley *et al.*, 2005; MA, 2005; Chapter 4). African biodiversity and ecosystems are currently undergoing massive structural changes (MA, 2005; Daily *et al.* 2009; Effiom *et al.*, 2013c; Chapters 3 & 4,). A change in ecosystem structure implies a change in ecosystem functioning (Lavorel *et al.*, 2012); and, ultimately, the provisioning of ecosystem services, nature contributions to human that enhance human well-being and good quality of life (Chapters 3 & 4). The strong dependence of human on nature contributions through biodiversity and ecosystem services is evident on the African continent, as detailed in this chapter. The concept of sustainably utilising ecosystem services is thus gaining considerable attention globally, since it conveys the idea that ecosystems are socially and economically valuable, and vital in human well-being, in addition to their ecological value. This section will look at the impact of such change on basic material for good life, health and social security.

2.5.1 Impacts of changes in contributions of nature on basic material for a good life

Changes in nature's benefit to people influence all components of human well-being, especially the basic material needs for a good life. Environmental degradation caused by various drivers and through different pathways (Chapter 4) endangers provisioning of the basic material for human well-being.

Along with biodiversity erosion, as detailed in Chapters 3 and 4 to follow, we face erosion of indigenous and local knowledge, as mentioned earlier (SPM section B). The decline in ILK has a number of implications for biodiversity conservation efforts since, without an adequate understanding of the natural ecosystems and knowledge about natural resources, future local and rural communities will be challenged in maintaining these resources (Grainger, 2003; Solh *et al.*, 2003; Heneidy *et al.*, 2007). For example, local communities in the coastal desert of Egypt used to be traditional nomadic communities. Such communities have been subjected to changes due to urban encroachment and development activities over the last three decades. Such activities influenced the demographic structure and the nomadic lifestyle of local inhabitants. Abandonment of traditional practices threatens the sustainability of the indigenous local knowledge, since younger generations prefer to engage in the new economic activities (e.g., construction of coastal resorts, real-estate businesses, intensive agriculture, and quarrying activities) to the traditional practices (e.g., herding, rain-fed agriculture, collection of medicinal plants, amongst others) (Bidak *et al.*, 2015; Halmy, 2012; Halmy *et al.*, 2015a; Halmy *et al.*, 2015b & c). This may have led to a decline in number of the ILK holders in these communities.

Similar challenges to communities' traditional life ways have been recorded by Kaunga (2016) in Maasai community in northern Kenya, where the changes in land ownership and land-use due to developmental projects challenge the Maasai and Samburu communities to maintain their traditional lifestyle and associated indigenous local knowledge. The transfer of the ILK to the new generation has declined in these communities due to these socio-economic changes. Attempts have been made by the Samburu communities, as a response to the reduced attention to the traditional activities in favour of the new economic activities; through diversification of livelihood sources by include activities that would benefit from their ILK such as ecotourism (Oguge, 2016).

2.5.2 Impacts of changes in contributions of nature on people's health

There is a growing recognition worldwide of the crucial links between health and the natural environment. The linkages between biodiversity, ecosystem, ecosystem services (its conservation, sustainable use, status, trend, and degradation) and human health are increasingly taking centre stage in conservation and policy discussion in many parts of the world (SPM sections B & E). The issue has become more prominent following decisions at the 12th Conference of the Parties to the Convention on Biological Diversity in October 2014, which encouraged Parties to "consider biodiversity and health linkages in the preparation of national biodiversity strategies and action plans, development plans and national health strategies" (UNEP, 2014). This is due to the fact that, as mentioned earlier, many raw materials for the pharmaceuticals are tied to the conservation and sustainable use of certain plant or animal species or genetic resources (Kretsch *et al.*, 2016). In many traditional communities, watersheds and some rare species and special habitats that have high medicinal value or contribute to climate and water regulation have been inadvertently preserved by their status as sacred sites. Similarly, nature through biodiversity and ecosystem services contribute significantly to dietary health, mental health, emerging infectious diseases, in medical research, and the use of sentinel species in health risk assessments, (see Chivian *et al.*, 2008; Keune *et al.*, 2013; CBD Secretariat *et al*., 2015).

