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Shepherding Sub-Saharan Africa's Wildlife Through Peak Anthropogenic Pressure Toward a Green Anthropocene

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Abstract

Sub-Saharan Africa's (SSA's) iconic biodiversity is of immense potential global value but is jeopardized by increasing anthropogenic pressures. Elevated consumption in wealthier countries and the demands of international corporations manifest in significant resource extraction from SSA. Biodiversity in SSA also faces increasing domestic pressures, including rapidly growing human populations. The demographic transition to lower fertility rates is occurring later and slower in SSA than elsewhere, and the continent's human population may quadruple by 2100. SSA's biodiversity will therefore pass through a bottleneck of growing anthropogenic pressures, while also experiencing intensifying effects of climate change. SSA's biodiversity could be severely diminished over the coming decades and numerous species pushed to extinction. However, the prospects for nature conservation in SSA should improve in the long term, and we predict that the region will eventually enter a Green Anthropocene. Here, we outline critical steps needed to shepherd SSA's biodiversity into the Green Anthropocene epoch.

Contents

1. SUB-SAHARAN AFRICA'S UNIQUE AND INVALUABLE NATURAL ASSETS

Sub-Saharan Africa (SSA) is uniquely important for its functionally intact assemblages of megafauna; nowhere else on Earth has a comparable diversity and abundance of large mammals (1), and large mammals are currently less threatened than they are on other continents (2). The continent hosts one-fourth of the world's mammal species, one-fifth of the world's bird species, and significant reptile and amphibian diversity (3). SSA conservation efforts are underpinned by a vast network of protected areas (PAs), covering greater than 4.3 million km^2, in addition to substantial conservation areas on community and private land across the continent (4). SSA's wildlife and the landscapes on which it depends are of immense value to humanity worldwide (5) and to the local tourism industry. Before the COVID-19 pandemic, wildlife-based tourism in SSA was worth US$29 billion and generated 3.6 million direct jobs, and the region was one of the fastest growing tourism destinations in the world (6). SSA's biodiversity-rich landscapes provide a source of natural capital upon which tens of millions of people depend, particularly during times of hardship (7). The continent's vast remaining natural habitats provide a wide range of critical ecosystem services that benefit people and economies in SSA and the world at large by encompassing and protecting watersheds that supply cities, sequestering carbon to a globally significant extent, and providing sources of plant material used in a range of pharmaceuticals (5, 8). Additionally, SSA's wildlife has significant cultural and heritage value for many African people and confers significant existence value to innumerable people across the world (9). However, these natural assets face a grave future due to multiple anthropogenic pressures, including rapid human population growth and associated demands such as agricultural expansion, and increased local and global demand for resources, which consequently undermines the potential for a transition to a robust green economy across the continent (2).

SSA: sub-Saharan Africa

PA: protected area

HIC: high income country

LMIC: low to middle income country

2. ANTHROPOGENIC PRESSURES FROM GLOBAL CONSUMPTION

Much of this review details anthropogenic pressures from growing human populations within SSA. However, comprehensive framing of the environmental effect of anthropogenic impacts acknowledges that current consumption rates of energy, food, land, water, and materials in high income countries (HICs) have far-reaching environmental consequences that drive biodiversity loss (10, 11). Global consumption has risen rapidly over the past decades, with a geographic separation of those who produce and those who consume a substantial proportion of the goods and services. This discrepancy is an example of telecoupling, a term that refers to "socioeconomic and environmental interactions between distantly coupled human and natural systems" (12) and includes international trade and tourism, migration, and flows of ecosystem services (13). Global meat consumption has increased by 58% over the past 20 years, water consumption has increased by six times, and energy consumption has increased drastically, with increases continuing to outpace the shift to renewable energy (14–16). Similarly, the manufacture and purchase of consumer goods have risen dramatically, and such goods are sourced globally.

Telecoupling is intensifying with increasing globalization (12). Decisions around food consumption, for example, taken by HICs have long-distance impacts in low to middle income countries (LMICs). These forces can move with speed, leaving LMICs with little time to learn how to respond, leading to serious environmental or human costs. Telecoupling can thus have a pervasive influence on conservation interventions (17), especially in SSA countries due to poor governance, a high dependence on primary economic activity, and cheap labor and land prices. Because it separates consumers from the environmental costs of their consumption (i.e., the costs are externalized), telecoupling can exacerbate deforestation, land-use change from natural ecosystems to crop and grazing land, agricultural intensification following shifts to more resource-intensive crops, and increased pollution and greenhouse gas emissions (18). Telecoupling also facilitates the spread of diseases and exotic species (19).

ICPD: Cairo International Conference on Population and Development Program of Action

SDG: Sustainable Development Goal

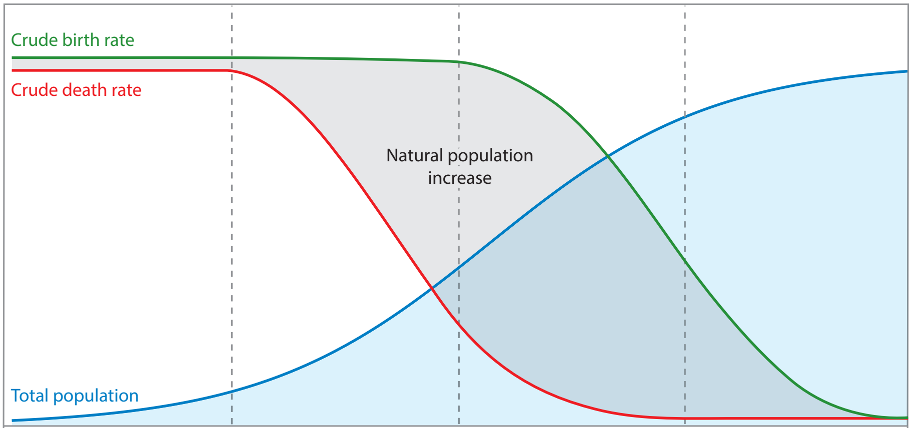
At present, 20 countries account for 70% of global resource consumption and are responsible for 74% of global ecological degradation (20). HICs achieved economic growth through consumption of natural resources and subsequently exported the environmental costs of this consumption to poorer countries (21). This leaves nature within some HICs relatively well protected but places great pressures on biodiversity in LMICs, including in SSA (22). This pattern has resulted from a combination of HICs having overshot their local biocapacity and efforts by corporations to avoid stringent environmental regulations in their home countries, coupled with increasingly cheap and rapid international transport (23, 24). For example, the importation of tropical wood by China increased rapidly in response to domestic restrictions on harvesting and to overexploitation of the commodity at home (25, 26). The combination of exploitation by foreign corporations and weak local governance is a key driver of deforestation in SSA (27), as is the production of commodity crops such as cocoa and tobacco for export and consumption elsewhere (28, 29).

As such, many HICs now live beyond their ecological means through fossil fuel use and through the stripping of the natural assets of LMICs, which frequently results in little economic growth for the producer nations (22). For example, biodiversity loss in SSA is exacerbated by demand for minerals, fish, and wildlife products as well as timber in China and the developed world (1, 24, 30, 31). Natural resource demand is driving a massive infrastructure boom in SSA, imparting severe ecological impacts and making hitherto inaccessible wilderness areas more vulnerable to exploitation (32). In addition, nature-based supply chains are typically dominated by large corporations that funnel income through tax havens, making them difficult to regulate (33).

3. ANTHROPOGENIC PRESSURES FROM GROWING HUMAN POPULATIONS

While there are the large impacts from global consumption, pressures on biodiversity across SSA will also be strongly affected by steep human population growth on the continent. The modern expansion of global human populations commenced around 1800, rising slowly from 1 to 2.5 billion by 1950 (34). During the second half of the twentieth century, population growth accelerated, especially in LMICs in SSA, Asia, and Latin America. Consequently, the world's population has tripled since 1950, reaching 7.6 billion by 2018. Population expansion is expected to continue for several more decades, reaching around 10.9 billion by 2100, with the majority of future growth occurring in SSA (34) and with significant implications for the natural environment.

The 1992 Rio Declaration and Agenda 21, the 1993 Population summit of the World's Scientific Academies, and the 1994 Cairo International Conference on Population and Development Program of Action (ICPD) reviewed the interrelationships between population growth, environmental impact, and poverty eradication. At times over the past two to three decades, there has been a reticence to consider the links between demography, environment, and development. However, recent key scientific reports (11), the Rio+20 Conference, and the 2015 Sustainable Development Goals (SDGs) identified population as a key driver of challenges related to climate change, the environment, and sustainable development. Both the Intergovernmental Panel on Climate Change and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2016) recognized the challenge of population pressure both globally and locally. Further, discussions of the environmental impacts of population pressure are viewed more objectively when framed within a human rights perspective that acknowledges the importance of female empowerment,



	Stage 1	Stage 2	Stage 3	Stage 4
Crude birth rate	High	High	Falling	Low
Crude death rate	High	Falls rapidly	Falls more slowly	Low
Natural increase	Stable/slow	Very rapid	Slows down	Falling then stable
African example(s)	Niger	Democratic Republic of the Congo, Somalia	Botswana, South Africa	Possibly none at the country level

Figure 1

The demographic transition highlighting the changes in birth and death rates in each stage.

whereby women are free to choose their preferred family size through access to secondary education and family planning services (35).

