4.3 Pressures from global environmental change

4.3.1 Protected areas exposure to climate change

Africa's climate has already changed considerably since pre-industrial levels. According to the Intergovernmental Panel on Climate Change (IPCC), mean temperatures and hot extremes have emerged above natural variability relative to the 19th century baselines and marine heatwaves have become more frequent[1]. These trends are likely to worsen by the end of the century unless global mitigation efforts increase.

These feature maps show the projected increase in mean annual temperature and the projected percentage change in mean annual precipitation by the end of the century (2081–2100), relative to a pre-industrial baseline (1850–1900)[2]. These projections are based on the combined outputs of multiple climate models from the Coupled Model Intercomparison Project Phase 6 (CMIP6). Shown here are the projections for the SSP2-4.5 scenario, which is the 'middle of the road' Shared Socioeconomic Pathway (where global trends do not shift markedly from historical patterns), and the 'intermediate' Representative Concentration Pathway (where emissions peak by 2040 and then decline). This is a useful midpoint, though future climate could be considerably better if the international community makes strong progress on our collective climate goals. At the same time, projections might be much worse if mitigation efforts deteriorate.

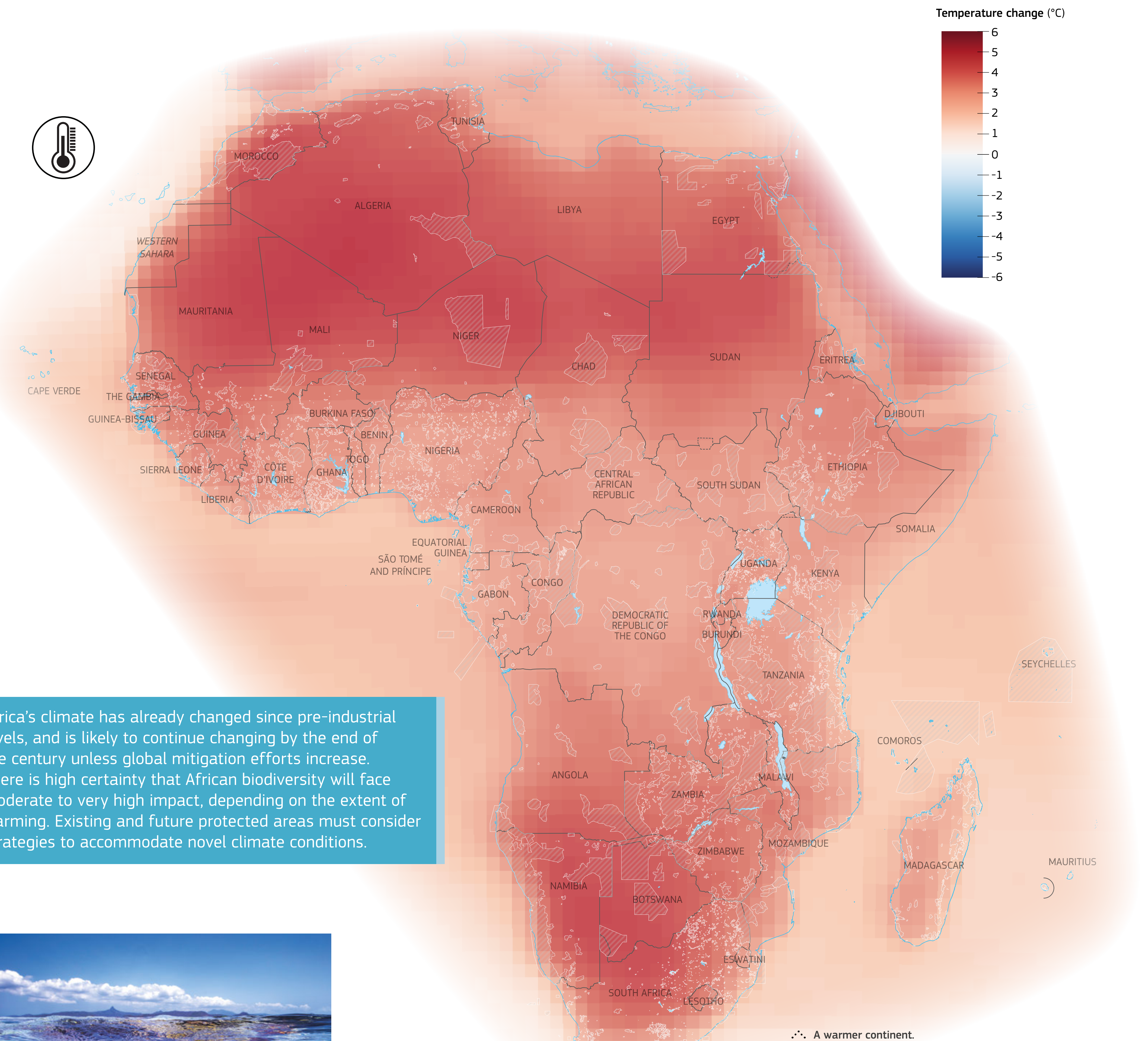
Climate change will not affect all parts of Africa in the same way[3]. For example, Western and Central Africa are at higher risk of heavy precipitation and flooding, while the western portion of Southern Africa will face drier conditions and greater fire risk. The eastern part of Southern Africa, Madagascar, and southern portions of East Africa may experience more tropical cyclones. The Sahel may receive more rain in the future, but the West African monsoon season is expected to arrive later than it has in the past.

