PART 4: Protected areas under pressure

What are the main pressures on African protected areas, and what can we do about it?

There would be no reason for establishing protected areas if nature were not imperilled. The chapters that follow unpack:

- Human pressures related to food security and shelter needs, and how integrated development strategies intersect with the conservation of protected areas;
- How the pressure on African protected areas from extracting and transporting raw materials can be reduced through sustainable industrial standards and policies;
- Approaches explored by protected area authorities in responding to global environmental drivers, such as climate change, invasive species and land degradation, and their associated challenges.

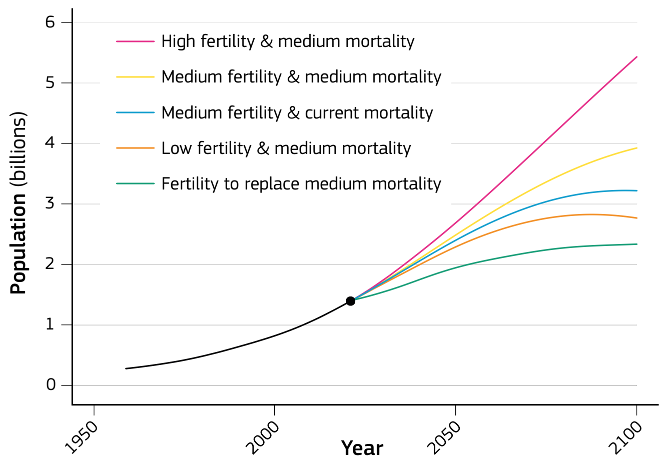
Rice paddies in Madagascar.
Source: Grégoire Dubois, with permission, all rights reserved.

4.1 Pressure from people, crops and livestock

4.1.1 Human population growth and urbanisation

Africa's population will keep growing throughout the rest of the century, but by exactly how much remains to be seen. Many more Africans will live in cities, contributing to ongoing urbanisation trends. In the future, protected areas will face pressure from growing human populations within their boundaries, as well as increasing pressure from adjacent urban areas. If left unchecked, this will have negative consequences for biodiversity.

There are currently more than 1.4 billion Africans. By the end of this century, the United Nations predict that the African population can grow to anywhere between 2.3 and 5.4 billion people[1]. This is a very large range, which depends on future fertility and mortality rates. The eventual population trajectory will depend on various social and economic factors that vary geographically, so it is unlikely that the whole continent will grow at the same rate. For instance, female education has a striking effect on fertility rates. An African woman with no education will have 5.4 children on average, double the average number of a high school graduate[2]. College educated African women have 2.2 children on average, which is slightly higher than the replacement value of 2.1 children to compensate for current mortality rates[2]. Therefore, social policies – which will vary from country to country – will have a major impact on eventual populations.



Projected population growth in Africa.

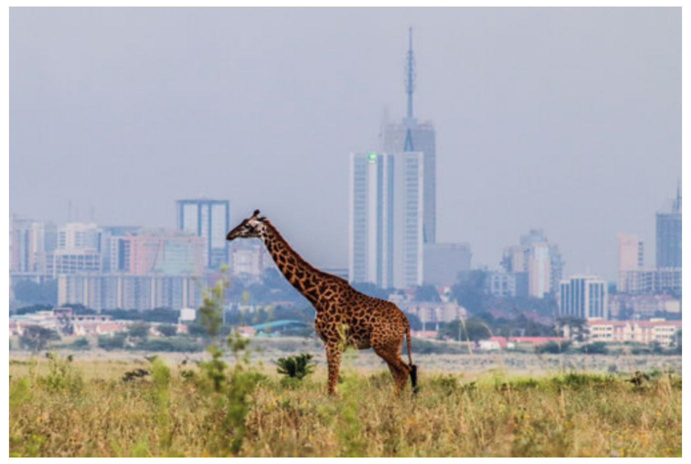
While projections all agree that Africa's population will keep growing for the rest of the century, where it eventually ends up will depend on various factors. Shown here are a selection of projections illustrating how combinations of future fertility and mortality can lead to vastly different population trajectories.

Source: United Nations, Department of Economic and Social Affairs, Population Division (2022) *World Population Prospects 2022*, Online Edition: https://population.un.org/dataportal/home

Since population growth will be uneven across the continent, we need spatially explicit estimates of population densities to fully grasp its impact on biodiversity. A study released more than a decade and a half ago found that for most of Africa, population growth in the buffers surrounding protected areas was significantly higher than elsewhere in the rural landscape[3]. Suggested reasons for these trends were that protected areas offered employment opportunities, security, infrastructure, and natural resources, which were all enhanced by concentrated foreign financial assistance[3].

Today, the Global Human Settlements Layer (GHSL), funded by the European Union, provides a full suite of freely-available and high-resolution population data products. The main feature map presented here shows the number of people per km² (also available at a 100 m resolution)[4]. Also shown on the map are the major urban centres with more than 100 000 inhabitants from the GHSL Urban Centre Database[5]. African cities expand as populations grow, but also due the migration from rural areas of people seeking new opportunities.

As urban areas expand, they encroach on natural habitats, including protected areas, creating potential sources of conflict. On the one hand, urbanisation can impose pressures on nature, like habitat degradation, fragmentation, or pollution. A famous example is Nairobi National Park, which has more than 3 million people living within a 10 km radius of its boundary. On the other hand, living side by side with nature also leads to human-wildlife conflict. In Cape Town, for example, chacma baboons (*Papio ursinus*) from Table Mountain National Park have learnt to raid neighbouring residential areas, stealing food form gardens, garbage bins, and even unsecured kitchens.