The assessment of the impact of the change in ecosystem services on health is critical because when health is affected, there is bound to be a cascading effect on the other aspects of well-being such as quality of life, livelihood security and freedom of action. According to Kretsch *et al.* (2016), apart from the many recognised connections between ecosystems and health, health comprises a major element of self-reported assessments of personal (subjective) and population (objective) measures of well-being, with health status also affecting personal perceptions of the other aspects of well-being. Additionally, health and health care delivery are also some of the most significant areas of national, regional and local government activity and expenditure. Since ecosystems may be viewed as "settings" in which health is determined or important determinant of human health (Horwitz *et al.*, 2011; Myers *et al.*, 2013), quantifying the impact of change of nature (biodiversity and ecosystem) on health is, therefore essential to provide insights to the nature and extent of the impact, as well as cascading effects on other aspects of well-being (Chapter 4, section 4.4.4.3.1). There is, however, in certain circumstances, a paradox in that some major changes to natural systems have been associated with public health benefits. For example, early efforts to reduce malaria in certain parts of sub-Saharan Africa (Keiser *et al.*, 2005) by draining swamps that were habitats for mosquito vectors was for the eradication of malaria, while certain deforestation, dams, and irrigation projects been to increase the supply of food and clean energy – critical building blocks for public health (Keiser *et al.*, 2005; Myers *et al.*, 2013).

2.5.3 Impacts of changes in contributions of nature on livelihood security

The decline in biodiversity and ecosystem services is resulting in more variable ecological dynamics, the decline in nature contributions to humans, and more human exposure to catastrophic hazards and diseases and increasing loss of livelihoods, especially to marginalised communities in the tropics especially in Africa (Chapters 3 & 4). It, therefore, implies that sustainably managed ecosystems that enhance the continuous flow of ecosystem services are vital to sustaining human well-being, as both are mutually beneficial (SPM section E). It is becoming clear that promoting the conservation of one ecosystem service, (for example, in safeguarding watersheds to maintain water regulation), a bundle of other ecosystem services will be provided such as prevention soil and soil nutrient erosion (Maukonen *et al.*, 2017), thus showing positive synergies (Chapter 6; SPM section E). For example, according to Effiom (2013b), 95% and 86% of primate-dispersed trees utilised by rural households provide fruit and/or nuts and other non-timber forest products, respectively, showing that these trees are significantly very important for human sustenance (Chapter 3). This study corroborates previous findings from other studies from the African region (Fa *et al.*, 2006; Kone *et al.*, 2008) in terms of a general reliance on forest resources, such as bushmeat, fruits and/or nuts, medicinal plants, timber and other non-timber forest products, including firewood as source of livelihood (Chapters 3 &

4). The take home message here is that structural and functional change to biodiversity which diminishes nature's capacity to contribute benefits to human will impact negatively on livelihood security. This impact becomes particularly prominent in localities that lacks provision of alternative livelihood options and /or viable adaptive measures to combat environmental change. It, therefore follows that achieving human livelihood security especially that in the developing world, will depend greatly on achieving environmental security (Biggs *et al.*, 2014).

Environmental security is a component of 'Environmental Livelihood Security (ELS). The concept of ELS encompasses a balance between natural resource supply, nature contribution to people, and human demand on the environment to promote sustainable livelihood (Biggs *et al.*, 2014). ELS describe the challenges of maintaining global food security, universal access to freshwater and energy to sustain livelihoods and the promotion of inclusive economic growth, whilst sustaining key environmental systems functionality. Maintaining this balance poses a significant challenge, as shown earlier and in Chapters 3 and 4 to follow, as livelihood activities contribute in many instances to the undesirable transformation of natural ecosystems (Chambers *et al.*, 1992). The interactions between environmental changes and the effect of human utilisation for livelihood is enormously complex. Hence in 1992, the UN Conference on Environment and Development adopted the term sustainable livelihoods, as a means of linking socioeconomic and environmental concerns (Brocklesby *et al.*, 2003), stressing that degradation of ecosystem services could be significantly slowed or reversed if the full socioeconomic value of ecosystem services were taken into account in policy planning and decision-making (Chapter 6; SPM sections A & E).