These changes will have major consequences for biodiversity[1]. In some cases, species will be unable to adjust their geographical distributions to match suitable climatic conditions. An iconic example of this is the quiver tree, *Aloidendron dichotima*, in Namibia and South Africa. High quality field data found that the population growth at the southern edge of the species' range lags behind climate-induced mortality rates at the northern edge, suggesting that the species cannot shift its range southwards fast enough to adjust to the changing climate[4]. In addition to individual species, whole ecosystems may be harmed by climate change. To date, coral reefs in the Mozambican Channel have served as valuable refuges against climate change for the entire coastal East African Region, but projections suggest that up to 90% of East African coral could be destroyed by bleaching if temperatures rise by 2°C[5].

In addition to the ecological impacts, climate change is likely to harm nature-based tourism in Africa. Currently, tourism contributes 8.5% to African GDP, but protected area visitation rates may decline by 4% at 2°C warming[5]. Sea level rise and beach erosion will threatened beach tourism, and hydrological shifts may negatively impact iconic natural tourist destinations, like the Victoria Falls, the Okavango, and Chobe National Park[5].

In response, protected area authorities need to be creative in the ways they consider climate change. Possible interventions include: (1) protecting climate refuges likely to maintain current climate conditions; (2) prioritising ecological connectivity to facilitate the free movement of species; (3) establishing temporary or movable protected areas or marine no-take zones, which can adjust to shifting climates; and (4) performing vulnerability assessments for existing protected areas[6].

Ultimately, climate and land use change will interact to erode the effectiveness of African protected areas[5]. However, ecosystem protection and restoration is highly likely to improve carbon sequestration and storage, and enhance ecosystem resilience[5]. Therefore, researchers and protected area authorities should prioritise climate-smart planning and management to ensure that the climate benefits from protected areas outweigh the costs of climate change.



Africa's climate has already changed since pre-industrial levels, and is likely to continue changing by the end of the century unless global mitigation efforts increase. There is high certainty that African biodiversity will face moderate to very high impact, depending on the extent of warming. Existing and future protected areas must consider strategies to accommodate novel climate conditions.

A warmer continent.

Projected change in mean annual temperature by the end of the century (2081–2100), relative to a pre-industrial baseline (1850–1900), according to 34 models from the Coupled Model Intercomparison Project Phase 6 (CMIP6) under the SSP2-4.5 scenario.

Source: Gutiérrez, J.M., et al. (2023) Atlas. In: Climate Change 2021: *The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Masson-Delmotte, V., et al. (eds.). Cambridge University Press. Interactive Atlas available from Available from http://interactive-atlas.ipcc.ch/

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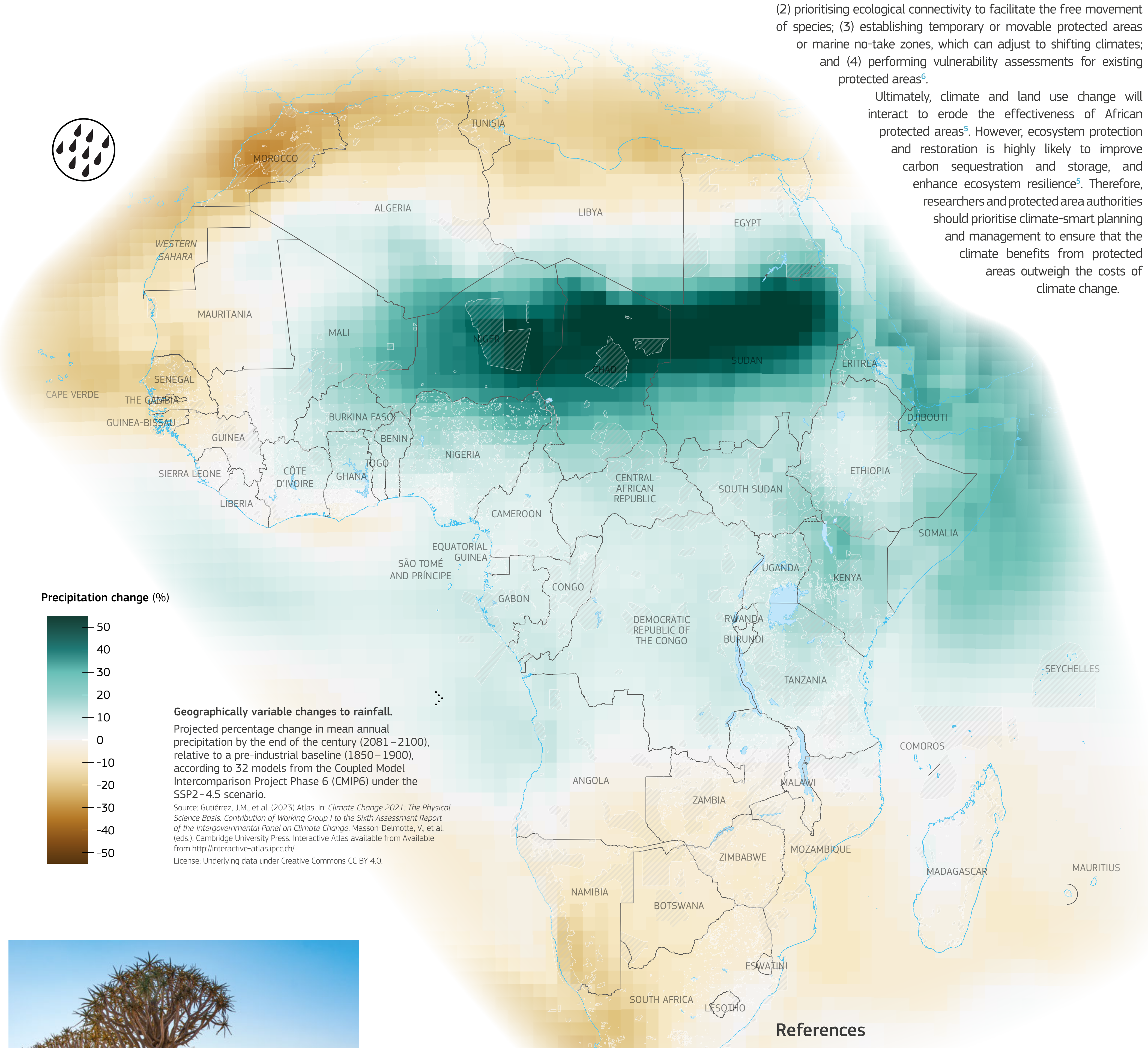
Coral reefs in the Western Indian Ocean.