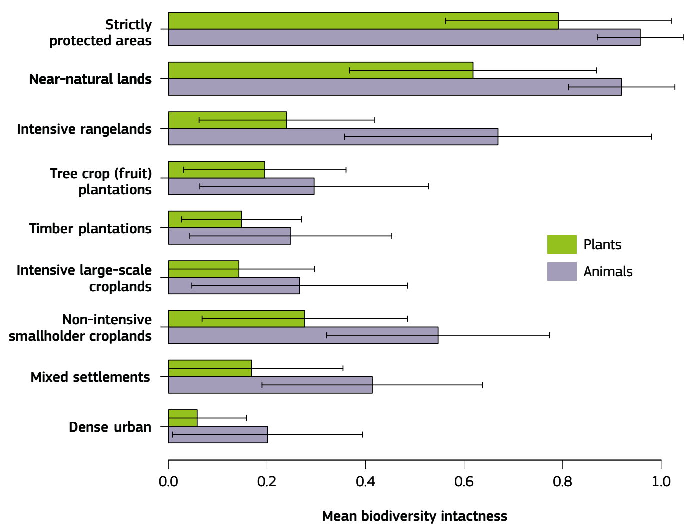
The urban protected area, Nairobi National Park.

Although people are ubiquitous in and around most African protected areas, Nairobi National Park is unique in providing habitat to four of the big-five species right on the margins of the nation's capital.

Source: Alexmbongo on Wikimedia Commons CC BY-NC 4.0.

While examples from Nairobi and Cape Town show dynamics at the interface between cities and protected areas, most urbanisation is a continuous process. Unlike the abrupt transition between Nairobi National Park and the densely populated urban centre, most urbanisation happens as a gradual increase in population density. This means that the same protected landscape can be surrounded by different levels of urbanisation. For example, the landscape around Lake Edward at the borders between the Democratic Republic of the Congo (DRC), Uganda, and Rwanda is surrounded by various degrees of urbanisation (based on the GHSL Degree of Urbanisation layer[6]). On the DRC side, people aggregate in urban centres, like Butembo (home to more than 150 000 people). By comparison, on the Ugandan side, people live in peri-urban and semi-dense urban clusters, where populations are spread out at lower densities.

The gradual change in urbanisation has varying impact on biodiversity. A new African dataset based on expert judgement estimated how land use change affects the relative abundance of plants and vertebrates[7]. This dataset showed how strictly protected areas tend to have the highest levels of intactness, while relative intactness is lowest in dense urban areas. Although still low, the relative intactness of mixed settlements and smallholder croplands is higher than in urban centres. This suggests that the way people concentrate across a landscape affects species differently, so urban planning that strikes the right balance between the geographical extent and intensity of urbanisation will be important in mitigating the negative impacts on biodiversity.



The average biodiversity intactness across different land uses.

The relative abundance of populations across different land uses depicted as the average biodiversity intactness (where 0 corresponds to no individuals remaining and 1 is equivalent to pristine reference conditions) of approximately 5 400 terrestrial vertebrates and 45 000 vascular plants. Error bars depict one standard deviation.

Source: Clements, H.S., et al. (2024) The bii4africa dataset of faunal and floral population intactness estimates across Africa's major land uses. *Scientific Data*, 11 art. 191.

Managing the effect of urbanisation in nature is a priority, not only for conservation but also for city planning. Even though monitoring tools exist[8], African cities have cited insufficient financial and human resources as an obstacle to monitoring urban nature. To improve capacities, Target 12 of the Global Biodiversity Framework calls on parties to *"ensure biodiversity-inclusive urban planning… contributing to inclusive and sustainable urbanization"*. Freely-available high resolution population and urban data[4-6] will assist managers and policy officers to make more efficient decisions that contribute to better outcomes for biodiversity.

Urbanisation as a continuous process in equatorial Africa.

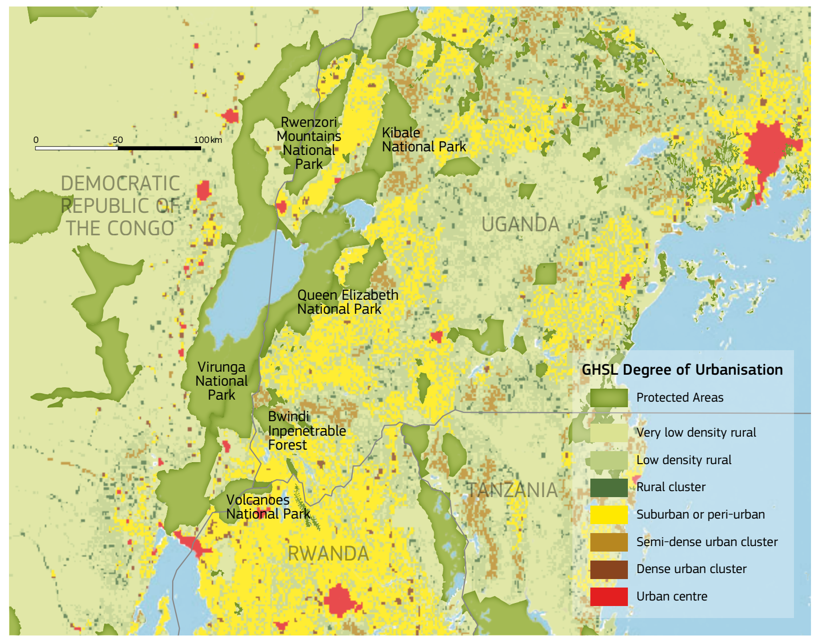
Shown here is the degree of urbanisation in 2020 at the border region between the Democratic Republic of the Congo, Uganda, and Rwanda. Clearly, nature and people coexist along a continuous gradient of population density, rather than a clear distinction between cites and wilderness.

Source: Schiavina M., et al. (2023) *GHS-SMOD R2023A - GHS settlement layers, application of the Degree of Urbanisation methodology (stage I) to GHS-POP R2023A and GHS-BUILT-S R2023A, multitemporal (1975-2030)*. European Commission, Joint Research Centre (JRC).

Living alongside elephants in Uganda.