However, political pressure to grow the population still exists in some SSA countries due to religious and cultural sensitivities (36). In several SSA countries, politicians and/or the media have lauded or encouraged rapid population growth as a means for increasing national power and influence [e.g., Tanzania (37) and Nigeria (38)].

4. A DELAYED DEMOGRAPHIC TRANSITION AND OTHER RELEVANT DYNAMICS OF POPULATION GROWTH IN SSA

A key process that influences the speed and extent of population growth is the demographic transition (39) where populations undergo a set of predictable changes as a result of staggered declines in mortality and fertility rates (**Figure 1**). This transition was seen in parts of Europe starting in the eighteenth century, followed by Asia and Latin America during the twentieth century (**Figure 1**). Although an increasing number of countries have now reached the point where populations have started to decline, SSA has been collectively slower to transition than elsewhere, despite its cultural, ethnic, political, economic, and demographic diversity (**Table 1**).

Demographic transition: "is a long-term trend of declining birth and death rates, resulting in substantive change in the age distribution of a population" (39, p. 91)

The effects of variation in culture and historical context have led to differences between the demographic transition in Europe and that seen in LMICs. Europe started from lower levels of fertility and mortality, and the decline was steady and slow. By contrast, the LMICs started from higher levels of mortality and fertility; both then fell faster but had a longer lag between the fall in mortality and fertility, resulting in faster population expansion. In most SSA countries, mortality is falling relatively slowly, and fertility remains high.

High rates of childbearing are the main driver of future population growth in SSA and remain higher in SSA than elsewhere (**Table 1**), possibly because of ongoing pronatalism, and the fact

Table 1 Key demographic indicators in Africa relative to other regions (27)

Demographic indicator	Year/Period	Geographic region: Africa	Asia	Europe	Latin America and the Caribbean	North America	Oceania
Median age (years)	1950	19.3	22.1	28.9	19.8	30.0	27.7
	2020	19.7	32.0	42.5	31.0	38.6	33.4
	2100	34.9	46.7	48.2	49.3	45.6	42.6
Total fertility (children per woman)	1950–1955	6.6	5.8	2.7	5.8	3.3	3.9
	2020–2025	4.2	2.1	1.6	2.0	1.8	2.3
	2095–2100	2.1	1.8	1.8	1.7	1.8	1.8
Life expectancy at birth (years)	1950–1955	37.5	42.3	63.7	51.4	68.7	59.1
	2020–2025	64.1	74.2	79.1	76.1	79.5	79.3
	2095–2100	76.2	83.7	88.8	86.8	88.9	86.7
Infant mortality (deaths per 1,000 live births)	1950–1955	183	155	72	126	31	64
	2020–2025	42	22	3	14	5	16
	2095–2100	13	5	1	3	1	4
Average annual population change (%)	1950–1955	2.1	2.0	1.0	2.7	1.7	2.1
	2020–2025	2.4	0.8	−0.1	0.8	0.6	1.2
	2095–2100	0.6	−0.4	−0.1	−0.5	0.3	0.4
Urban population (% of total population)	1950	14.3	17.5	51.7	41.3	63.9	62.5
	2020	43.5	51.1	74.9	81.2	82.6	68.2
	2050	58.9	66.2	83.7	87.8	89.0	72.1

that any recent reduction in family size is primarily driven by the lengthening of birth intervals across social strata (40–43). Most countries in SSA have begun the fertility transition and started to observe a reduction in their total fertility rate (TFR), the average number of children women have during their reproductive life. However, declines in TFR are slowing or stalling in many SSA countries. Various explanations have been posited, including low GDP per capita, the AIDS epidemic, and the low levels of educational access for girls and slow adoption of contraception (1, 44–46). With the exception of southern African countries, two-thirds of SSA countries experienced no significant decline in TFR in the first decade of the millennium, 4 have yet to start fertility decline, and 10 have experienced fertility stalls (47). Overall fertility rates in SSA are not predicted to fall below replacement level until 2063 (34, 48).

There is clearly considerable diversity across the region in demographic indicators. Middle Africa [a United Nations (UN) statistical grouping of countries similar to the African Union's designation of central Africa] and western Africa have TFRs that remain high at 5.53 and 5.18, respectively, while eastern Africa stands at 4.43, and southern Africa has fallen to 2.50 (34). The contrast is particularly striking when considering indications of future fertility via desired family size, or average ideal number of children (AINC) as opposed to TFR. While AINC is higher in SSA for women of every educational level, this is particularly the case in western/middle Africa compared to eastern/southern Africa. For women with no education, the mean AINC is 5.9 in SSA countries compared to 3.6 elsewhere. For women with higher education, the difference between SSA countries and elsewhere is smaller, but at 3.7 the mean AINC in SSA is still a whole child more than the 2.7 observed in other LMIC countries. A small group of SSA countries (Central African Republic, Chad, and Niger) stand out as having an AINC above 5.0 for women with higher education (42). Western/middle Africa is particularly distinctive in terms of the large proportion of women who say that their ideal fertility is higher than their achieved fertility and the fact that education level–specific desired family sizes have not shown substantial decline.

TFR: total fertility rate; the average number of children women have during their reproductive life

AIDS: acquired immunodeficiency syndrome

UN: United Nations

AINC: average ideal number of children

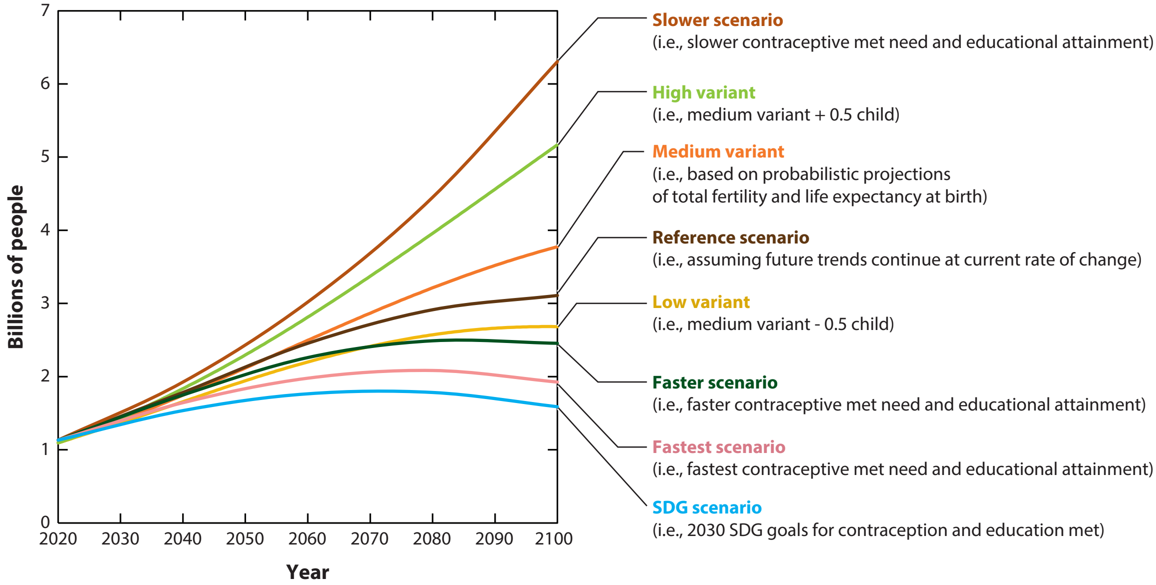


Figure 2

Projected human population numbers in Africa based on varying scenarios of changing fertility. List of data sources: slower, reference, faster, fastest, and SDG scenarios, Reference 48; high, medium, and low variants, Reference 34. Abbreviation: SDG, Sustainable Development Goal.

However, currently no SSA country outside of southern Africa is observed to have a desired family size below 3.0, and most have desired family sizes above 4.0 (42).

In the past few decades, the proportion of SSA living in extreme poverty has fallen substantially, access to education is improving, the proportion of children in school has increased from 40% to 75% (49), and SSA's economies are projected to grow quickly in the coming years (50, 51). Although the peak population in SSA could be as low as 1.9 billion if access for girls to education can be expedited (or as high as greater than 6 billion if it is not) (48, 52) (**Figure 2**), the education bonus seen in other regions does not yet appear to have been as effective in SSA. Several mechanisms likely underpin the relationship between education and fertility, including increased autonomy for women, exposure to new childbearing and gender norms, increased employment opportunities, growing opportunity costs of childbearing, improved health measures, delayed marriage, and lower child mortality (53–57). However, one of the most important relationships affecting reduced levels of childbearing is the quality of education for girls (53), and countries in SSA consistently rank among the worst in the world (58). Thus, meeting the aspirations of the UN's SDGs for improving girls' access to education will require concomitant efforts to improve the quality of their education in SSA.