Coral reefs in the Mozambican channel have served as climate change refuges for the entire coastal East African Region, but up to 90% of East African coral may be destroyed by bleaching at 2°C of global warming.

Source: Gaby Barathieu/Ocean Image Bank under Creative Commons CC BY-NC 4.0 DEED.



Geographically variable changes to rainfall.

Projected percentage change in mean annual precipitation by the end of the century (2081–2100), relative to a pre-industrial baseline (1850–1900), according to 32 models from the Coupled Model Intercomparison Project Phase 6 (CMIP6) under the SSP2-4.5 scenario.

Source: Gutiérrez, J.M., et al. (2023) Atlas. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Masson-Delmotte, V., et al. (eds.). Cambridge University Press. Interactive Atlas available from Available from http://interactive-atlas.ipcc.ch/

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The quiver tree, *Aloidendron dichotima*, Namibia.

The quiver tree is a sentinel of the negative effects of climate change on biodiversity. High quality field data from Namibia found that the population growth at the southern edge of the species' range lags behind climate-induced mortality rates at the northern edge, suggesting that the species cannot shift its range fast enough to adjust to the changing climate.

Source: Falcodigiada on Wikimedia Commons CC BY-SA 4.0.

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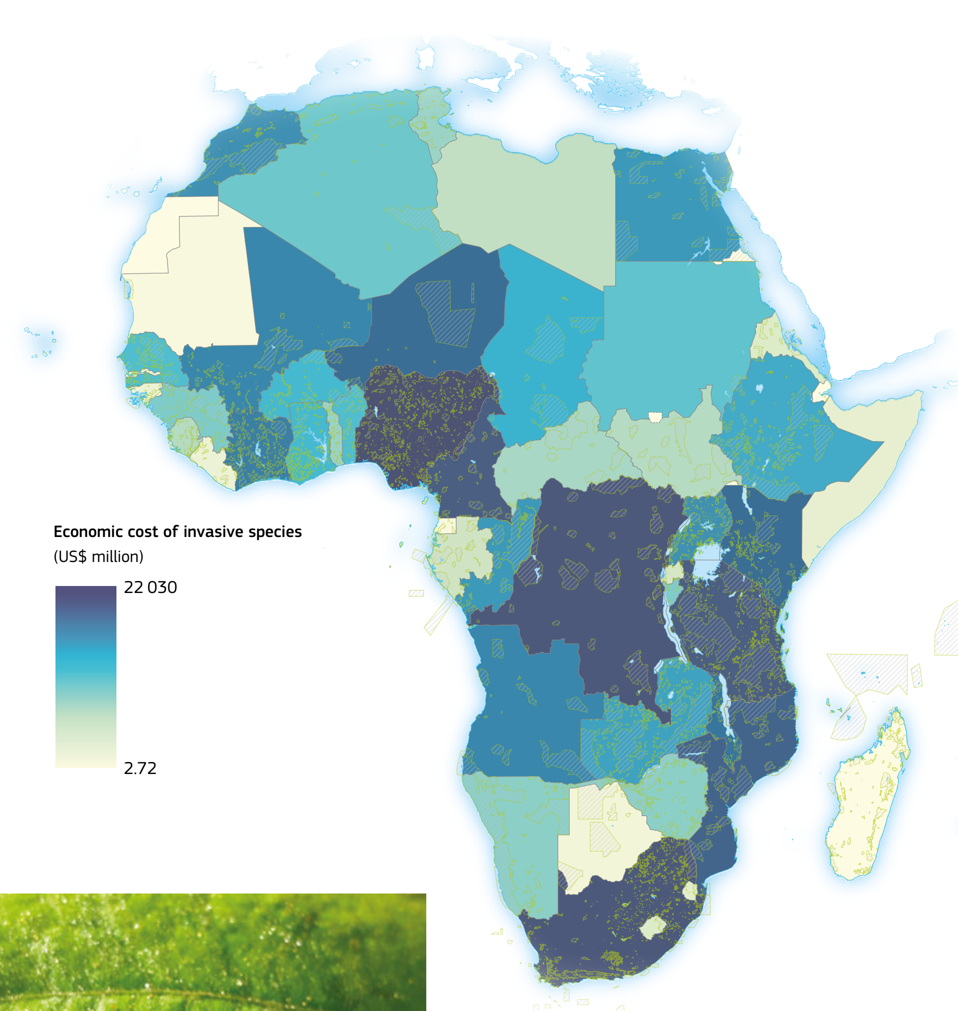
4.3.2 The impact of invasive alien species