Villages along Lake Edward's shoreline exist within the boundaries of Queen Elizabeth National Park, Uganda.

Source: Grégoire Dubois, with permission, all rights reserved.



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[6] Schiavina M., et al. (2023) *GHS-SMOD R2023A - GHS settlement layers, application of the Degree of Urbanisation methodology (stage I) to GHS-POP R2023A and GHS-BUILT-S R2023A, multitemporal (1975-2030)*. European Commission, Joint Research Centre (JRC)

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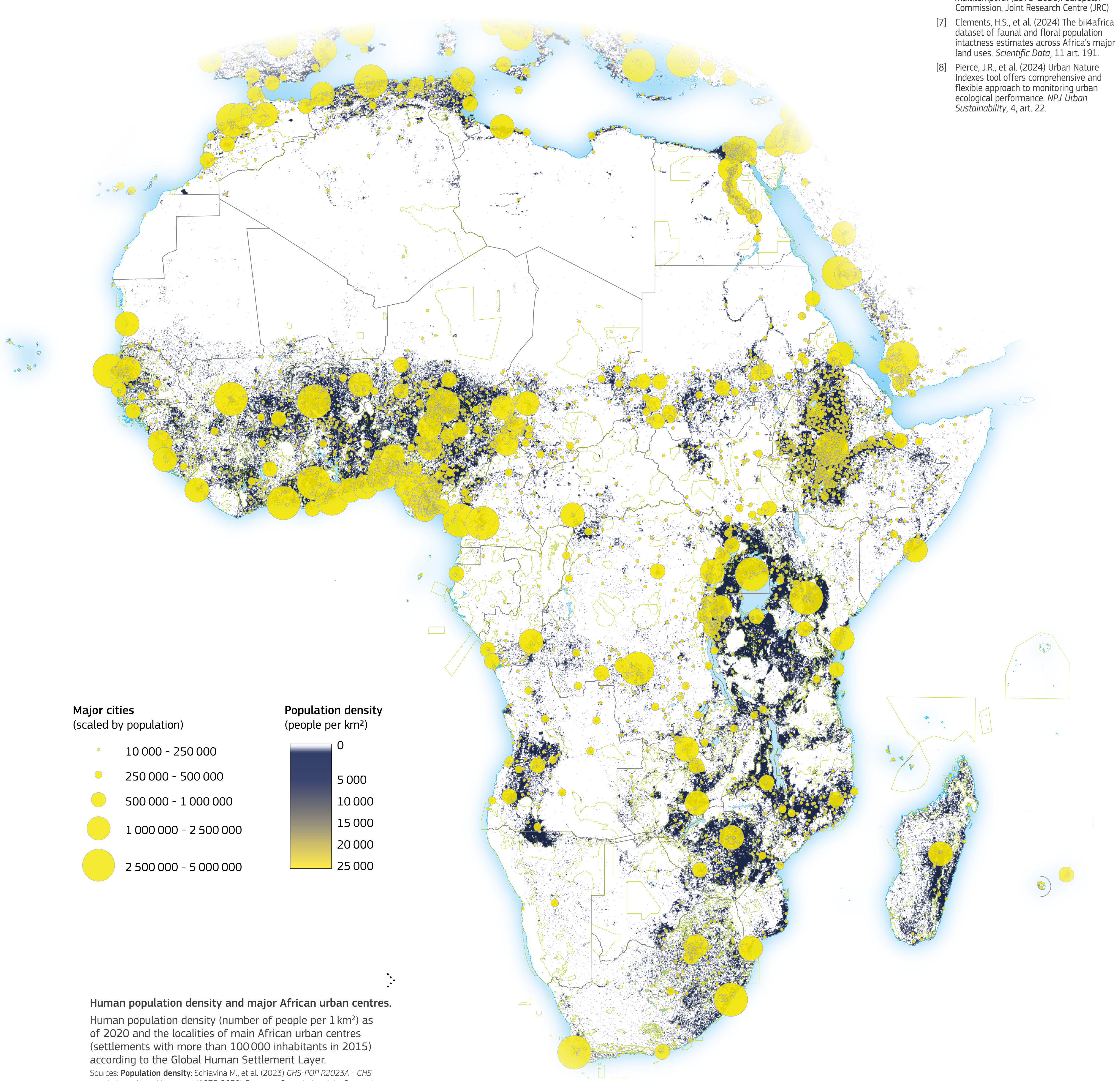


Human population density and major African urban centres.

Human population density (number of people per 1 km²) as of 2020 and the localities of main African urban centres (settlements with more than 100 000 inhabitants in 2015) according to the Global Human Settlement Layer.