Future population sizes in SSA are uncertain and debated, but there is consensus that populations will grow substantially after replacement-level fertility has been achieved, due to demographic momentum arising from high concentrations of women of childbearing age. Populations in SSA will likely near-quadruple to almost 4 billion by 2100, and nearly all of the future growth in the world population will occur in SSA. By the end of the twenty-first century, SSA may contain 4 of the world's 10 most populous countries: Nigeria (733 million), Democratic Republic of the Congo (DRC) (362 million), Ethiopia (294 million), and Tanzania (285 million) (1, 34, 48, 59). The highest population densities are predicted for east (325 ± 200 people/km^2 in 2100) and west

(306 ± 56 people/km^2) Africa, with lower densities in southern (135 ± 50 people/km^2) and central Africa (93.6 ± 56.2 people/km^2) (34) (**Figure 3**).

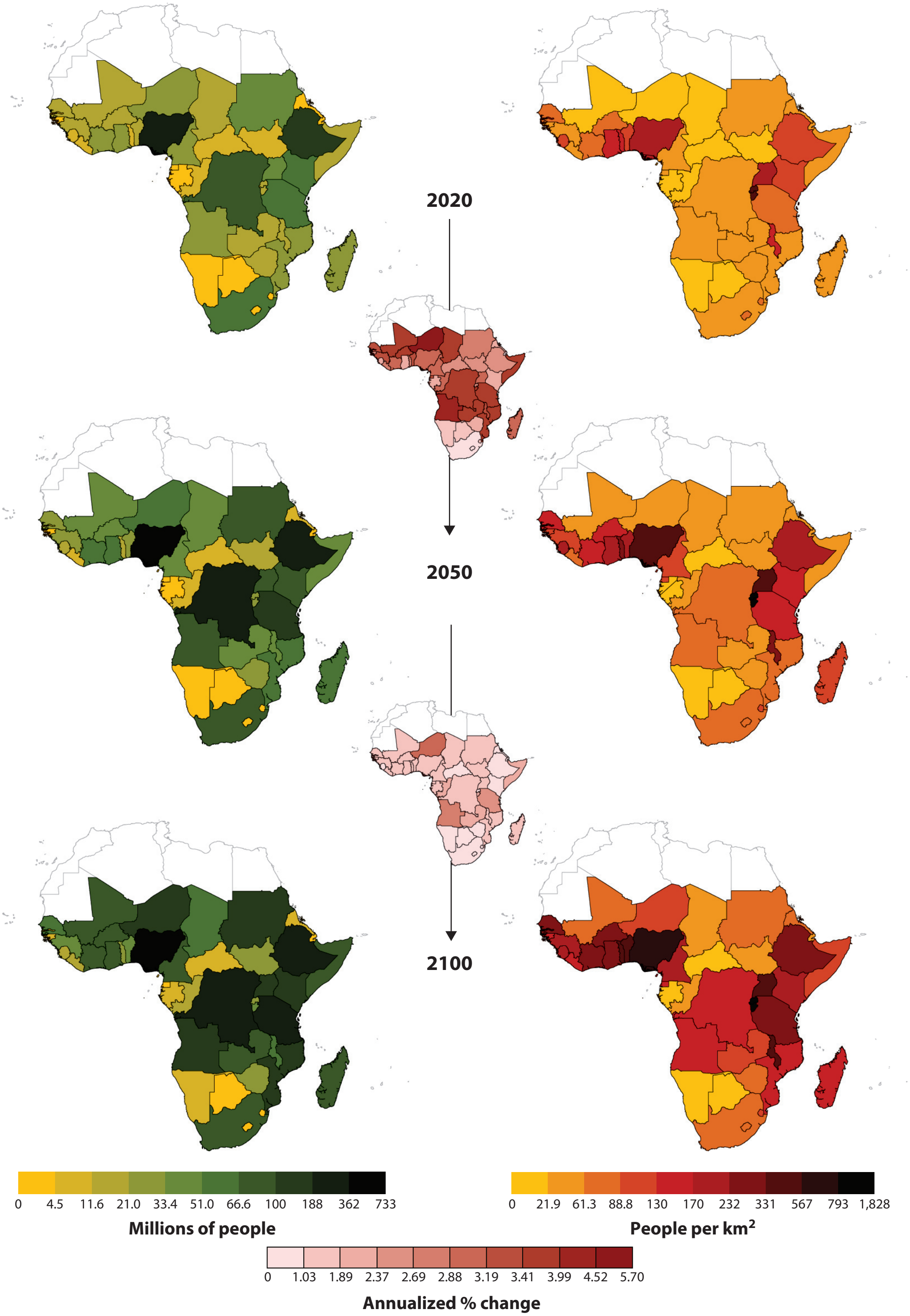
5. THE SIGNIFICANCE OF POPULATION GROWTH FOR DEVELOPMENT AND CONSERVATION

Population growth can confer benefits to host countries via increased geopolitical power, increased labor pool, and elevated scope for economic growth. However, rapid population growth imposes real challenges for governments—for example, by inhibiting poverty reduction, limiting resources that can be invested in education per child, creating shortages of available land and water, increasing deforestation and ecological degradation, rendering commensurate infrastructure development impossible, creating high child-dependency ratios, causing high levels of maternal mortality, and resulting in youthful populations that are more predisposed to conflict (60–62). The acute effects of climate change will exacerbate instability further, creating conditions conducive to forced displacements of people (63). Smaller and more stable populations usually make it easier for governments to reduce poverty, reduce inequality, prevent conflict, improve services and standards of living, increase economic growth, and expedite attainment of the SDGs (64–66). Critically, lower anthropogenic pressure usually makes it easier to protect the environmental services on which humanity and economies depend (1).

While high levels of consumption, particularly by wealthy nations, are highly problematic for the environment, rapid human population growth in SSA also has potentially serious implications for nature (1, 67). This is particularly true in areas with low Human Development Index scores (68), as is the case across much of SSA because these populations are heavily dependent on natural capital for survival (7, 68). While HICs are primarily responsible for natural resource consumption, they are generally facing projected population declines although they continue to extract natural resources from poorer nations. SSA, however, not only is challenged by continued high population growth but also is gradually adopting the increasing consumption pattern of HICs due to their expanding middle classes (Polasky et al., article in review).

SSA's natural assets, already under massive pressure, are set to pass through a phase challenge where human populations are high, the impacts of climate change are increasingly felt, widespread poverty and food insecurity persist, and substantial proportions of people continue to rely on the consumption of natural capital for survival (21, 69, 70) (**Figure 4**). SSA's human population is growing faster than the job growth rate (0.2%/year), placing growing pressure on natural resources (although per capita consumption in SSA remains far lower than in many developed countries) (71). Even under the most optimistic scenarios, SSA will have 300 million people living in extreme poverty by 2030 (72), and COVID-19 has only increased poverty risks (73). Meanwhile, the African continent has gone from being a net exporter of food to a net importer, with food production and crop yields stalling or even declining over recent years (74). Under these circumstances, SSA governments, already facing severe shortfalls for key human and developmental needs (62), may struggle to prioritize nature conservation (75).

A number of mechanisms arising from these growing pressures may impart negative environmental impacts in the short to medium term, particularly the demand for land for agriculture and settlement (**Figure 4**). Indeed, the expansion of smallholder agriculture is the biggest driver of deforestation in African tropical forests (26), population densities are a strong predictor of forest loss in Africa (76), and the expansion of agriculture is associated with negative outcomes across diverse taxonomic groups (77). As an estimated further 4.3 million km^2 of land will be cleared for agriculture in SSA by 2060, Africa will be the continent worst affected by such land clearing, and there is a real risk that many PAs will be lost along the way (2). The need for land clearing will



(*Caption appears on following page*)

Figure 3 (*Figure appears on preceding page*)

Projected changes in human populations and densities during 2020–2100. Data from Reference 34.

likely be further exacerbated by reductions in agricultural yields arising from climate change (78), further increasing the release of vast quantities of greenhouse gases (79). Elevated human populations will also require greater volumes of water for agriculture, mining, household, and other uses, impoverishing river systems and threatening downstream habitats (80).

Africa's forests are subject to numerous interacting threats that will intensify with expanding human populations and economic development: habitat fragmentation due to transport infrastructure; fire; small-scale farming; dam construction and mining; and increased harvests of timber, charcoal, fuel wood, and bushmeat (26). The depletion of wildlife populations due to bushmeat hunting often precedes habitat conversion and can rapidly result in empty forests or savannahs if allowed to proceed unchecked (26, 81, 82). Although the drivers are complex, growing human populations and diminishing wildlife populations can potentially cause an escalating value of rarity where a species can potentially be driven to extinction either directly by its increasingly higher value or by opportunistic exploitation, via an anthropogenic Allee effect (83, 84).

