Africa's Protected Natural Assets

The importance of conservation areas for prosperous and resilient societies in Africa

Green Value

NATURAL CAPITAL IN AFRICA

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Africa's Protected Natural Assets

THE IMPORTANCE OF CONSERVATION AREAS FOR PROSPEROUS AND RESILIENT SOCIETIES IN AFRICA

'The full story of Africa's endowment by nature is yet to be told and, as a result, the true value of biodiversity's contributions to human well-being is underappreciated in decision-making processes.'

IPBES Africa Regional Assessment-SPM [A3], 2018

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Authors:
Augustin Berghöfer (Helmholtz Centre for Environmental Research – UFZ),
Nina Bisom (Deutsche Gesellschaft für International Zusammenarbeit – GIZ),
Elias Huland (GIZ), Volker Koch (GIZ), Johannes Kruse (GIZ), Karla Locher-Krause (UFZ),
Marius Philipp (Würzburg University), Isabel Renner (UFZ), Karim Thibault (Biotope),
Michael Thiel (Würzburg University), Ulrike Tröger (UFZ),
Hugo van Zyl (Independent Economic Researchers).

Further research input by:
Morocco: M. Mohamed Ziyadi, M. Khalil Allali, M. Abdelhamid Fanzi.
Mauritania: M. Mohamed Lemine Abdel Hamid, M. Khalidou.
Ethiopia: Zelealem Tefera, Abiyot Tilahun, Fassil Teffera.
Democratic Republic of the Congo: Gérard Imani, Janvier Bashagaluke Bigabwa, Marie Bernard Dhedya, Pierre Kiloso.
Madagascar: Harifidy Rakoto Ratsimba.
Côte d'Ivoire: Inza Kone, Ariane Amin, Karim Ouattara.
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Würzburg University: Frederic Schwarzenbacher, Patrick Sogno, Sandro Groth, Aida Taghavi Bayat, Helena Wehner.
Independent Economic Researchers: James Kinghorn.
UFZ: Constantin Suppee.

External Reviewers:
Sofia Ahlroth (World Bank), Martin Boström (KfW, Germany), Tracey Cumming (BIOFIN-UNDP), Nigel Dudley (Equilibrium Research, UK), Tadesse Woldemariam Gole (Environment and Coffee Forest Forum, Ethiopia), Inza Kone (Centre Suisse de Recherches Scientifiques, Cote d'Ivoire), Alphonce Kyessi (Ardhi University DSM, Tanzania), Günter Mitlacher (WWF-Germany), Fabien Quetier (Biotope, France), Chantal Shalukoma (Institut Congolais pour la Conservation de la Nature, DRC), Juha Siikamaki (IUCN), Sue Stolton (Equilibrium Research, UK), Anthony Waldron (Conservation Research Institute, UK).

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GREEN VALUE

NATURAL CAPITAL IN AFRICA

This report has been produced as part of the BMZ Green Value Initiative.

Green Value Initiative

The Green Value Initiative is the umbrella program of the German Federal Ministry for Economic Cooperation and Development (BMZ) on the value of nature in Africa. In providing multiple benefits such as clean air and water, productive soils, extreme weather and erosion protection, health benefits, and solutions to climate change, Africa's natural wealth is an important asset that contributes significantly to the continent's welfare and achievement of societal development goals. The Green Value Initiative supports its African partner countries and development institutions to integrate the value of these assets in decision-making. Its objective is to mainstream natural capital into policies and planning, financial markets and development finance, as well as measures of economic progress and national accounts (natural capital accounting). With that, the Green Value Initiative contributes to one of the key building blocks for transformative change towards nature-positive economies and development in Africa.

Under its protected area-pillar 'Africa's Protected Natural Assets', the Green Value Initiative aims to raise awareness and ambition for the key role conservation areas play in safeguarding the multiple benefits of Africa's natural capital. The 'Africa's Protected Natural Assets Report' is the pillar's flagship product; its aim is to tell the largely untold stories of the value of these conservation areas for economic prosperity and resilient societies. In addition, Green Value collaborates with six African countries to assess the value of selected conservation areas: Banco National Park (Côte d'Ivoire), Lomami National Park (Democratic Republic of the Congo), Bale Mountains, Simien Mountains, Chebera Churchura and Borena-Sayint Worehimeno National Parks (Ethiopia), Ankarafantsika National Park (Madagascar), Diawling National Park (Mauritania) and Arganeraie Biosphere Reserve (Morocco).

The Green Value Initiative comes at a pivotal moment with mounting evidence clearly articulating the risks and costs associated with the unprecedented loss of biodiversity and degradation of ecosystems witnessed around the world. To halt and revers the loss of nature, governments need to embark on a decade of ambitious and bold action until 2030 and beyond, starting with the new Global Biodiversity Framework of the Convention on Biological Diversity.