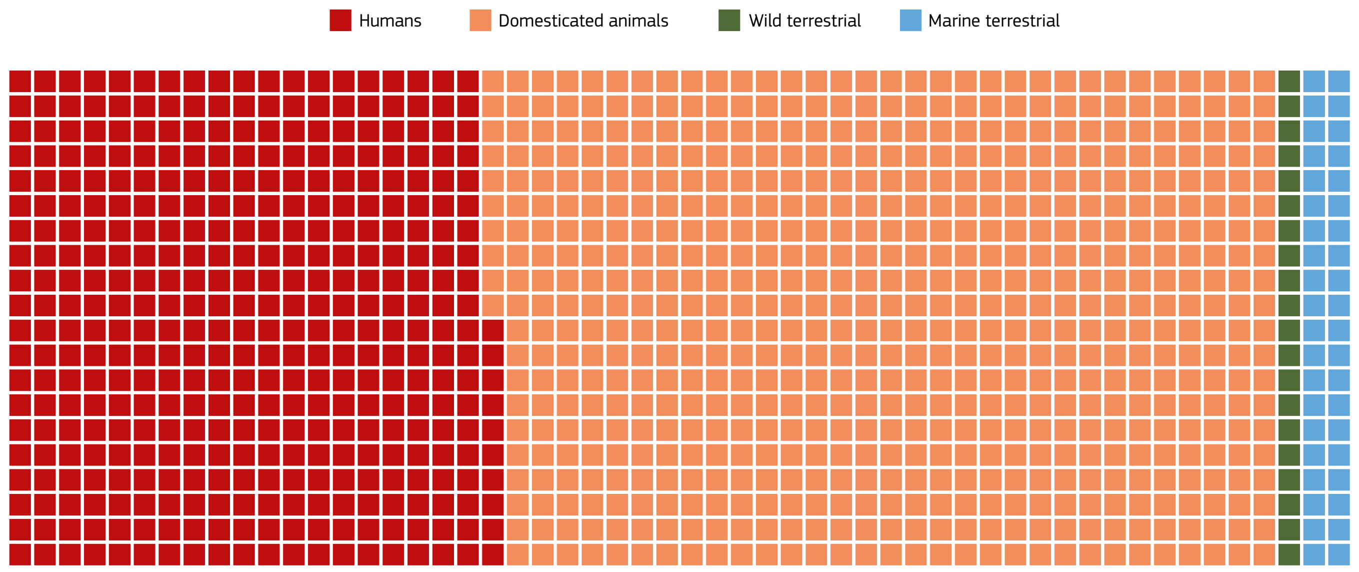
Sources: **Population density**: Schiavina M., et al. (2023) *GHS-POP R2023A - GHS population grid multitemporal (1975-2030)*. European Commission, Joint Research Centre (JRC). **Urban centres**: Florczyk A., et al. (2019) *GHS Urban Centre Database 2015, multitemporal and multidimensional attributes, R2019A*. European Commission, Joint Research Centre (JRC).

4.1.2 Livestock and protected areas

Livestock have been a central feature of African ecosystems for centuries, but they currently outnumber wild species. This may have long-term ecological consequences, in protected and unprotected landscapes alike. Scientific advances in animal husbandry can potentially mitigate these negative impacts, but only if they are able to overcome the strong cultural and economic incentives behind livestock ownership.

Domesticated livestock have roamed African ecosystems alongside their wild relatives for centuries. Unlike in the past, however, nowadays the numbers of livestock far exceed those of wild species. This trend is not unique to Africa, as globally the total biomass of domesticated mammals dwarfs that of wild species[1]. While roughly one-third of mammal biomass on the planet is in the form of humans, nearly 60% of the total biomass walks around in the form of domesticated cattle, sheep, pigs, or goats (and other pets and livestock). Today, wild mammals on land (1.9%) and in oceans (3.7%) only make up a tiny proportion of total mammal biomass globally[1]. In Africa, domesticated livestock densities tend to be higher in non-forested ecosystems throughout the Sahel, Eastern and Southern Africa. This feature map shows the densities of cattle across the continent[2], but similar maps for sheep or goats show the same general patterns.

Although declining extents of grazed rangelands would have positive effects on biodiversity, it would not necessarily return land to its previous natural state. Across the continent, herders enclose their livestock at night to protect them from thieves or predators. Such enclosures – known locally as bomas or kraals – can change biogeochemical cycles across whole landscapes. When livestock graze widely, but only excrete within a small area, they essentially concentrate a whole landscape's nutrients into their enclosures. Research from Kenya showed that the effects of nutrient concentration could last for more than 40 years after enclosures were abandoned; even if the area had since been colonised by native vegetation[5]. N_2O fluxes at abandoned sites did not return to the low levels found in savannah control sites even after half-a-century.



The global biomass of mammals.

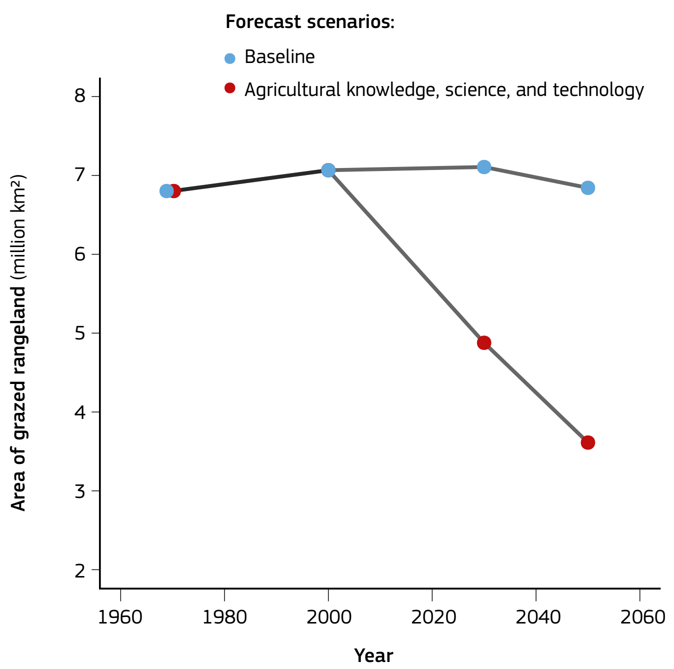
Here, each square represents one million tonnes of biomass differentiated between humans, domesticated animals (including livestock), and wild species from terrestrial and marine ecosystems.

Source: Greenspoon, L., et al. (2023) The global biomass of wild mammals. Proceedings of the National Academic of Sciences, USA, 120, e22024892120.

Even though livestock now make up most of Africa's biomass, the total biomass across the continent has generally declined since pre-colonial times[3]. This is mostly because elephants – which traditionally dominated mammal biomass – have been extirpated across most of their historical range. The few exceptions where total biomass is consistently higher today than it was 1000 years ago are in arid areas, receiving less 250 mm rainfall per year. Although some might assume that reduced biomass lowers the grazing pressure on natural vegetation, this is not always the case because domestic animals are not perfect ecological substitutes for wild herbivores.