Invasive alien species are a major threat to nature. While no African country is free from invasive alien species, there are geographical differences in both the scale of, and knowledge about, the problem. Alien invasive species are not only bad for ecosystems and native species, they also lead to economic agricultural losses of US$ 65 billion per year. These economic losses have increased fourfold every decade. Although managing invasive alien species is an urgent policy priority, the most cost-effective solution is preventing introductions from happening in the first place.

As humans travelled the world and began exploring faraway places, they brought other species along with them, both accidentally and on purpose. Many of these species failed to survive beyond their native ranges, dying unnoticed. But others flourished. In the absence of natural predators and pathogens, alien species can establish self-sustaining populations. When these established populations have negative impacts on local ecosystems and species, they are referred to as invasive alien species[1].

While no African country is free of invasive alien species, there are geographical differences in the scale of the problem. This feature map shows the number of invasive alien species (plants and vertebrates) in each country as reported by the Country Compendium of the Global Register of Introduced and Invasive Species[2]. These data are based on information originating from published scientific papers, technical reports, national checklists and databases, as well as unpublished government reports and datasets held by researchers and practitioners[3]. This means that the data shown here represent not just the scale of the problem posed by invasive species, but also the state of knowledge in each country.

Even without complete knowledge of invasive alien species, evidence of their negative impacts is unequivocal. Estimates suggest that the impact of alien invasive species on African agricultural production can be as much as US$ 65 billion per year[4], comparable to the GDP of the Democratic Republic of the Congo. Slightly more than half of this figure is due to labour costs associated with weed eradication, the rest mostly attributable to yield losses caused agricultural pest species, with a small proportion of the total cost due to reduced grazing potential of invaded rangelands[4]. Perhaps more concerning, however, is the four-fold global increase in the economic cost caused by invasive alien species each decade[5].



Economic cost of invasive species to agriculture.

Total estimated annual economic costs to agriculture of invasive species by country. Values (US$ million) combine management costs, yield losses, and reduced grazing potential.

Source: Eschen, R., et al. (2021) Correction to: Towards estimating the economic cost of invasive alien species to African crop and livestock production. *CABI Agriculture and Bioscience*, 2, art. 30.

Larvae of the fall armyworm, *Spodoptera frugiperda*.

This little caterpillar leads to crop losses in Africa worth an estimated US$ 9.3 billion each year. It orginates from the Americas, where it is unable to survive sub-zero winter temperatures. In Africa, the larvae has spread to more than two-dozen countries, where it causes significant damage to maize crops.

Source: Wee Hong on Wikimedia Commons CC-BY-SA 4.0.

A suite of management actions can curb the impacts of invasive alien species[6]. The best and most cost-effective management option remains preventing introductions from happening in the first place. Biosafety procedures play an important role in this context. However, when prevention is not possible, early detection, eradication, containment, and control, can limit scale of negative impacts. Research on invasion pathways and monitoring of known alien species – guided by data in the Global Register of Introduced and Invasive Species – can encourage action before a problem becomes unmanageable. Once an invasive species becomes established, it can be eradicated using a combination of mechanical, chemical, and biological control, but this process can be long and expensive (see Box).

Managing alien invasive species is an urgent priority, both inside and outside of protected areas. Therefore, Target 6 of the Kunming-Montreal Global Biodiversity Framework aims to:

"Eliminate, minimize, reduce and or mitigate the impacts of invasive alien species on biodiversity and ecosystem services by identifying and managing pathways of the introduction of alien species, preventing the introduction and establishment of priority invasive alien species, reducing the rates of introduction and establishment of other known or potential invasive alien species by at least 50 percent, by 2030, eradicating or controlling invasive alien species especially in priority sites, such as islands".

The invasion and eradication of cats in the sub-Antarctic Marion Island

In 1948, five cats were intentionally introduced to the sub-Antarctic Marion Island[7,8], a territory of South Africa. The researchers based at the meteorological station at the time hoped their new pets would control the mice that had themselves established on the island more than a century earlier. Although the feral cat population stayed relatively small for the next two decades, by the 1970s it had grown upwards of 2 000 and were responsible for killing more than 450 000 ground-nesting birds that had, until then, faced no natural predators on the island[8]. Realising the extent of the problem, the South African Scientific Committee on Antarctic Research approved an eradication programme in 1974. This seven-phase programme required continuous monitoring, the introduction of feline panleucopaenia virus, nighttime hunting, intensive trapping, and poisoning before the last cats were finally eradicated in 1993. Even though the eradication programme lasted nearly 20 years, researchers eventually concluded that its success was in a large part due to the unique context of the Island (i.e. susceptibility to the virus, the lack of high vegetation for shelter, the absence of other species that might succumb to traps and poison), and unlikely to be emulated elsewhere[7]. Today the whole of Marion Island is a National Park, but its successful eradication programme reminds us that avoiding the introduction of alien species is much more cost effective than controlling them after they become invasive.