PAs offer some safeguarding against anthropogenic pressures, particularly regarding forest loss (85), but most of Africa's PAs are critically underfunded, meaning that management is already insufficient to deal with human threats in most countries (86, 87). Many PAs on the continent are already severely depleted of wildlife (86, 88), and indicator species are furthest below their

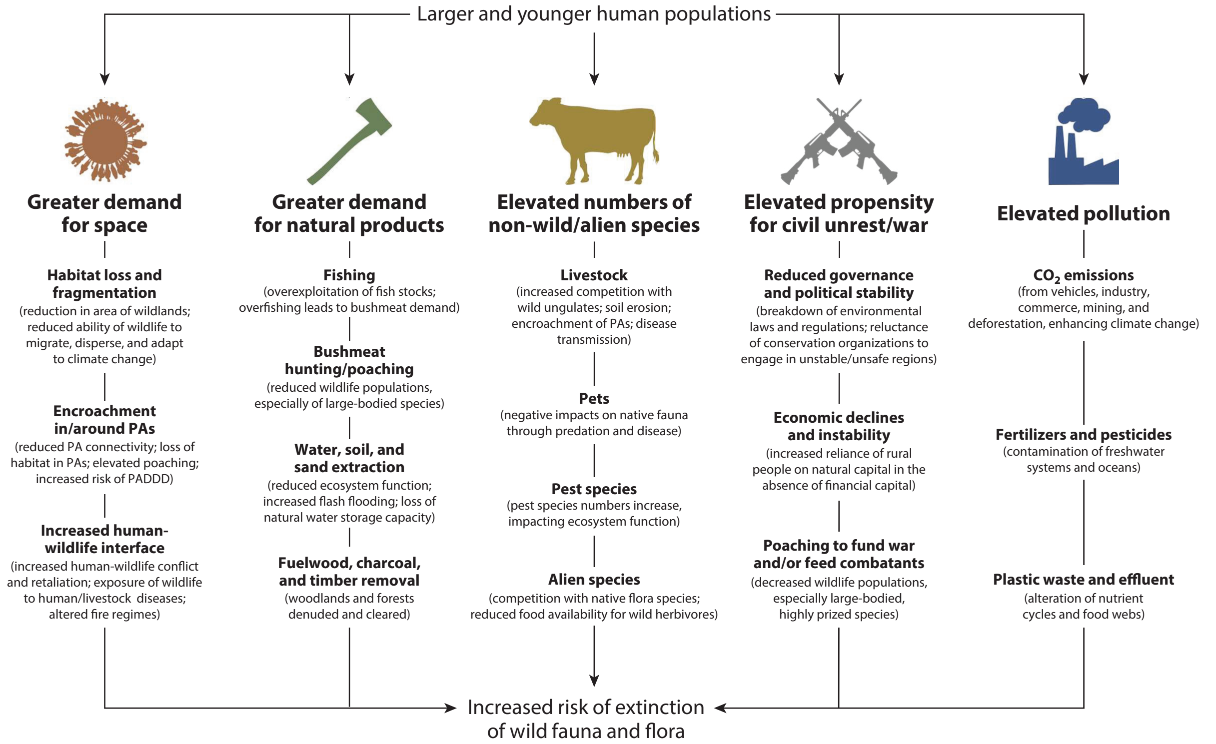


Figure 4

Examples of mechanisms of how rapidly growing human populations could negatively impact nature, for example, through elevated demand for space, demand for natural products, numbers of alien species, and propensity for civil unrest. Abbreviations: PA, protected area; PADDD, protected area downgrading, downsizing, and degazettement.

potential carrying capacities in PAs that are adjacent to higher human population densities (89, 90). As human populations grow, the pressure for access to PAs for bushmeat, timber, charcoal, grazing, minerals, cropland, and settlement will likely grow, posing a risk of severe encroachment and progressive loss of biodiversity. The opportunity costs of retaining large PA networks will grow, creating pressures for governments to reallocate protected lands (91), particularly those unable to generate significant revenues from tourism or other sources at the site level. In addition, as competition for land grows, tensions around the historical displacement of people from PAs (75) may grow, increasing the risk of land conflicts and adverse outcomes for conservation.

Hence, terrestrial, freshwater, and marine ecosystems in SSA are becoming increasingly degraded, reducing the abundance and diversity of species (86, 88, 92–95). Worryingly, some of the countries with the highest projected population growth rates are notable for their biodiversity, endemism, populations of charismatic wildlife, and vast PA estates, such as DRC, Ethiopia, and Tanzania (**Figure 3**). During the coming decades, we expect substantial further reductions in the distribution and abundance of wild species, high rates of local extirpation, and elevated risks of global extinction.

The Anthropocene—a period of pervasive human impact on nature and natural systems—has triggered a great acceleration of environmental degradation (26) and is causing the sixth mass extinction in Earth history (96). Regionally, South Asia, India, and China (SAIC) experienced the greatest population growth between 1960 and 2010, resulting in the highest proportions of bird and mammal species currently threatened with extinction. SSA is expected to undergo the fastest population growth in the coming decades, and correspondingly its vertebrate taxa are forecast to suffer the greatest increase in extinction risks, reaching similar levels as SAIC by 2060 (2). However, it is not clear whether the extent of negative human impacts on nature in SSA will be less than or exceed that in other continents in 50 to 100 years' time as the formation and protection of so many of SSA's PAs explicitly link ecotourism to biodiversity conservation.

5.1. Contextual Factors Exacerbating Human Impacts on Nature in SSA

Several factors in SSA exacerbate the impacts of anthropogenic pressures on nature, noting the diversity of contexts within the continent. These include the following, among others:

- Local governance challenges, global and local populism, poverty, political instability, and conflict (e.g., 97)
- Unsustainable natural resource use: increasingly commercialized usage, international demand for natural resources including wildlife products, and the tendency to export raw materials (e.g., 22)
- Low-productivity agriculture, unsustainable livestock numbers/poor livestock husbandry, and poorly designed land tenure systems that create tragedy of the commons scenarios or promote exploitation by outside actors (98)
- Rapid and insufficiently planned development and infrastructural development without careful planning that risks severe impacts on nature, including PAs (32)
- Political, societal, and economic undervaluation of nature and climate change impacts, as is common worldwide (99)

There is uncertainty regarding the future impact of human populations on biodiversity in different parts of SSA because of the complex feedback loops between economic development, ecosystem services, biodiversity, and human well-being (21, 100). In addition, much will depend on the extent to which human ingenuity can reduce human reliance on natural resources and the amount of land required for agriculture. Human impacts will also depend on contextual factors, such as the country's biome, developmental trajectory, settlement patterns, cultures, lifestyles, levels of consumption, degrees of urbanization, and alignment of government policies with land-use patterns. While future innovations may provide positive impacts from development and growth, larger and younger populations are likely to pose increased threats to biodiversity (**Figure 4**). Thus, the timing and context of SSA's demographic transition are highly relevant to future risks for biodiversity. In Europe, the demographic transition preceded the age of globalization. Production was generally localized, governance and multiparty democracy were relatively (albeit varyingly) well-developed, and the demographic transition was accompanied by a rapid improvement in living standards (69). This process is not guaranteed in SSA due to the combination of weak governance, corruption of host governments and international corporations, international demand for SSA's natural resources, the tendency to export a high proportion of raw materials without value addition, armed conflicts, and climate change (8, 20).

5.2. Contextual Factors That May Mitigate Human Impacts on Nature in SSA

Several factors may help ameliorate the impacts of growing anthropogenic pressures on nature in SSA.

5.2.1. Improved governance and reduced poverty. Better governance would help reduce poverty and improve food security. Already an increasing proportion of elections are genuinely competitive (albeit with much improvement still needed in many countries) (101). Improved governance and reduced poverty are correlated with reductions in some threats to nature [e.g., elephant poaching (102)]. There is some evidence that the 'environmental Kuznets curve' (where ecological impacts are predicted to increase with development and then ultimately decline) is flattening and moving to the left in LMICs (i.e., environmental impacts are peaking at lower levels of GDP) because countries are adopting environmental regulations earlier in their development than HICs did (103). However, increasing wealth can exacerbate threats to biodiversity, for example by increasing demand for bushmeat and increasing industrial development (1, 104–106). Nevertheless, reducing poverty in SSA is a fundamental human rights issue and should help to reduce the reliance on direct consumption of natural resources, improve agricultural production (see Section 6.1.1.4), and provide more people with the opportunity and financial means to enjoy and value nature.