Although livestock fulfil some of the ecological roles left vacant by disappearing wildlife, today 90% of Africa's livestock are cattle (water-dependent grazers), goats (generalist feeders), and sheep (browser-grazer intermediates)[3]. This means that they are unable to replace the ecological roles of obligate grazers (e.g. reedbuck, waterbuck, or blesbuck), browsers (e.g. giraffe), and frugivores (e.g. duikers). The consequences of replacing wild species with livestock, and leaving important ecological niches vacant, is encroachment of woody vegetation and changing fire regimes[3].

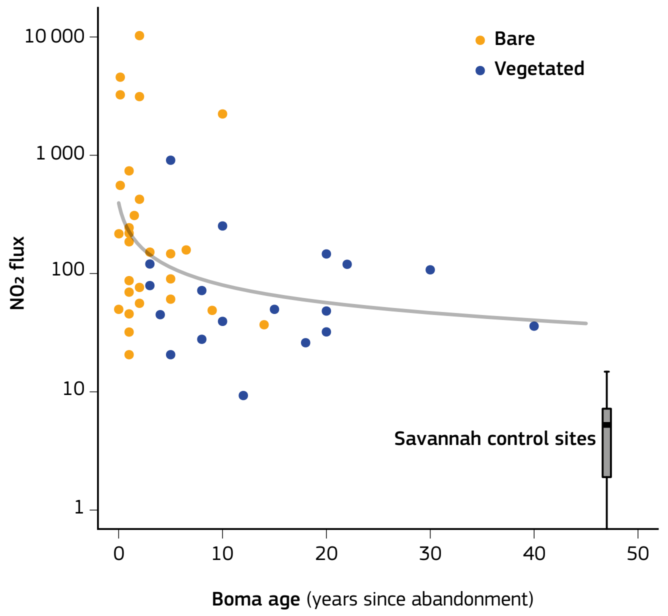
Forecasting models suggest that although the total area of grazed rangeland in Africa increased between 1970 and 2000, the current area of grazed rangeland will likely remain stable until 2030, eventually decreasing slightly by 2050[4]. While the decline in rangeland extent was modest under the baseline scenario, rangeland could shrink by as much as half under a scenario with high uptake of agricultural knowledge, science and technology[4]. Applying best practice veterinary and animal husbandry approaches could increase meat and milk productivity by more than 30%[4], making it possible to sustain production on less land[4]. The ultimate outcome of this would be that livestock production would have fewer negative effects on the abundance of wild species by mid-century.



The projected change in the extent of grazed rangelands in Africa.

Forecasting models indicated that under a baseline scenario, the extent of grazed rangeland will increase slightly until 2030 followed by a slight decline by mid-century. By contrast, under a scenario that assumes the uptake of the latest agricultural knowledge, science and technology, grazed rangeland could half by 2050 because meat and milk productivity can increase without requiring more grazing land.

Source: Greenspoon, L., et al. (2023) The global biomass of wild mammals. Proceedings of the National Academic of Sciences, USA, 120, e22024892120.



The persistent impacts of livestock enclosures on the nitrogen cycle.

Data from Kenya show how the NO_2 flux (measured as µg N_2O-N m^{-2} h^{-1}) from abandoned bomas (i.e. lifestock enclosures) do not return to levels comparable to savannah control sites within 40 years, regardless of whether the enclosure sites have been revegetated or not.

Source: Butterbach-Bahl, K. et al. (2020) Livestock enclosures in drylands of Sub-Saharan Africa are overlooked hotspots of N_2O emissions. *Nature Communications*, 11, art 4644.

Even if herders can be convinced to reduce livestock numbers (see Box), historical grazing may have long-lasting effects on African ecosystems. When open rangelands become encroached by woody vegetation, fire regimes are disrupted, and biogeochemical cycles are changed, then it might take decades, or possibly even centuries, to restore these systems to the same conditions that came before the rapid increase in livestock densities. Therefore, it would be important to consider the need to minimise and avoid these irreversible changes, especially in protected areas.

The Bovine Mystique

The relationship between African herders and their livestock has long been romanticised by anthropologists. This is understandable, since cattle are culturally significant and have an important role in social status, cultural events, and dowries. The way cattle are regarded by many African cultures, especially compared to goats or sheep has been described as the 'Bovine Mystique'. However, these kinds of narratives risk overlooking much more practical explanations. Ethnographical research from Lesotho unveiled economic reasons why herders seem to revere cattle[6].

Quite simply, livestock were for long used as a store of wealth by migrant workers without access to formal banking services. Many Basotho men went to South Africa to work in the mining sector. Since they had limited access to banks, they invested their wages in livestock. Large stock, like cattle, are illiquid assets because their high price means it is hard to find willing buyers. By contrast, small goats and sheep are traded more easily. So, migrant workers treated their cattle as a long-term store of wealth (i.e. their pension funds), while sheep and goats were more suited for day-to-day transactions (i.e. their chequing account). This also explains why it was cultural more accepted for Basotho women to keep sheep and goats, because these could be traded to fund for household expenses. Ultimately, any efforts to reduce the number of livestock across Africa are destined to fail if they do not recognise the important role of these domestic animals in local economies.

Livestock enclosures in East Africa.