Randy the cat, pictured with his sheathbill prey, Marion Island (1954).

Islands are particularly susceptible to invasive species. Cats were introduced to sub-Antarctic Marion Island as pets and to control mice, but soon began harming the native populations of breeding birds. After a 19-year control programme, the last cat was eradicated in 1993.

Source: William John Deysel, made available for research, academic and non-commercial use by the Antarctic Legacy Archive.

The Nile Perch.

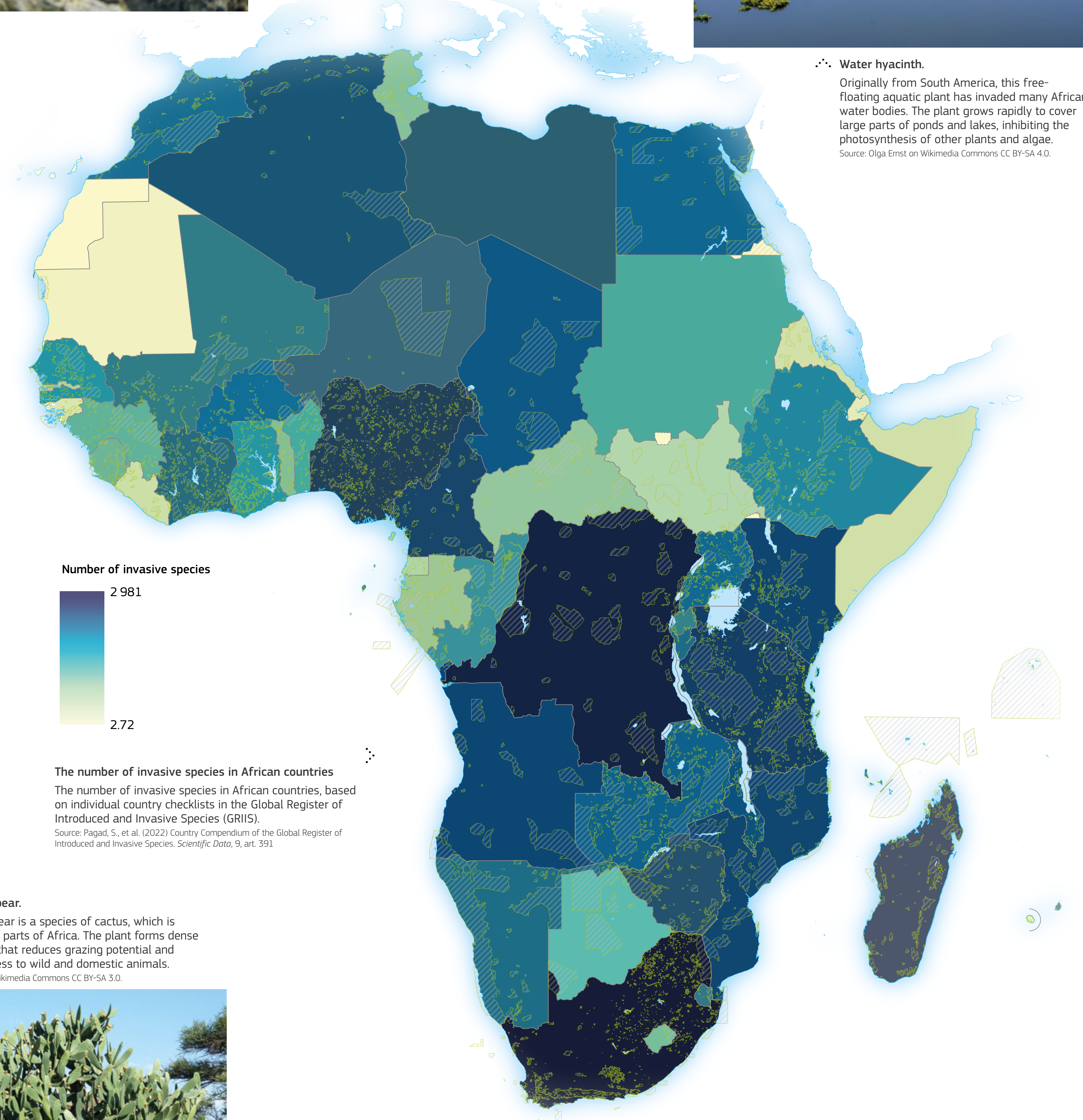
The Nile Perch was intentionally introduced to Lake Victoria for food, but has since become one of the worst examples of an invasive alien species. This species has altered the lake's food web and caused the extinction or near extinction of several hundred native species.

Source: Daiju Azuma on Wikimedia Commons CC BY-SA 4.0.

Water hyacinth.

Originally from South America, this free-floating aquatic plant has invaded many African water bodies. The plant grows rapidly to cover large parts of ponds and lakes, inhibiting the photosynthesis of other plants and algae.

Source: Olga Ernst on Wikimedia Commons CC BY-SA 4.0.



The number of invasive species in African countries

The number of invasive species in African countries, based on individual country checklists in the Global Register of Introduced and Invasive Species (GRIIS).