5.2.2. Demographic dividends. The relationship between population growth and economic development varies with population structure. An increasing number and proportion of people of working age can yield a demographic dividend that stimulates economic growth (34, 107). As a country's TFR falls, the proportion of dependents begins to decrease. Families are thus able to concentrate resources on the well-being of fewer children. In addition, women with fewer children are better able to enter and contribute to the formal labor market. For a period of time, countries can capitalize on the increased productivity from their workforce and invest more in health, education, and technological progress. However, without adequate infrastructure, economic management, good governance, and political stability, a youth bulge may simply lead to greater poverty, unemployment, and civil strife (108).

5.2.3. Well-planned urbanization. Urbanization, if well planned and regulated, could create substantial opportunities for conservation on the continent (109). Urban living is associated with more and better employment opportunities, improved living standards, lower per capita carbon emissions, smaller families, and the emancipation of women (69). Urbanization further facilitates the provision of education and health care, which reduces child-bearing, and SSA's rate of urbanization is unprecedented: With currently more than 40% of the population in SSA already living in cities, this is predicted to rise to 55% by the middle of the century (66, 69, 71, 109).

However, poorly planned and managed urbanization risks proliferating slums and further degradation of natural resources via, for example, elevated demand for bushmeat and expansion of transportation networks (109, 110). Furthermore, poorly planned urbanization does not have the same impact on reducing TFR as planned urban development that explicitly supports health care and education. Urban infrastructure has often not kept pace with urbanization in LMICs, resulting in lack of green spaces, public transportation, housing, clean water, and sanitation and overcrowded schools and health facilities (59). A large proportion of SSA's future population will likely live in such conditions in the absence of decisive planning.

CMP: collaborative management partnership; a partnership between an NGO or the private sector and national wildlife authorities for the management of protected areas

5.2.4. A strengthened green economy. We predict that an eventual strengthening of the green economy will motivate increased domestic and international investment in protecting nature, including the following:

1. Strong growth of the tourism industry, involving both international and domestic tourists: Global revenues from nature-based tourism are expected to grow seven times faster than those from agriculture and fisheries (111). Assuming the COVID-19 pandemic is controlled effectively, tourist visitation to SSA should double within the next 10 years, wildlife being the primary drawcard (112). Tourism generates 40% more jobs than the same investment in agriculture, and SSA's PAs already attract $48 billion of direct investment, dwarfing expenditures on their management (87, 112). Numerous efforts are also underway to develop domestic tourism, increase overall revenues, and increase the industry's resilience (113, 114).
2. Expansion of mechanisms to attract investment in conservation and nature-based land uses in SSA, such as by scaling up collaborative management partnerships (CMPs), which are improving conservation outcomes in PAs as a result of their ability to attract funding and technical expertise (115, 116).
3. Accounting for the value of ecosystem services: Countries could potentially begin to capture the value of ecosystem services provided by wild lands in national accounting systems. Such accounting would encourage SSA governments to view nature as an asset rather than a liability, potentially elevating domestic budgets for conservation (113). For example, protecting watersheds to supply cities will become increasingly important as populations grow and urbanize.
4. Formalizing and scaling up the trade in ecosystem services: The increasing ambition of the Paris Agreement, with the associated formalization of carbon markets, has led to a growing pressure for countries, developers, and polluters to compensate and neutralize emissions, and this has the potential to create critical opportunities for SSA governments to monetize wilderness in a sustainable manner. Certainly, developed countries will be forced to invest more to mitigate climate change when local impacts outweigh the cost of reactive action (117).
5. More ambitious, inclusive and effective conservation strategies: Calls are growing for increased commitments to protect land and oceans. For example, the Nature Needs Half and Half Earth initiatives aspire for half of the world's surface to be protected (118). Similarly, the Global Deal for Nature calls for 30% of Earth to be formally protected and 20% to be allocated as climate stabilization areas by 2030 (119). These calls are contentious, and it is crucial that they enhance rather than undermine the land-use rights of local people (75). The challenge will be to effectively enable conservation in ways that positively contribute to rural livelihoods (see below for suggestions).

5.2.5. Changing relationships with nature among African people. Utilitarian perspectives of nature diverge between ruralists versus the protectionist perspectives common among urbanites (69) with concomitant declines in environmental pressures in wealthy urbanized countries, especially where corruption is least prevalent (120). In SSA, growing urban populations and expanding middle classes may foster environmental consciousness with the potential to elevate political will for conservation.

5.2.6. Stabilizing and declining human populations. The present demographic transition combined with urbanization may provide future opportunities for rewilding some of the lands that are converted to cropland during the coming decades, providing opportunity for some level of ecological recovery.

5.2.7. Innovation in conservation and beyond. Conservation challenges and opportunities are dynamic, but so are the human societies within which they are embedded. Innovation means that past trajectories may not accurately project future ones. The relative youth of SSA's population, coupled with their skills, ingenuity, and willingness to embrace new technology, has led the way in globally transformative approaches such as mobile banking (121). This aptitude for innovation has the potential to transform the impacts of anthropogenic pressures upon conservation in Africa. This has already been demonstrated through the development of rhino bonds in Kenya and South Africa, representing the world's first outcomes-based financial instrument designed to conserve a species (122), or the rapid rollout of CMPs for PA management on the continent (116). African innovation is already playing a pivotal role in transforming agricultural potential, which should weaken the link between anthropogenic pressure and habitat loss. Just two examples include push–pull technology to intercrop plants, which results in significant grain yield increases (123), and a system in Nigeria where streamlined subsidies for farmers using improved seeds are paid directly to farmers' mobile phones, significantly improving household income, welfare, and diversification (124). However, it is important that innovation should be measurably pro-poor and locally appropriate, rather than externally imposed, which can risk undermining autonomy, land tenure, local knowledge, and actually exacerbating poverty (125).

6. THE GREEN ANTHROPOCENE: STEPS NEEDED TO SHEPHERD SSA'S WILDLIFE THROUGH THE BOTTLENECK

At some stage over the next 100 years, the global degradation of nature could potentially be followed by a Green Anthropocene: a period where human influence remains pervasive but where people prioritize nature conservation and adopt adequate mechanisms to avoid consistent loss of biodiversity, thus achieving coexistence and improved prospects for ecological restoration. While we envisage a brighter future for biodiversity in the long term, the full consequence of human impacts on nature may take hundreds or even thousands of years to manifest (26, 126). Reaching the Green Anthropocene will require extraordinary efforts to improve agricultural yields and to achieve the SDGs in Africa and to reduce consumption by citizens of the developed world. Such achievements will require great strides not only by African nations but also by the nations of the world, elevated international cooperation, and significant targeted financial support from the international community.

The biodiversity that makes it through to the predicted Green Anthropocene should experience more favorable prospects for long-term conservation. In the meantime, however, SSA's natural assets will pass through a period of unprecedented and existential threats. Policy decisions taken now and over the next 20–50 years will determine what will be left for future generations. We postulate that the Green Anthropocene could be reached with a reasonable proportion of