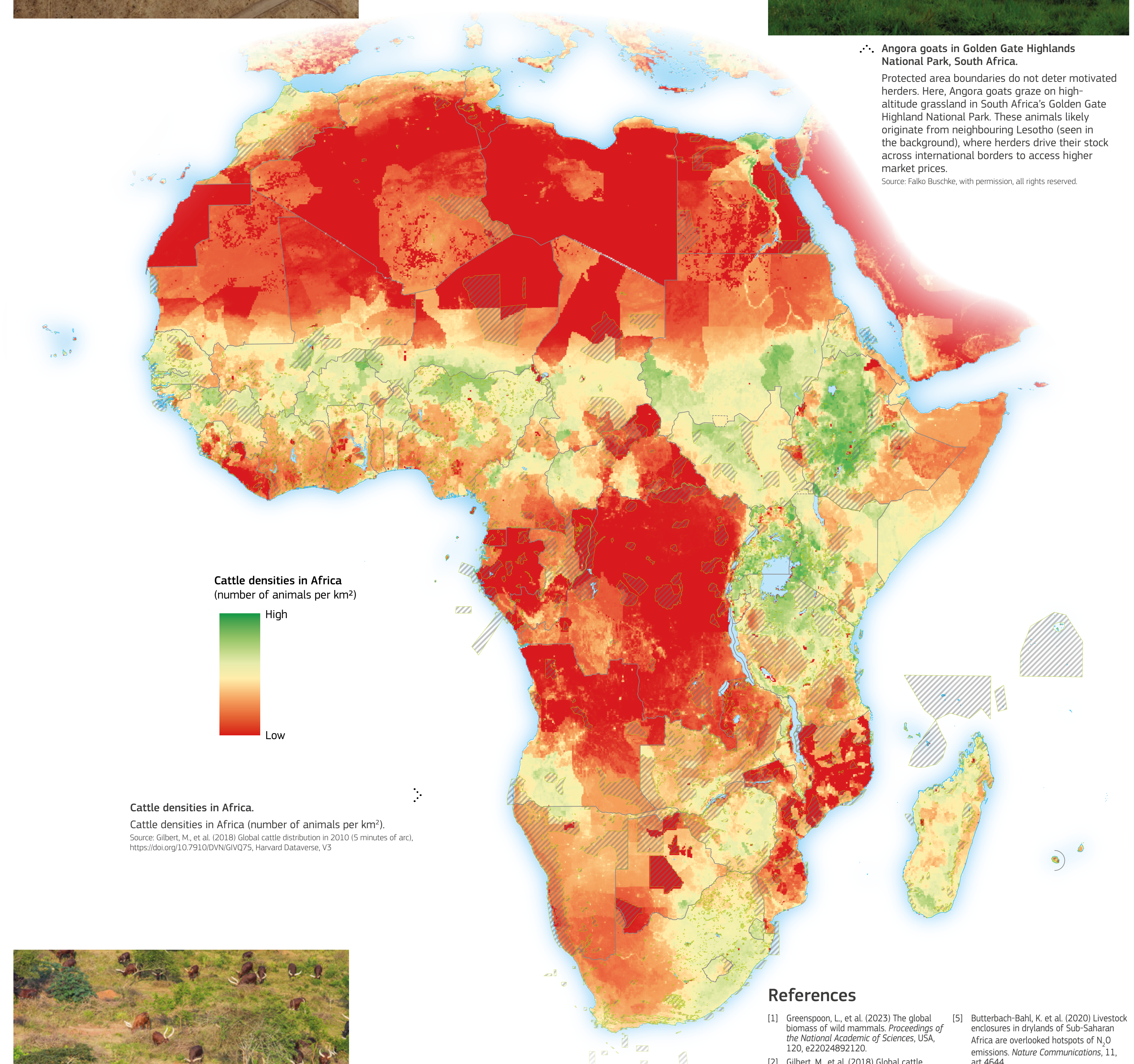
Across the continent, herders keep their stock safe in makeshift enclosures known as bomas or kraals. These sites concentrate nutrients from across the landscape and alter biogeochemical cycling for decades, long after livestock have been removed.

Source: Matti Barthel on Imaggeo CC BY 3.0.

Angora goats in Golden Gate Highlands National Park, South Africa.

Protected area boundaries do not deter motivated herders. Here, Angora goats graze on high-altitude grassland in South Africa's Golden Gate Highland National Park. These animals likely originate from neighbouring Lesotho (seen in the background), where herders drive their stock across international borders to access higher market prices.

Source: Falko Buschke, with permission, all rights reserved.



Cattle densities in Africa.

Cattle densities in Africa (number of animals per km²).

Source: Gilbert, M., et al. (2018) Global cattle distribution in 2010 (5 minutes of arc), https://doi.org/10.7910/DVN/GIVQ75, Harvard Dataverse, V3

Bushbuck and Ankole-Watusi cattle grazing inside the Lake Mburo National Park, Uganda.

Although livestock have existed alongside wild species in Africa for centuries, they currently outnumber their wild relatives to an unsustainable degree.

Source: Grégoire Dubois, with permission, all rights reserved.

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4.1.3 Cultivated croplands and protected areas

Millions of Africans experience food insecurity each year. The pursuit of higher food production has led to cultivated croplands expanding across the continent. The conversion of natural vegetation to cropland has accelerated over the last twenty years, and protected areas have not been spared. However, conservation and food security need not oppose one another. Integrated land use policies can help feed the continent while preserving nature.

Too many Africans still lack access to sufficient nutritious food. Over 80 million people in the Democratic Republic of the Congo, Ethiopia, Nigeria and Sudan experienced high levels of acute food insecurity in 2022, placing these countries amongst the 10 worst affected worldwide[1]. Increasing food production is an urgent priority.

Promoting food production has resulted in conversion of large tracts of natural vegetation to cropland. These croplands have unique spectral signatures, which means they can be mapped from space using satellite sensors[2]. As shown in the feature map, most non-forest habitat in Africa has some form of cultivated cropland, especially in Southern and Eastern Africa, the Sahel, and North Africa. Half of all African agricultural fields are very small (< 0.64 ha), but farm sizes vary geographically[3]. In South Africa, for example, the majority of fields are large (16 – 100 ha) to very large (> 100 ha)[3].