2.5.4 Impacts of changes in contributions of nature on people's freedom

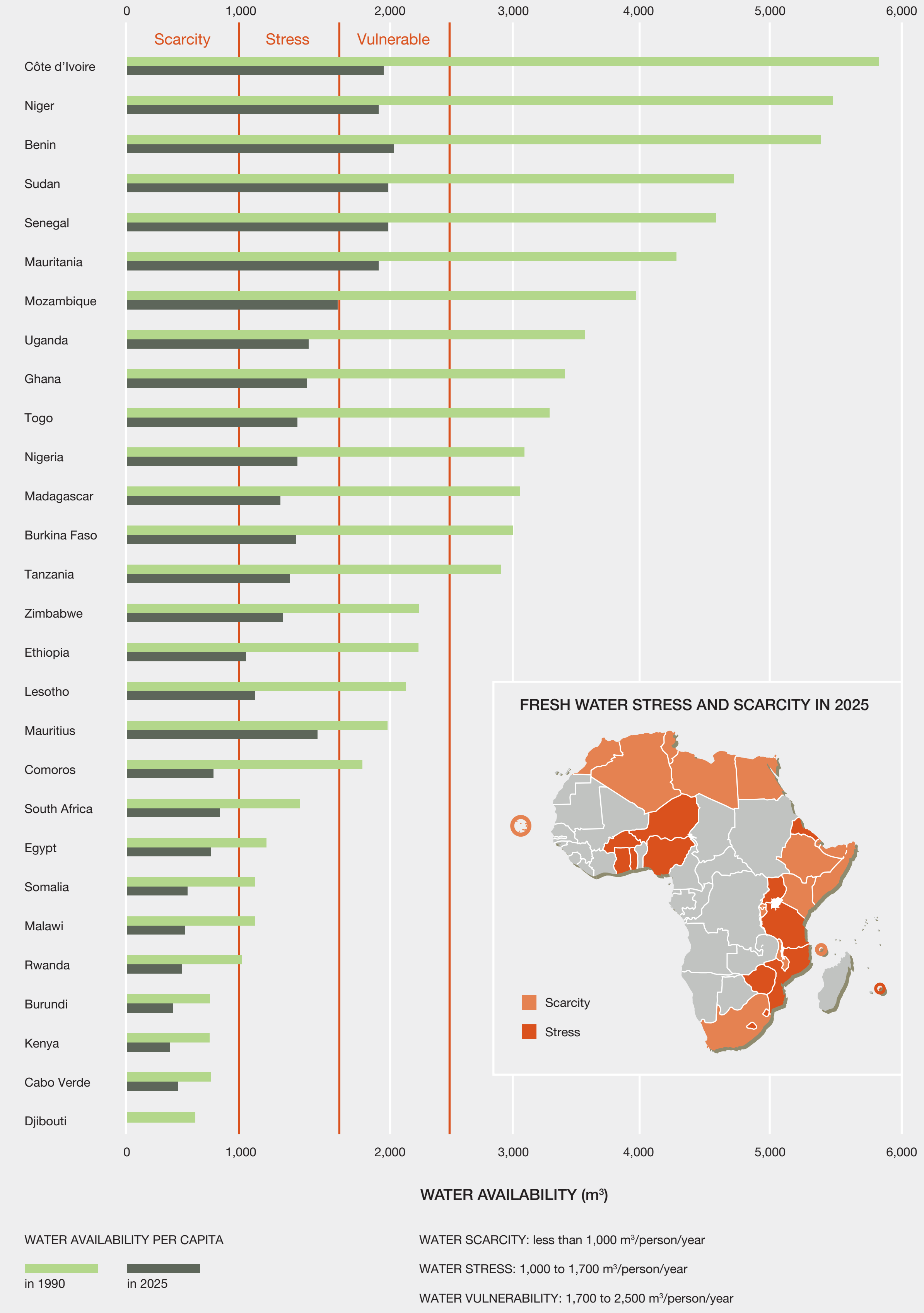
Freedom and, in most cases, the ability to make choice(s) cannot exist without the presence of the other elements of well-being–including human basic needs of food, shelter, clothing, and income. Nature contributions to people through the different forms of ecosystems services (supporting, provisioning, regulating, and cultural) underpin human well-being (MA, 2005). Degradation of natural ecosystems that limits nature's capacity to contribute to the supply of these elements of well-being has an indirect negative impact on human freedom of choice or action. This has been evident throughout the continent – for example, conditions such as degraded natural forest may lead to a poor harvest of non-timber forest products, and, ultimately, result in a substantial loss of livelihood (Chapter 3).

The impact of change on nature contributions to human well-being is bound to adversely constrain the actions of the poor, whose economic and social sustenance depend greatly on the services of natural systems. Conversely, people living in countries with effective environmental governance, where, for instance, energy, quality education, and safe drinking water are affordable and accessible, can exercise and maintain freedom. There are currently limited studies providing evidence as to how a change of ecosystem structure and services may impact human freedom, a research gap that requires prioritisation. This section thereby recognises the need for improved research to grant a better understanding of the impact of impacts of the alteration of the ecosystem on livelihood, health, and freedom, to better inform decision-making in the land-use planning, biodiversity and nature conservation and resource allocation for the attainment of total well-being for a man in the African region.