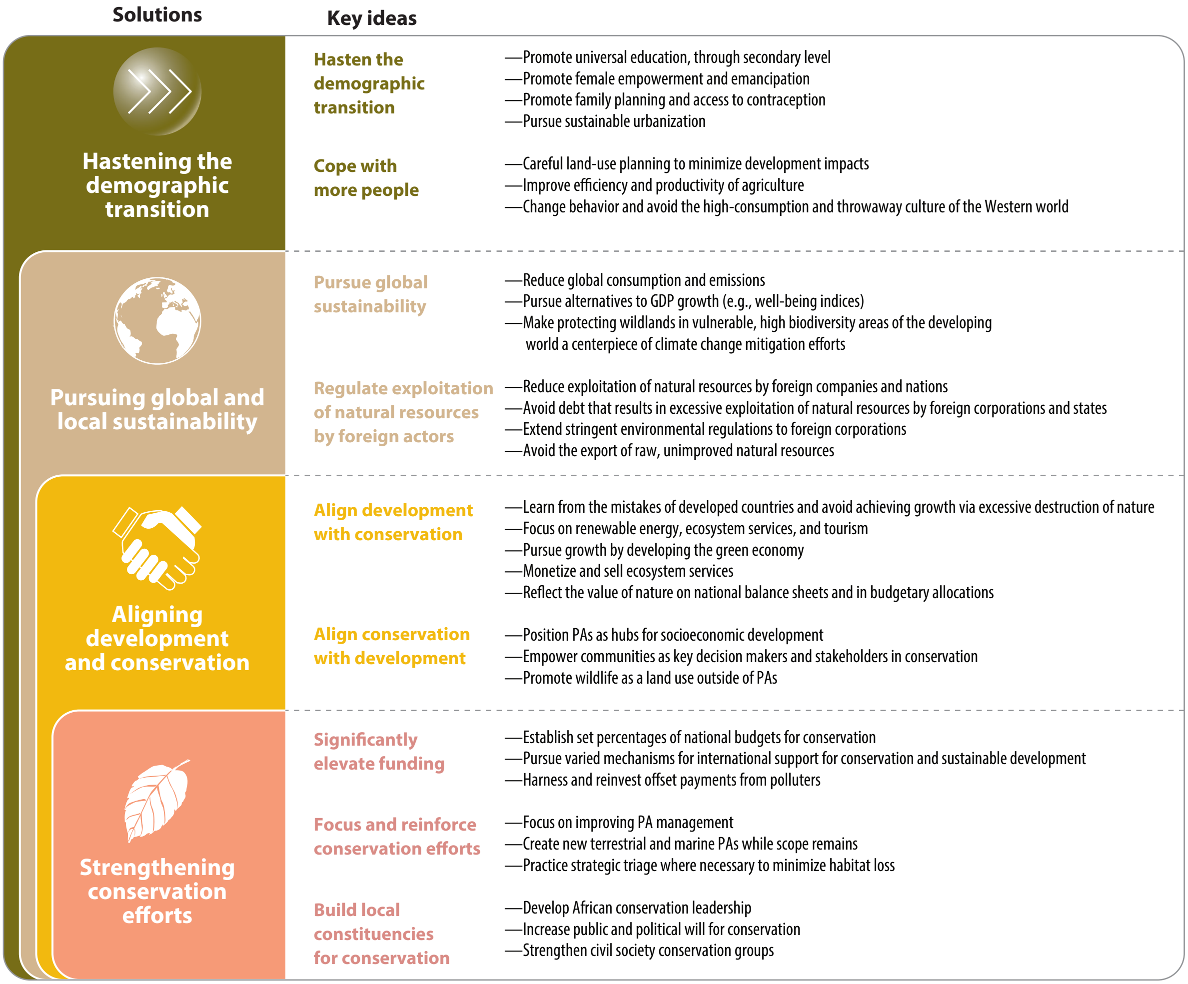


Figure 5

Steps to help shepherd Africa's natural resources through the next few decades, hastening the demographic transition, pursuing sustainability, aligning conservation and development, and strengthening conservation efforts. Abbreviation: PA, protected area.

SSA's biodiversity intact if bold steps are taken by both SSA and the international community (**Figure 5**). We acknowledge that the type and extent of threats and the solutions needed will vary by biome and country. In this section we focus on high-level interventions with applicability across a wide range of scenarios.

6.1. Fast-Tracking the Demographic Transition and Coping with More People

Hastening the demographic transition in Africa is not only critical to reduce future anthropogenic pressures on the continent's biodiversity but also essential for improving the living standards of hundreds of millions of people in some of the poorest countries on Earth.

Repeated experiences from a diverse range of LMICs demonstrate that comprehensive development programs (**Figure 5**) can facilitate demographic transitions even before achieving advanced economic development (67). Critical steps for such fast-tracking include promoting universal education through secondary school for both sexes, and especially for women; the cultural, economic, social, legal, and political emancipation of women; access to sex education, contraception, and family planning; planned urbanization; and a shift away from subsistence agriculture (48, 66, 67, 127).

In addition to improving access to quality education and enabling girls to remain in secondary education (as outlined in Section 4), access to modern family planning and improved health care is essential for primary and public health, as well as acute and chronic care (48, 66, 67, 127). For these steps to be taken at a national scale, much greater emphasis should be given to the benefits associated with reduced family sizes and the jeopardy posed to SDGs by rapid population growth and high human population densities (11).

6.1.1. Feeding people without unduly compromising nature. Conserving areas of natural habitat in SSA that are expansive enough to sustain viable populations of wild species, particularly large-bodied mammalian species, is a major challenge. Land clearing for agriculture already poses the greatest single extirpation threat to vertebrate species, both from overall loss of habitat and from habitat fragmentation (128, 129), and is a major source of carbon emissions (130, 131). With the exception of urban agriculture, which has the potential to improve food security with comparatively much lower ecological impacts than clearing natural vegetation (132), these pressures are likely to increase massively as SSA populations and domestic consumption rise and combine with export production for HICs and poor agricultural yields that are projected to slow or even reverse with climate change (2, 133). The critical challenge from both conservation and human rights perspectives is therefore how to produce enough food for large and growing populations without unduly compromising the ecosystem services on which human well-being depends and driving catastrophic biodiversity loss.

A key variable in this challenge will be agricultural yields (production per unit area). Put simply, higher yields allow more people to be fed from the same area, potentially conserving land from agricultural conversion elsewhere (sometimes termed the Borlaug hypothesis or land sparing) (134, 135). Such yield increases can reduce on-farm biodiversity or carbon stocks (129, 136), but empirical studies have consistently shown that these losses are outweighed by the benefits of larger-scale natural habitat conservation (137, 138). While in the long term, average crop yields rise with per capita GDP (2), yields in SSA remain low and are increasing at slower rates than many other LMIC regions and are unlikely to keep pace with increasing demand (2, 133), and the rate of cropland expansion slows dramatically as per capita GDP reaches ∼$5,000 (139). Accelerating yield increases is therefore likely to be vital for the future of SSA's biodiversity, an outcome that could conceivably be achieved by a number of approaches.

6.1.1.1. Improving land rights. One of the main developmental challenges in Africa is lack of clear land rights for rural communities. Much of Africa is under customary or communal tenure (140), which reduces incentives for long-term investment by communities to increase yields and maintain sustainable production and introduces a risk that communities will be displaced or subject to land grabs by governments or corporations. Establishing clear land rights for communities over land is critical, although the issue of how best to transition from customary tenure is complex and increased security of tenure can lead to adverse outcomes such as poor farmers selling land and moving to slums (140). However, land rights can help prevent alienation of land, foster more sustainable land-use practices and limit harmful practices such as shifting cultivation, and position communities as the rightful beneficiaries of private investments. Indeed, productivity gains have been observed in scenarios where land rights have been accompanied by investments by corporations (140). Exactly how to improve land rights and whether, for example, to issue ownership to individuals or to delineated communities will depend on the local context.

6.1.1.2. Intensifying and improving small-scale agriculture. Eighty percent of farmland in Africa is managed by smallholders (141), and any agricultural effort will therefore have to include this sector. Across much of SSA, soils are effectively being mined for nutrients, with more being removed through harvesting and soil erosion than returned through either organic or inorganic fertilizers (142). Reversing this trend and otherwise sustainably intensifying small-scale agriculture have been extensively studied (143) but remain serious challenges. Simple interventions such as the use of improved seed varieties, modest quantities of fertilizer, mulching, and improved plant spacing can improve crop yields and reduce deforestation (135, 144, 145). However, the application of agricultural inputs (improved seeds, fertilizers, pesticides, etc.) remains low for most crops, owing to their unaffordability for many farmers, weak agricultural credit systems, strong gender differences (input use is far lower in female-headed households), and national-scale policies and processes that are poorly aligned with agricultural and environmental goals (146). Another key intervention is reducing postharvest losses of food, which in SSA are significant (147, 148).

In addition, as new lands are invariably cleared, shared Earth approaches, whereby communities are incentivized to leave a proportion of village lands in a natural state, could potentially reduce impacts of agricultural expansion (75). In the case of croplands, this could involve leaving islands of natural vegetation that may have potential to conserve birds, plants, invertebrates, and small mammals, if not necessarily large mammals. In the case of pastoral lands, this could involve practicing livestock production in combination with wildlife conservation, as is being achieved in community conservancies in various parts of the continent (149, 150). If such efforts target land with low-potential yields, relatively large biodiversity gains could be attained for little or no cost in terms of agricultural productivity. However, if these conservancies merely displace agricultural production to other areas, the loss or fragmentation of larger, more valuable habitats might often outweigh any biodiversity benefits of these conservation islands (135, 151).

However, there are also reasons to believe that small-scale agriculture alone is not sufficient to meet projected food demand in SSA and that a shift away from traditional land use over time is needed. First, small-scale agricultural yields in Africa are generally poor and stagnating (143). Small-scale farmers frequently lack the economic capital to benefit from higher yielding crop varieties, which frequently rely on irrigation and inputs such as fertilizer (152). As climate change proceeds and as rainfall becomes less predictable, rain-fed agriculture will become increasingly perilous. In addition, reliance on small-scale agriculture for livelihoods perpetuates large family sizes, creating a poverty trap because more children mean less land for each to inherit (143). As African populations urbanize, there is a real question around whether small-scale farming will be able to supply sufficient food to burgeoning urban populations.

6.1.1.3. Pursuing commercialized agriculture. Intensification that permits land sparing can have clear positive conservation impacts over the long term (77) and appears to result in more favorable conservation outcomes than are possible via land sharing (135). Experiences in South Africa, Zimbabwe, Zambia, and parts of Kenya have demonstrated that high yields can be achieved in parts of the continent via commercialized agriculture (143, 153), while highlighting the important role that commercial agricultural farms can play in conserving wildlife via leaving hilly parts of farms untilled (154).