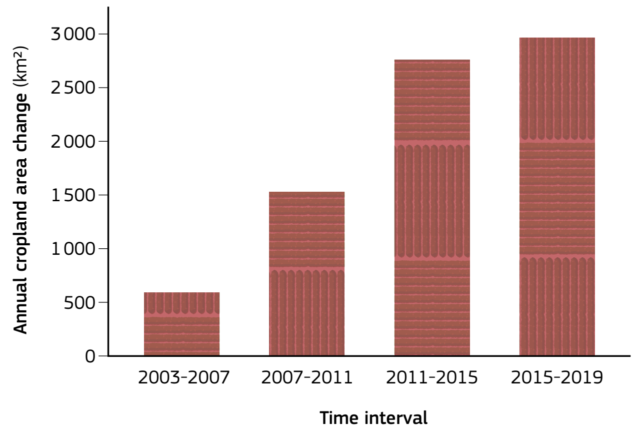
Even though agriculture has always been important, the last two decades has seen accelerating rates of cropland expansion. For the five years between 2015 and 2019, cropland extent has grown by roughly 3 000 km² per year; five times faster than at the turn of the century[4]. Research suggests that protected areas have not escaped the wave of habitat conversion.

A recent study used sophisticated statistical matching to quantify whether protected areas have resisted widespread cropland conversion[4]. This approach divided the African protected areas into tens of thousands of 1 km pixels. It then identified the physical characteristics of each pixel (e.g. its topography, climate, soil, existing cropland, human population) and scoured the rest of the landscape to find an equivalent pixel within the same country. This ensured that the analysis compared protected and unprotected sites that were otherwise identical. Unexpectedly, protected areas experienced higher average rates of cropland conversion over the last 20 years.

Protected area's inability to withstand cropland conversion should be concerning because it limits the options available to policymakers. Broadly, the relationship between conservation and food security can be conceptualised as a dichotomy between land-sharing and land-sparing. Land-sharing presumes that conservation and low-impact agriculture coexist in the same landscape, so larger tracts of land must be farmed to increase yields. By contrast, land-sparing aims to spare large areas of natural land, while increasing yields by farming restricted croplands more intensively. The downside of land-sparing is the risk of increasing the secondary impacts of agriculture, such as water abstraction, excess fertiliser, and pesticide run-off. To date, the balance of evidence from Africa suggests that land sparing is the better choice because it specifically benefits threatened species without worsening yields[5]. However, a land-sparing approach is undermined when protected areas cannot be 'spared' from cropland conversion.

A more nuanced approach is into integrate conservation and agricultural policies more closely. In this approach, protected areas are not viewed as separate from production landscapes, but rather as integral components of them[6]. Some, strategically identified, parts of the landscape might practice land-sharing, while others practice land-sparing. This perspective considers farming and nature as part of the same socio-ecological system and encourages agroecology as a win-win outcome for biodiversity and food security[7]. Integrated policies are better off considering whole socio-ecological systems because food security is not just about increasing food production. It is also about nutritional quality, social and economic accessibility, and cultural preferences.

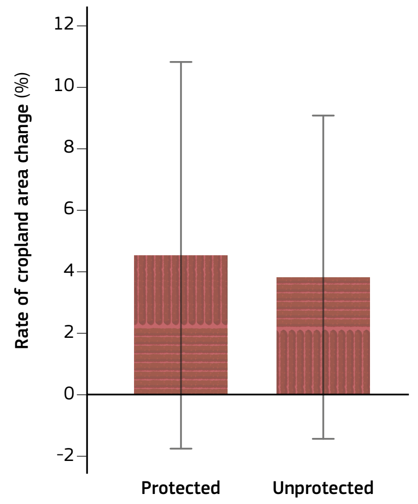
Win-win outcomes for conservation and food security are possible. But they need to draw from traditionally separate policy spheres. Integrated and spatially explicit land use policies will be essential to reap the benefits of land-sparing within agroecological landscapes, thereby meeting the ambitions of the Global Biodiversity Framework.



Increased rates of land conversion to cropland in Africa since 2003.

The annual expansion of cropland extent (measured in km²) has increased consistently in recent decades.

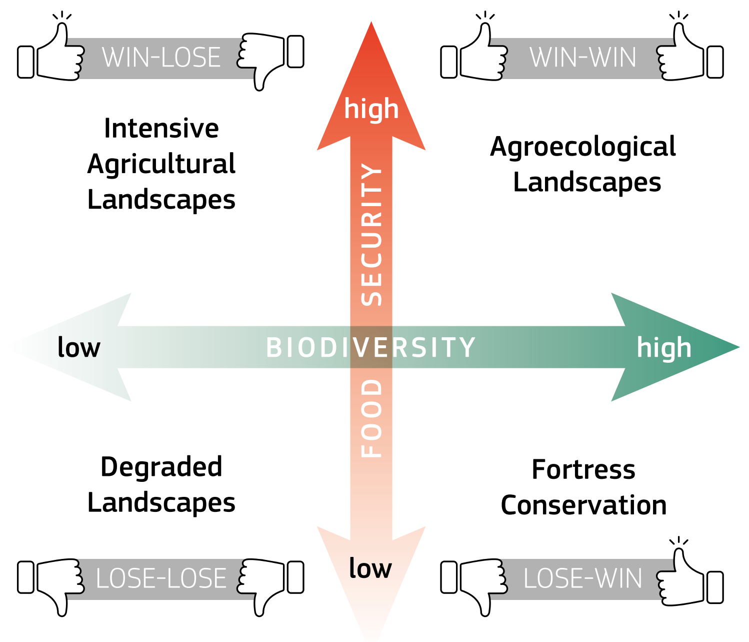
Source: Meng, Z. et al. (2023) Post-2020 biodiversity framework challenged by cropland expansion in protected areas. *Nature Sustainability*, 6, 758-768.



Rate of cropland change across Africa in otherwise identical protected and unprotected sites.

The average rate of expansion of cropland extent between 2000 and 2019. The bars compare the mean values of 147,191 pairs of pixels and the error bars show the standard deviation. Pixels were matched using a statistical approach that identifies pairs of sites with near identical climate, topography, and ecology, differing only in whether they are protected or not.