Source: Pagad, S., et al. (2022) Country Compendium of the Global Register of Introduced and Invasive Species. *Scientific Data*, 9, art. 391

The prickly pear.

The prickly pear is a species of cactus, which is invading arid parts of Africa. The plant forms dense infestations that reduces grazing potential and restricts access to wild and domestic animals.

Source: JMK on Wikimedia Commons CC BY-SA 3.0.

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4.3.3 Protected areas and land degradation and desertification

The growing demand for land resources, human population growth, poverty, limited options to expand agriculture, water stress, and biodiversity loss threaten African land systems. The risk of desertification in African drylands has increased over recent decades, led by land use change, climatic variability, and poor land management practices.

Land degradation and desertification are among the world's greatest environmental challenges. The United Nations Convention to Combat Desertification (UNCCD)[1] was established in 1994 to protect and restore land and ensure a safer, just, and more sustainable future. The UNCCD is the only legally binding framework set up to address desertification and the effects of drought. There are 197 Parties to the Convention, including 196 country Parties and the European Union.

- In 1993, the United Nations Convention to Combat Desertification (UNCCD)[1] defined Land degradation as the "*reduction or loss, in arid, semi-arid and dry subhumid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns such as: soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation*".
- A special report issued by the Intergovernmental Panel on Climate Change in 20202 acknowledged the role of anthropogenic climate change amongst drivers of land degradation "*expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological integrity or value to humans*".
- Land degradation in dry areas (arid, semi-arid and dry sub-humid) is characterised by desertification, which is defined by the United Nations Environmental Programme[3] as the "*loss of productivity and land biodiversity in arid, semi-arid and dry sub-humid areas due to natural factors or processes resulting from human activities*".

Drylands (Aridity Index < 0.65: the ratio between precipitation and potential evapotranspiration) represent two-thirds of African land, of which nearly 320 million hectares have been estimated to be highly vulnerable to desertification. These areas are concentrated in Sahelian region, Horn of Africa, and the Kalahari. Evidence shows growing poverty in African drylands, where 41 % of the total population lives in extreme poverty, which is partly attributable to desertification[4]. Under projected climate change scenarios, temperatures in African drylands are expected to increase by twice as much as the global mean, worsening the risk of heatwave days, and high fire-danger days[2].

Land degradation and desertification in Africa are the result of complex interactions among different drivers – both natural and human-related – among which land use change and anthropogenic climate change play a significant role. However, institutional, political, and socio-economic factors are often the drivers underlying unsustainable resource use and poor adaptation capacity.

This table outlines the major drivers of land degradation and desertification in Africa.

Natural drivers	Anthropogenic drivers	Institutional, policy and socio-economic drivers
• Soil erosion. • Global warming. • Sea surface temperature anomalies, which drive rainfall changes. • Invasive plants that affect ecosystem services. • Wildfires that reduce vegetation cover, increase runoff and soil erosion, reduce soil fertility, and affects soil microbial communities.	• Cropland expansion • Unsustainable land management practices, such as overgrazing by livestock. • Urban expansion and infrastructure development. • Extractive industries.	• Land tenure insecurity, lack of property rights, access to markets, and to rural advisory services, lack of technical knowledge and skills. • Agricultural price distortions. • Agricultural support and subsidies contributing to desertification, • Lack of economic incentives for sustainable land management.

Land degradation and desertification in Africa is triggered by both social and ecological factors.

Natural, anthropogenic and socio-economic factors can affect land systems either through local (e.g. wildfires, management practices and knowledge gaps) or distant phenomena (e.g. global warming, extractive industries, agricultural price distortion).

Source: African Group of Negotiators Experts Support (2020). *Desertification and Climate Change in Africa*. Policy Brief No. 1 African Group of Negotiators Experts Support. Nairobi, Kenya.

Land degradation is a multifaceted global phenomenon. There are distinct differences across regions and land systems, which cannot easily be captured by one or a limited set of indicators[5].

Land Productivity Dynamics represent the overall quality of land and soil. This variable is one of a suite of metrics used as evidence for the processes of land degradation or recovery[6,7]. In Africa, nearly 22 % of the vegetated land surface showed signs of declining or unstable land productivity between 1999 and 2013. Persistent reductions in land productivity signals declining health and productive capacity, both characteristic of land degradation. Declining productivity can erode ecosystem services and jeopardise sustainable livelihoods.

In African croplands and grasslands, the extent of declining land productivity exceeded the global average, outweighing the extent of land with increasing productivity. By contrast, 34 % of tree-covered land showed signs of increasing productivity. This may be a positive signal of the impacts of conservation and sustainable forest management projects[5].

The feature map shows how land productivity dynamics in protected areas were predominantly stable or increasing between 1999 and 2013[8]. However, in some areas land degradation and desertification has led to biodiversity loss. For example, long-term monitoring (1978 – 2014) in North Africa has shown loss of important perennial plant species due to drought and desertification e.g. *Stipa tenacissima* and *Artemisia herba alba*[4].

Restoring steppe to halt expanding desert in Algeria.

Esparto grass (*Stipa tenacissima*) is a drought-adapted species endemic to the Western Mediterranean. Historically, it was a dominant species in the Algerian Steppe, covering 5 million hectares. However, more than 50 % of the esparto steppes have disappeared in the past century.