As SSA economies develop and wages elsewhere rise, and as landholdings per person shrink, smallholder agriculture is likely to become less economically viable or appealing—mirroring trends across the world (155). It is essential that any decline in smallholder production is matched, or preferably exceeded, by increases in commercial agriculture. To minimize habitat losses, such commercial farming should occur on the same land that is currently used for small-scale farming, but care must be taken to ensure that a shift to more intensive agriculture does not intensify poverty or cause loss of livelihoods. Land-lease arrangements or joint ventures might be a way to ensure that agriculture could be intensified without resulting in dispossession of land or the loss of livelihoods (156, 157). In addition, care should be given to minimize the negative impacts of industrialized agriculture via excessive water extraction for irrigation and the use of fertilizers and pesticides. Measures do exist to minimize the negative ecological impacts of commercial farming, for example, via applying integrated soil fertility frameworks (143), intercropping (158), and targeted application of nitrogen (159). Another risk is that, unless tightly regulated, commercial agriculture, with its access to global commodity markets and the greater purchasing power of HICs, will divert production to exports rather than meet the food security needs of SSA. While the expansion of commercialized agriculture would thus carry socioeconomic and ecological risks, its access to capital and agronomic expertise could potentially lead to more rapid yield increases, greatly reducing the need to convert natural habitat to cropland (2).

6.1.1.4. Outsourcing agriculture. There is considerable scope for outsourcing some of Africa's food production. A huge proportion of cropland in developed countries is used for biofuels and animal feed, and the sensible redirection of this land's production, combined with population declines in the world's wealthiest nations, could allow their highly productive croplands to meet much of the future food needs of the poorest nations (Polasky et al., article in review). Concentrating food production in high-yielding, relatively low biodiversity parts of the world would greatly reduce global impacts on biodiversity and climate change compared to expanding into natural habitats in SSA and across the tropics (2, 138). Although such a system of crop expansion-minimizing trade could potentially eliminate the need for further habitat conversion, the socioeconomic impacts could be devastating without carefully negotiated multilateral treaties that guaranteed food security, job training, etc. in the importing countries. If markets for ecosystem services are formalized and prices made fair, then Africa could sell ecosystem services to yield foreign currency, which would contribute to food security and enable African countries to import food. To make provision for producing food for export, however, countries such as the USA may have to reduce the amount of land used to produce beef or ethanol (Polasky et al., article in review). This highlights once again how the ecological impacts of local population growth in Africa and excess consumption in the West are intertwined.

6.1.2. Land-use planning. Careful land-use planning is critical to creating and stringently enforcing clear zoning for different types of activity, such as wildlife, forestry, agriculture, development, and urbanization, and minimizing fragmentation from future economic development, roads, mining, forestry, fishing, and other extractive industries. Development corridors could be focused on areas of high agricultural potential and low conservation value (32). As infrastructure is developed and croplands are expanded, governments should take into account high-value natural habitats and take steps to ensure that negative impacts are minimized (Polasky et al., article in review). As PAs become more isolated and surrounded by higher densities of people, fencing will likely become increasingly important to minimize edge effects (90, 160). There is already growing pressure to develop infrastructure and mines inside PAs in SSA, and in many cases, PAs are degazetted or downsized to accommodate mining (161). Clear, strictly enforced policies are needed to minimize such development and, where unavoidable, to ensure that environmental impacts are reduced and that degazetting and downsizing of PAs are minimized, and to offset impacts with payments in support of conservation efforts.

Coping with more people will also require a strong local commitment to conservation. Developing strong local constituencies for conservation in SSA is essential. Such constituencies will help hold governments accountable and advocate for environmental considerations as development proceeds [as occurred in the industrialized nations in the 1960s and 1970s (162)]. Fostering local passion for conservation will require a broad suite of efforts, including environmental education at all levels; encouraging domestic tourism and growing cultures of nature-based holidays; engaging the youth through music, social media, radio, and film; and developing local conservation leaders that inspire youth to enjoy and protect nature (for further suggestions, see 163).

6.2. Pursuing Global and Local Sustainability

Tackling global imbalances in natural resource use is imperative. Reducing reliance on biofuels and grain-fed meat could help reduce average consumption from 11,600 kcal/person/day most of the way to 5,000, a rate that would allow current croplands in the richer nations to meet much of the growing global food demand in the next century (Polasky et al., article in review). The international community could make further meaningful steps to respect global ecological limits, reduce consumption [particularly of superfluous single-use goods (164)], shift toward plant-based diets and renewable energy, and decisively tackle climate change (63). The perpetual pursuit of GDP growth encourages overexploitation of natural resources, whereas indices such as gross ecosystem productivity or human well-being targets would incentivize the protection of biodiversity (165, 166). The extent of global efforts to achieve sustainability or the Shared Socioeconomic Pathway chosen will have an outsized bearing on the pace of demographic transitions and on conservation outcomes (127).

Locally, SSA countries could moderate the exploitation of their natural resources by foreign states and corporations (as well as local industries) by (*a*) introducing strict and properly enforced environmental regulations; (*b*) avoiding the export of raw natural resources; (*c*) avoiding debt tied to access to natural resources, as is common in agreements with China, for example (167); (*d*) minimizing land conversion to produce commodity crops for export; and (*e*) discouraging the domestic production of food crops for biofuel and grain-fed meat. Critical precursors to such changes are improved governance, reduced corruption, and the development of more sophisticated economies that permit the local production of finished goods.

6.3. Aligning SSA's Economic Development with Conservation and Vice Versa

SSA's economies must inevitably grow to improve human well-being, but how can this be achieved without unduly compromising the biodiversity on which human well-being depends?

SSA has an opportunity to foster growth based on harnessing the value of its iconic biodiversity through tourism and the sale of ecosystem services to more consumptive and ecologically impoverished nations. Sustainable growth will require investments in natural, social, cultural, and physical assets, whether it is monetized or not (165). Greater cooperation among SSA states could allow for more strategic development, peace, and stability and more assertive engagement with foreign states around natural resource use, and it could enable coordinated efforts to tackle environmental challenges (168).

Whether SSA manages to pursue a different developmental pathway than the rest of the world remains to be seen. Worryingly, most of the fastest growing SSA economies rely on consumption as the major engine for growth (169). Achieving sustainable development will depend on strong leadership and political will. Fortunately, the intention to conserve nature is clearly articulated in the African Union's strategic framework for inclusive and sustainable development (170). Engagement and support from the international community are also critical as SSA requires massive support for agricultural intensification, environmental protection, PA management, and hastening the demographic transition. Inasmuch as aligning development with conservation is key, aligning conservation with development is also critical to position nature as a driver of sustainable economic growth and poverty alleviation. To this end, monetization of nature-based assets is key, via varied mechanisms.

We see four mutually reinforcing pathways to aligning conservation with development and achieving improved conservation outcomes in an increasingly human-dominated continent.

1. Making PAs involve and benefit local people: A critical first step to this is recognizing the legitimacy of local communities as stakeholders, decision-makers, and in some cases landowners and involving them in the governance and management of PAs (63, 171). For example, PAs can be positioned as hubs for economic development through the tourism industry, as well as for service delivery and even disaster relief (113). Recent examples can be seen in the CMPs between nongovernmental organizations (NGOs) and wildlife authorities (116, 172).
2. Sharing land more effectively: As agriculture inevitably expands within SSA, pursuing shared Earth approaches to ensure that a minimum proportion of working landscapes is retained for nature could help retain connectivity, minimize biodiversity loss, and ensure that communities benefit from ongoing service provisions such as fresh water provision and pollination (75). Conversely, in many PAs there will be a need for land sharing and compromises to make provision for the needs of people (e.g., emergency grazing rights granted to pastoralist communities in drought-prone areas). This means that some PAs may have to shift from strict protection to multiple land-use models. Such a shift may require changing the legal status of land to accommodate mixed land uses and to recognize local communities as the owners of the land. Such steps would help preempt open-access challenges and also position local people as the appropriate beneficiaries for returns from disaster relief, tourism, or the sale of environmental services (173). Strictly PAs excluding people do arguably have particular value for conservation because there is no need for compromises on land use and also because detecting and limiting illegal activities is easier—and indeed, high levels of human disturbance inside the PAs in SSA are often associated with ecological deterioration (88). Thus, retaining some strict PAs is important. However, there is increasing recognition and evidence that properly empowered indigenous communities can be very effective at delivering conservation (63), and there is no doubt that the only realistic pathway for conserving a high proportion of SSA's land area in the future will require shared, mixed land-use approaches.
3. Expanding PAs and promoting nature-based land uses where possible: Scope for proclaiming new PAs should be pursued before the window of opportunity closes, with a focus on under-represented biomes and improving connectivity. Similar to growing tourism markets and the sale of ecosystem services, community conservancies could be developed in many parts of the continent that effectively connect, buffer, and expand PA networks. With climate change, increasingly variable rainfall will pose formidable challenges for agriculture and livestock production, and nature-based activities may provide a route for rural communities to diversify livelihood options while permitting enhanced mobility of wildlife to access increasingly patchy primary productivity (70). Precedents from a variety of contexts in Africa, including Kenya and Namibia, have demonstrated the potential for wildlife to coexist effectively with people and livestock in some contexts (149, 150). Key to the success of such land uses are legislation to recognize community rights over land and

natural resources and laws, funding and technical support that facilitates the establishment of effective governance, and management of natural resources (174, 175).