2.6 NEGATIVE NATURE'S CONTRIBUTIONS TO PEOPLE

As mentioned in Chapter 1 and throughout this chapter thus far, nature provides benefits for human well-being (MA 2005; IPBES, 2016). It should be noted, however, that not all nature`s contributions are positive; some are negative with adverse impacts on human well-being (Lukamba, 2010). Certain studies refer to contributions by ecosystems that are perceived to have a negative impact on human well-being as ecosystem disservices (Lyytimäki *et al.*, 2009; von Döhren *et al.*, 2015). For instance, the decimation of large primates in hunted tropical forest is associated with a lower richness of seedlings for large-seeded trees that are dispersed by primates, and a higher richness of seedlings for small-seeded species that are dispersed abiotically or by other animals (Nunez-Iturri *et al.*, 2008; Effiom *et al.*, 2013c; Effiom, 2013a; Chapter 3). Plant richness may significantly affect the way in which ecosystems function, which may, in turn, determine the provisioning of certain ecosystem services (Lewis *et al.*, 2004; Bunker *et al.*, 2005; Brodie *et al.*, 2009; Lavorel *et al.*, 2012). Hunting may cause community-level shifts along the leaf economics spectrum (Wright *et al.*, 2004), with significant effects on processes such as herbivory, litter decomposition, and soil fertility and productivity (Lavorel *et al.*, 2012). In other cases, ecosystem disservices may result from inappropriate land-use, such as the incorrect application of fertilisers and pesticides, increasing cultivation on slopes and overuse and harvest (Power, 2010; Escobedo *et al.*, 2011; Firbank *et al.*, 2013; von Döhren *et al.*, 2015; Chapters 3 & 4).

Figure 2 10 Water crisis in Africa. Source: UNECA (2005).



Chapter 4 (Section 4.2.1.4) provides more detail on natural disasters; and the role of natural ecosystems in impact and/or driver. For example, the provisioning of material contributions, other than food that is central to human well-being, is also very difficult to realise under drought conditions–water security providing a particularly critical example in this regard **(Figure 2.10)**.

2.7 CONCLUSION

African ecosystems provide material, non-material and regulating nature's contributions to the people of Africa and the world. Material contributions are the provisioning services that describe the material or energy outputs from ecosystems. The materials considered in this section are food, energy, health and water. Food production serves as an important material contribution of ecosystem services in terms of nature's contributions to people. Many communities in Africa depend on food provided by natural ecosystems such as forests, grasslands, wetland areas and water bodies sustaining fisheries for their food security. The main food items that are sourced come from bushmeat, insects, fresh fruits, nuts, seeds, tubers and green leafy vegetables, edible oils, drinks spices, condiments, mushrooms, honey, sweeteners, wild tubers, and snails, amongst others. Fuelwood is the dominant source of energy in Africa, with over 90% of energy needs in rural areas supported by fuel wood. Urban areas rely more on charcoal as source of energy for cooking and demand for household energy from rapidly growing urban centres exerts massive pressure on forests. Up to 80% of the population in Africa rely on traditional medicine to help meet their primary health care needs. Furthermore, numerous plant products are used in traditional African medicine. Nature's non-material contributions from land- and seascapes provide important areas for recreation, relaxation, healing, nature-based tourism and aesthetic enjoyment, religious and spiritual fulfilment, cognitive development, as well as the promotion of social cohesion and a sense of identity. Tourism is well developed and an important source of income in northern, southern, and eastern parts of Africa as well as the oceanic Islands. Many sites in Africa have been classified as protected or heritage sites for their non-material contributions. Regulating contributions from nature are increasingly being appreciated and valued higher in national accounting systems. Highly valued services are mainly linked to agricultural production, including climate, air and water regulation, disease and pest control and pollination. Other services include nesting, feeding and mating sites for birds and mammals, e.g., the Important Bird and Biodiversity Areas.

The true value of biodiversity and nature's contributions to human well-being tend to be under-appreciated in decision-making processes in Africa, particularly for non-material and regulating contributions. Existing studies on the valuation of biodiversity and nature's contributions to people in Africa are few and limited in both geographical scope and the types of ecosystems covered. Valuation of biodiversity and its contributions to people is a tool used in decision-making and in communicating their importance to humanity, thus serving as support for their conservation and sustainable use as well as the sharing of benefits from the utilisation of biological resources. Knowing the value of biodiversity components and their contribution to people can thus encourage investments for their management through the most appropriate methods, and assist in assessing the trade-offs between different policy options as well as the cost and benefits of biodiversity conservation and use policies. Failure to reflect values in decision-making often results in unsustainable use and depletion of biodiversity and ecosystem services. Valuation of biodiversity and nature's contribution to people has received limited attention across Africa. More studies were conducted in coastal and marine areas, inland waters and forests than in the other ecosystems. Most value studies were conducted in Southern Africa and East Africa and adjacent islands than in other subregions on the continent.

By taking into account the economic value of the whole range of ecosystem services, including the ones that don't have a market value per se (water purification, coastal protection, etc.), valuation studies have shown that many ecosystems have a higher overall value when kept in their pristine or optimal health condition than used for material purposes such as timber production. For instance, tropical forest and mangrove have a value 4 times higher when maintained for providing services such as carbon sequestration, non-timber material provisioning, etc. than use for timber production only. Therefore, valuation should be conceived as a tool to guide policy and management decision-making. Overall, policy interventions should be devoted to the maintaining or restoration of an optimum health status of the all ecosystem as well as an optimum use. This will guarantee the resilience of African ecosystem against global changes.

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