Source: Carsten Niehaus on Wikimedia Commons CC BY-SA 3.0.

Land degradation due to natural or human-induced causes may affect protected areas in multiple ways. Directly, habitat degradation may drive biodiversity loss. Indirectly, productivity loss in surrounding lands can contribute to food insecurity, leading to agricultural encroachment within protected areas. Further, protected areas in a degraded landscape may become isolated islands, disconnected from ecosystem functions and services.

The concept of Land Degradation Neutrality has been set up by the UNCCD as the main tool to combat desertification. It is included in Sustainable Development Goal 15.3 and refers to a state of zero net land degradation, where "*the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystem.*"

A mining site in Burkina Faso.

Land degradation is often the result of multiple interacting factors. Declining crop yields due to poor rainfall can trigger the search for other ways to generate income, such as gold extraction. Mining activities can cause widespread land degradation.

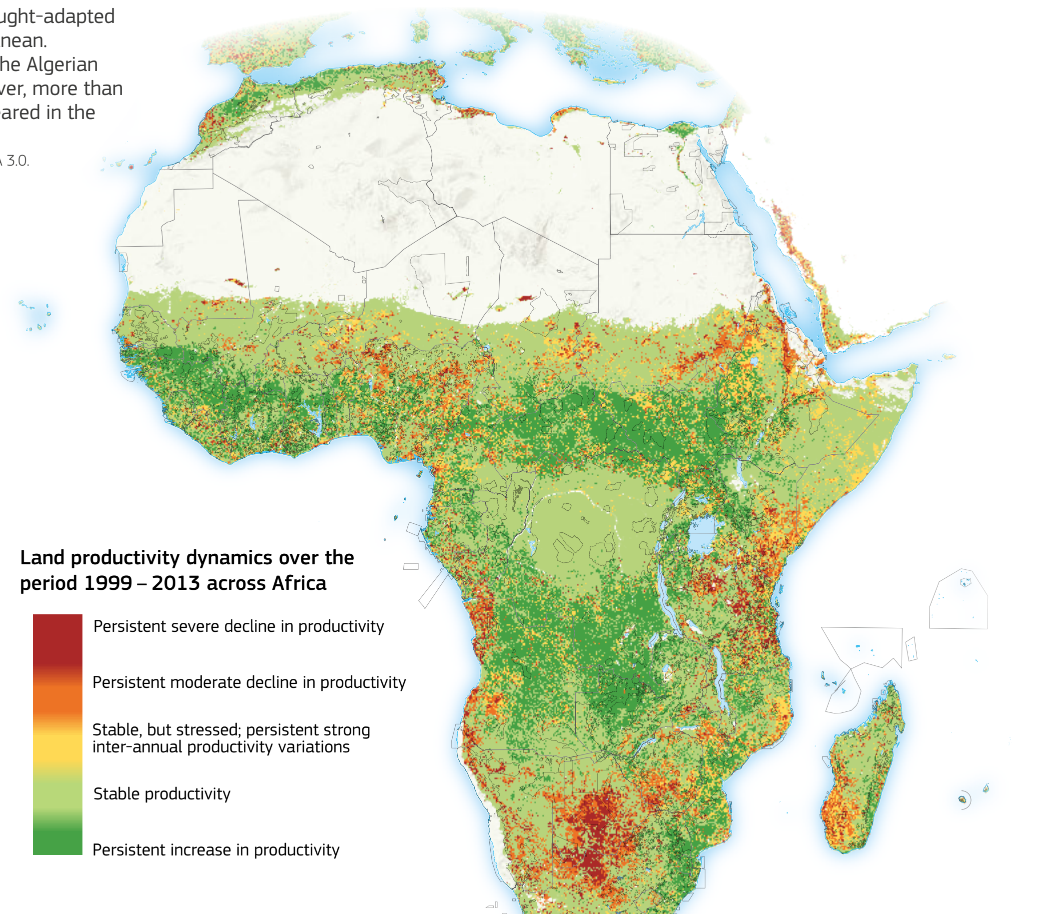
Source: Ollivier Girard/CIFOR on flickr CC BY-NC-ND 2.0.

Land productivity dynamics over the period 1999-2013 across Africa.

Land productivity dynamics refers to trends in vegetation net primary productivity derived from phenological analyses of a 15-year time series (1998-2013) of global normalized difference vegetation index (NDVI) observations from SPOT-VGT, composited in 10-day intervals at a 1 km resolution. Dynamics are summarised as five classes of vegetation productivity: 'Persistent and severe decline', '*Persistent and moderate decline*', '*Stable, but stressed*', '*Stable*, and '*Persistent increase*'.

Sources: Sommer, S., et al. (2017). Mapping land productivity dynamics: detecting critical trajectories of global land transformations. In: The Global Land Outlook (first edition), United Nations Convention to Combat Desertification. Annex Two. Bonn, Germany

Cherlet, M., et al. (eds.). (2018). World Atlas of Desertification. Publication Office of the European Union, Luxembourg.