4. Across all of these scenarios, there is a need for mechanisms to position and reward rural communities as custodians over nature and ecosystem services on behalf of the world. Such roles would seem a sensible use of development funding because unlike many traditional donor projects, communities would be employed for performing the valuable service of protecting ecosystem services for mutual benefit, rather than being recipients of aid. Again, some exciting experiments are being performed in this area via performance payment projects where communities are rewarded for the effective protection of wildlife (176). Examples include Niassa Special Reserve, Ngorongoro Conservation Area, and around Ruaha National Park, where communities are being rewarded varyingly for compliance with conservation agreements and for the proven persistence of wildlife (**https://www.lionrecoveryfund.org/**). Some have gone as far as to recommend basic income grants for communities living adjacent to (or within) PAs (75).

6.4. Better Financing and More Focus on Conservation Efforts Within SSA

Dramatic increases in the amount and diversity of finance for conservation both from SSA countries and via the international community are necessary to prevent wholesale loss of biodiversity during the tough years ahead (87, 113). There has been some question of the efficacy of conservation funding and even the suggestion that it is positively correlated with forest loss (76), although the veracity of those findings were questioned (177). However, more recent analyses demonstrated the strong positive correlation between funding and conservation performance of PAs (89, 178). Indeed, most of the best-performing PAs (in savannah Africa at least) are those under CMPs, which attract significantly more funding than purely state-managed PAs (86). These successes need to be urgently scaled up (**Figure 5**). To this end, SSA governments could become much more proactive about attracting private and NGO investment in PAs by creating enabling environments for tourism development, partnerships for the management of PAs, and the creation of conservancies on community lands (112, 113).

Many SSA countries will simply not be able to retain the vast lands they have set aside for PAs in the face of rapid population growth. For example, Mozambique, Tanzania, and Zambia all have massive PA networks covering 29.5%, 41.2%, and 38.2% of their surface areas, respectively (179), and yet they have very high birth rates. As such, many SSA countries carry a burden much greater than the global average for the protection of biodiversity and megafauna in particular (75, 178). The implications of large-scale conversion of wildlands in SSA are grave in terms of carbon release, biodiversity loss, and the jeopardy posed to fresh water supplies. Thus, we urge developed countries and corporations to make financial support for the protection of existing wildlands in SSA a central component of climate change mitigation efforts, although such programs should be monitored and contingent on verification of direct allocation of funding to conservation.

Creditor nations could play a key role by providing debt relief in exchange for the continued setting aside and protection of wildlands (a so-called debt-for-nature swap) (180). Such steps would position wilderness areas as justifiable and economically productive forms of land use. Direct payments to countries with large PA networks or large blocks of intact, unexploited forests may be necessary to avoid many of these areas being lost. Indeed, such payments would help to reduce the unfair burden currently placed on countries in the Global South for environmental protection (75). The recent carbon-based payment to Gabon by Norway for the setting aside of land as forests represents an encouraging precedent in this regard (113, 181). In tropical forest areas, setting aside of land would also need to be accompanied by steps to minimize logging and the development of roads, mines, and dams due to elevated fire frequency, encroachment for settlement and agriculture, and access by bushmeat hunters (26, 182).

In addition, mechanisms for SSA governments and communities to sell ecosystem services to the world at large should be improved, formalized, and strengthened to recognize the opportunity and actual costs of setting aside and managing vast tracts of wilderness for nature. The real risk of land conversion within or degazetting of PAs in many countries in the context of rapid human expansion means that governments should be supported to implement the various monitoring regimes (e.g., REDD+) required to monetize carbon assets from existing PAs. Furthermore, it is critical that carbon-financing mechanisms accurately reflect the value of SSA's PA network and that they include the safeguarding provisions necessary to compensate local communities for their role in protecting biodiversity and carbon stocks and, where appropriate, to integrate these communities into the maintenance of these areas.

Realistically, some form of conservation triage will likely be needed as human populations expand. Great care is needed during the process of considering triage involving conservation lands to minimize losses and ensure that the most critical assets are retained (183). In addition, if triage is deemed unavoidable, consideration should be given to land sharing and mixed land uses as outlined above, rather than outright degazetting of PAs.

There is also likely to be a growing need for reintroductions and rewilding to reverse wildlife depletion. A high proportion of SSA's PAs are already severely depleted of wildlife, and this proportion is likely to grow over the coming decades as human pressures intensify (88). Remarkable expertise has already been developed in the field of wildlife reintroductions in SSA (184), with impressive examples of success in large-scale reintroductions of wildlife to restock formerly depleted conservation areas in Malawi and Rwanda, community conservancies in Namibia, and private conservancies in Zimbabwe (185–187).

We see a process where natural land is lost to human settlement and crop production but becomes available again in the long term as rural human populations start to decline. Thus, reintroductions to restock depleted PAs will be necessary to restore species diversity in the Green Anthropocene. Because human pressures will likely be greater in certain parts of the continent (e.g., West relative to southern Africa), difficult decisions will arise regarding whether to reintroduce related subspecies or even ecologically equivalent species, thus mirroring debates around rewilding in other parts of the world (188).

7. CONCLUSIONS

Pressures on biodiversity and wildlife habitat are already intense and are set to worsen significantly over the next 50–100 years. Business as usual during this time will mean that much of SSA's biodiversity will be extirpated from large areas or even made extinct before we reach the envisaged Green Anthropocene. The challenge for SSA and international governments is to pursue sustainable development pathways that position nature as being central to SSA's development prospects. Achieving replacement-level fertility in SSA this century would provide significant benefits for SSA's people and nations. Progress in balancing the global carbon budget, achieving food security, and securing biodiversity will all be restricted or enhanced by the pace of population growth (189). Of critical importance are steps to hasten the demographic transition to help facilitate economic development, foster peace and stability, and protect the continent's natural assets for generations to come. Conservationists need to join the call for the empowerment of women, their families, and societies through educational and health initiatives that support African communities to choose the right to raise children with high levels of social capital who can thrive within their natural environments.

SUMMARY POINTS

1. Relative to other parts of the world, sub-Saharan Africa (SSA) is both late and slow to pass through the demographic transition and remains in a phase where human birth rates are high while life expectancy has increased, resulting in rapid population growth.
2. Almost all of the world's near-term future human population growth will occur in SSA, and depending on progress toward the Sustainable Development Goals, Africa's human population may increase to less than 2 billion or greater than 6 billion by the end of the century.
3. SSA's biodiversity is set to pass through a severely challenging period characterized by intense anthropogenic pressures, poor governance, significant corruption, political instability, ongoing reliance of high proportions of the population on natural resource consumption for survival, and resource extraction by foreign states.
4. There is a real risk that much of SSA's biodiversity will be lost in the coming decades, especially from habitat loss due to agricultural expansion and the proliferation of infrastructure through wildlife habitats.
5. Over time, we posit that prospects for nature conservation will improve as human populations stabilize and eventually decline, economies develop, governance improves, and national and international commitments to conservation solidify.
6. To reach this Green Anthropocene with a reasonable portion of SSA's biodiversity intact, multiple actions are needed at all levels. These include measures to empower populations to achieve demographic transitions without waiting for advanced economic growth, enable better land-use planning and meaningful environmental regulations so as to cope with higher human populations, pursue local and global sustainability, better align conservation with development, and massively elevate conservation funding. This last measure will require multiple revenue streams including formally monetizing ecosystem services and strengthening local constituencies for conservation.

FUTURE ISSUES

1. Research priorities relevant to the subject matter in this review include assessments of the drivers behind the relatively high desired family size among SSA women and the approaches that enable women to become more empowered over reproductive choices.
2. Assessments are needed to better understand the relationship between human population densities and trajectories, resource use, and conservation outcomes.
3. Research should mitigate the impacts of growing anthropogenic pressures on nature, such as by identifying methods to improve crop yields and to help guide low-impact infrastructure development, among many other issues.
4. Research is needed to help guide and improve formal embedded commodification of ecosystem services within effective and equitable debt-for-nature approaches along with significant global increases and targeting of conservation funding, enabling real benefits to accrue to local stakeholders from conservation.

DISCLOSURE STATEMENT

M. O'Brien-Onyeka discloses that at the time of this article's submission, he was employed with Conservation International and that he is a non-remunerated board member for the Human Rights Advancement, Development and Advocacy Centre. The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

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