Source: Meng, Z. et al. (2023) Post-2020 biodiversity framework challenged by cropland expansion in protected areas. *Nature Sustainability*, 6, 758-768.



The conceptual relationship between biodiversity conservation and food security.

In order to achieve win-win outcomes for conservation and food security, policies need to move away from siloed approaches focussing only on either (1) cropland expansion and agricultural intensification, or (2) protected areas and agricultural exclusion. Instead, policies should embrace integrated landscape planning across whole agroecological landscapes.

Source: Fischer, J. et al. (2017) Reframing the food–biodiversity challenge. *Trends in Ecology and Evolution*, 32, 335-345.

Food security in the Kunming-Montreal Global Biodiversity Framework

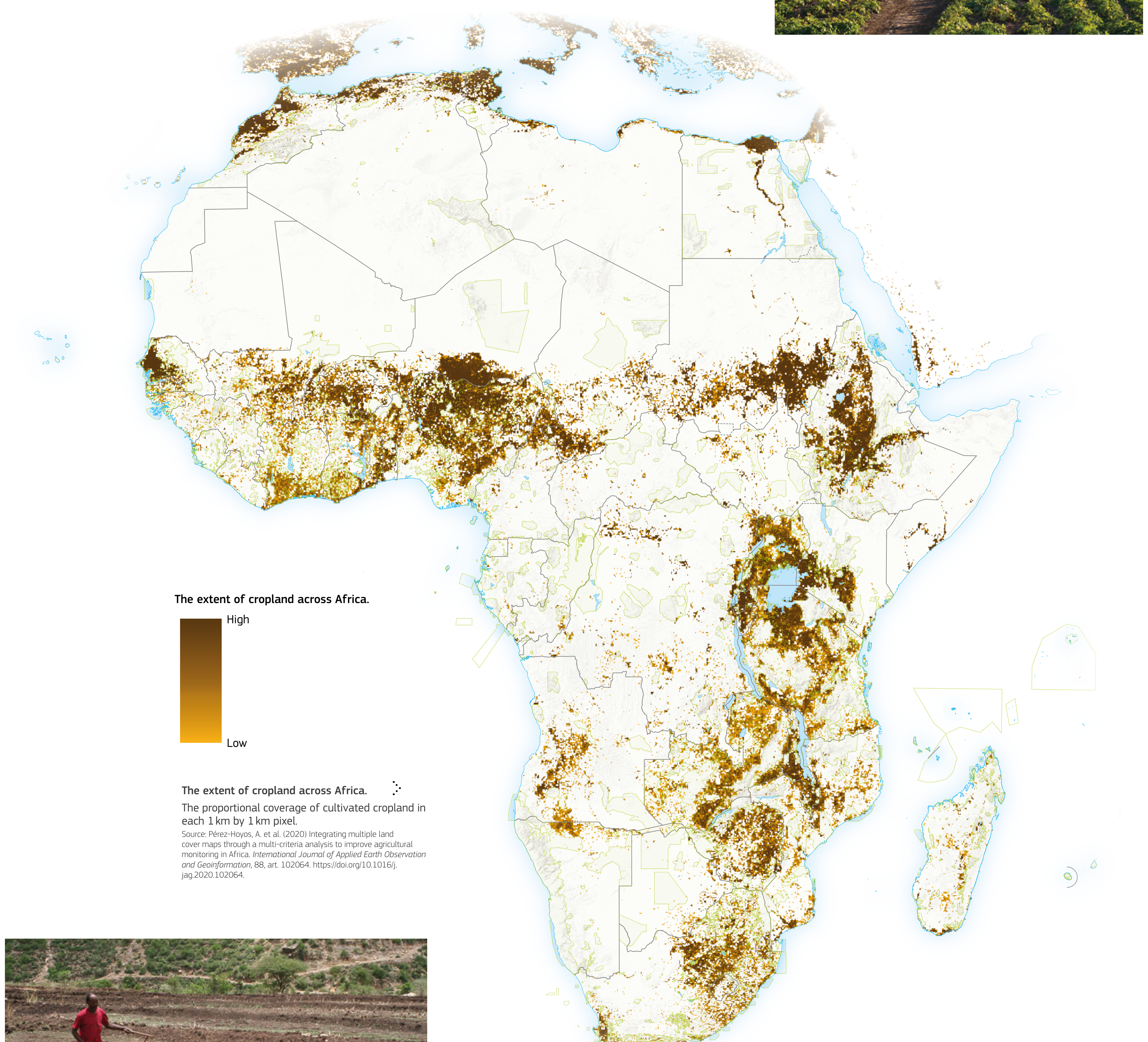
Target 10 of the Global Biodiversity Framework aims specifically to unite policies for conservation and food security (edited for brevity):

"Ensure that areas under agriculture, aquaculture, fisheries and forestry are managed sustainably... including through a substantial increase of the application of biodiversity friendly practices, such as sustainable intensification, agroecological and other innovative approaches contributing to ... food security, conserving and restoring biodiversity and maintaining nature's contributions to people"

Cultivated lands in Vioolsdrift, South Africa.

Throughout the continent, native vegetation has made way cultivated monocultures. Croplands vary from large commercial operations to smallholdings for local subsistence.

Source: South African Tourism from South Africa on Wikimedia Commons CC BY 2.0.



The extent of cropland across Africa.

The proportional coverage of cultivated cropland in each 1 km by 1 km pixel.

Source: Pérez-Hoyos, A. et al. (2020) Integrating multiple land cover maps through a multi-criteria analysis to improve agricultural monitoring in Africa. *International Journal of Applied Earth Observation and Geoinformation*, 88, art. 102064. https://doi.org/10.1016/j.jag.2020.102064.

Clearing land for crops, rural Ethiopia.

Whether by tractors or ox-drawn ploughs, natural ecosystems are increasingly being converted for agriculture.

Source: Petr Kosina on flickr CC BY-NC 2.0.

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