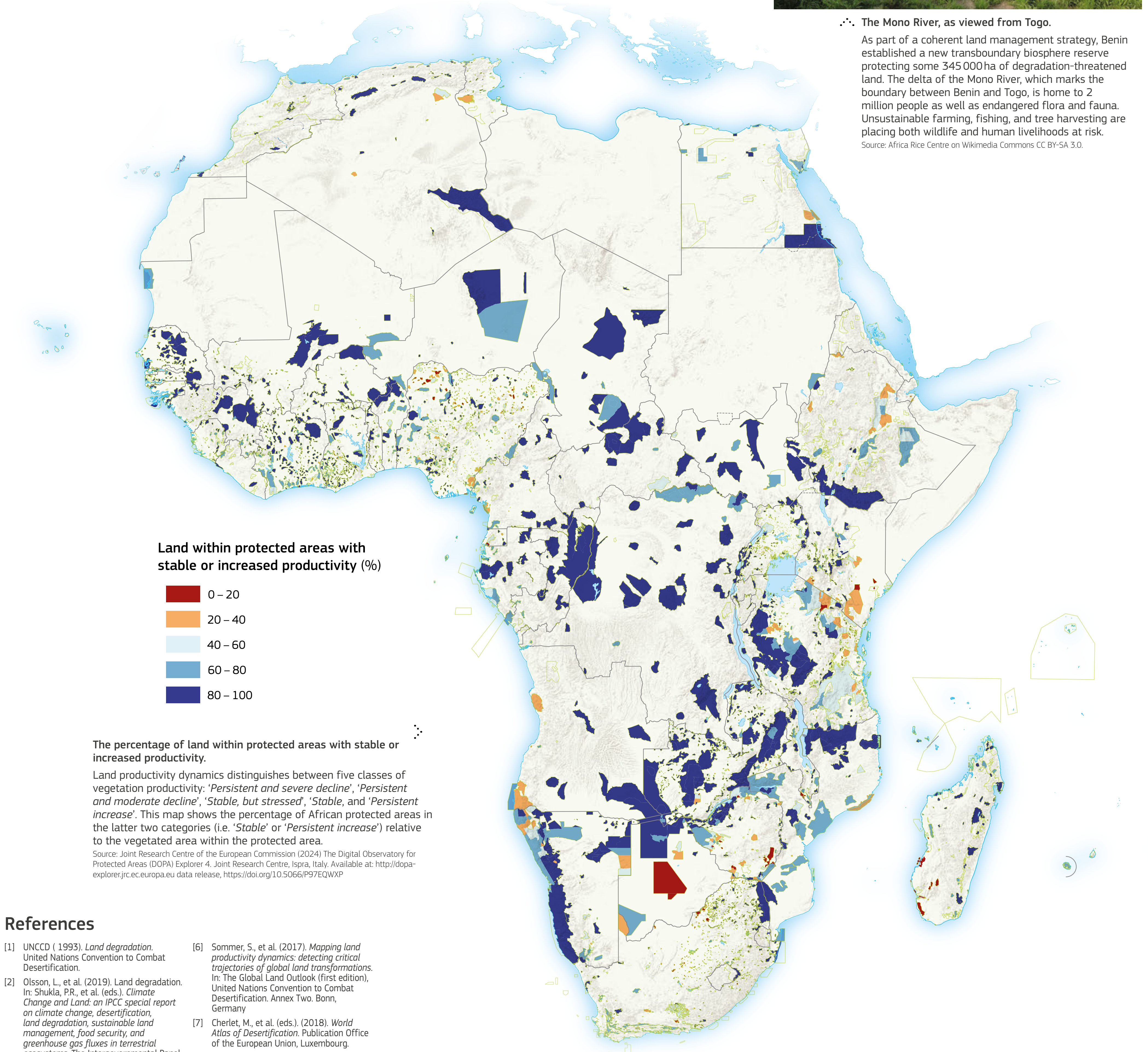
There are strong synergies between Land Degradation Neutrality, Nationally Determined Contributions to reduce emissions and adapt to climate change, and the National Biodiversity Strategies and Action Plans (NBSAPs) under the Kunming-Montreal Global Biodiversity Framework. Land Degradation Neutrality is built around the same principles of integrated land-use planning and good governance, which can support integrated environmental policymaking for biodiversity conservation.

Protected areas can contribute to the Land Degradation Neutrality objectives by conserving water and soil, restoring and connecting, and engaging indigenous community around managing natural resources sustainably.

The Mono River, as viewed from Togo.

As part of a coherent land management strategy, Benin established a new transboundary biosphere reserve protecting some 345 000 ha of degradation-threatened land. The delta of the Mono River, which marks the boundary between Benin and Togo, is home to 2 million people as well as endangered flora and fauna. Unsustainable farming, fishing, and tree harvesting are placing both wildlife and human livelihoods at risk.

Source: Africa Rice Centre on Wikimedia Commons CC BY-SA 3.0.



The percentage of land within protected areas with stable or increased productivity.

Land productivity dynamics distinguishes between five classes of vegetation productivity: '*Persistent and severe decline*', '*Persistent and moderate decline*', '*Stable, but stressed*', '*Stable*, and '*Persistent increase*'. This map shows the percentage of African protected areas in the latter two categories (i.e. '*Stable*' or '*Persistent increase*') relative to the vegetated area within the protected area.

Source: Joint Research Centre of the European Commission (2024) The Digital Observatory for Protected Areas (DOPA) Explorer 4. Joint Research Centre, Ispra, Italy. Available at: http://dopa-explorer.jrc.ec.europa.eu data release, https://doi.org/10.5066/P97EQWXP

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