Abbreviations

ANP	Ankarafantsika National Park
BAU	Business-as-usual
BER	Bale Eco-Region
BMNP	Bale Mountains National Park
BMZ	German Federal Ministry for Economic Cooperation and Development
CAs	Conservation Areas
CBD	Convention on Biological Diversity
CBD COP15	Fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity
CBNRM	Community-based Natural Resource Management
DRC	Democratic Republic of the Congo
EC	Ecological Consolidation
ETB	Ethiopian Birr
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GW	Gigawatt
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature and Natural Resources
LECZ	Low Elevation Coastal Zones
MCAs	Marine Conservation Areas
MW	Megawatt
NDVI	Normalized Difference Vegetation Index
OECMs	Other effective area-based conservation measures
REDD+	Reducing Emissions from Deforestation and Forest Degradation and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries
SDG	Sustainable Development Goal
TEEB	The Economics of Ecosystems and Biodiversity
UFZ	Helmholtz Centre for Environmental Research
UK	United Kingdom
UN	United Nations
UN SEEA	United Nations System of Environmental-Economic Accounting
UNEP	United Nations Environment Programme
UNEP-WCMC	UN Environment Programme World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey
WDPA	World Database on Protected Areas
WHO	World Health Organization
WWF	World Wide Fund for Nature

Contents

Forewords

The COVID-19 pandemic shows us that we have to halt the loss of biodiversity – not least in order to protect our own health and that of coming generations. Seventy-five per cent of all new infectious diseases – examples include Ebola and AIDS – are diseases where a virus jumps from its host, a wild animal, to humans. The more humans venture further into untouched nature, destroying intact ecosystems, and the more individual animal species are rendered extinct and contact between animals and humans increases, the greater the likelihood that such viruses will be transmitted to humans. Human health and sustainable economic development depend on a healthy planet. But things are moving in a different direction. Every four seconds, an area of rainforest the size of a soccer field is lost to logging. Every eleven minutes, a plant or animal species disappears from the planet forever.

The DASGUPTA REVIEW ON THE ECONOMICS OF BIODIVERSITY has put it in a nutshell: 'Our economies, livelihoods and well-being all depend on our most precious asset: Nature,' and 'our unsustainable engagement with Nature is endangering the prosperity of current and future generations.'

The AFRICA'S PROTECTED NATURAL ASSETS report highlights the extent to which Africa's economies and societies depend on the services provided by protected ecosystems and the urgency of developing an enhanced vision for protected areas, the guarantors of such services. In their function as safe spaces for Nature, protected areas are not only key to the conservation of biodiversity, they also provide vital public goods such as clean air and water, fertile soil, protection from extreme weather, and stable climatic conditions. More than 1,200 cities in Africa are more livable thanks to protected areas, and such areas ensure water supplies for 40 of Africa's 50 largest reservoirs and provide ecologically favorable conditions for nearly 30 per cent of Africa's agricultural land.

In order to ensure that these important services will still be available in the future, determined action is needed.

First, we need significant improvements in the funding and management of protected areas. Permanent, reliable basic financing for protected areas requires contributions from all partners, including private and public donors

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and the private sector. To that end, we need new and innovative approaches such as the Legacy Landscapes Fund. Another vital factor is the expansion of protected areas, provided that it takes place in a socially equitable manner and in line with human rights standards. The Federal Republic of Germany and many of our partners in Africa have committed themselves to put 30 per cent of the Earth's land and sea under protection by 2030.

Second, we need to better understand the value of Nature. Nature provides most goods at no cost. Their true value often remains invisible until ecosystems have been destroyed and their services have been irretrievably lost. Expanding protected areas so that they cover 30 per cent of the Earth's surface would generate economic and social benefits that are five times higher than the related costs.

Third, we also need effective protection of natural resources outside protected areas. To that end, we need a fundamental transformation of the way in which we produce and consume food, build infrastructure and engage in economic activity.

We have to make nature conservation a priority on the global agenda. At the global UN Biodiversity Conference in China, we need a breakthrough – the sort of breakthrough that the Paris Agreement brought for climate action in 2015. The Africa's Protected Natural Assets Report shows what decisions we need to take in order to protect the natural environment and what the next steps are that now need to be taken urgently. Let us get down to work and jointly implement the recommendations put forward in the Report.

Dr. Gerd Müller
German Federal Minister for Economic Cooperation and Development

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It is now clearer than ever that biodiversity loss and environmental degradation pose one of the most existential threats to humanity. The economic impacts of unsustainable development pathways are already being felt, putting at risk development prospects today and for future generations – particularly in developing countries. The AFRICA'S PROTECTED NATURAL ASSETS report is an important contribution to understanding the scale and urgency of what is at stake. It is a call to action.

The report presents clear evidence of the many ways that conservation areas in Africa contribute to the economy and to human development. In protecting intact ecosystems, these areas provide ecosystem services for key development sectors such as agriculture, energy, water, infrastructure and cities, to name just a few. In stark contrast to their socio-economic importance, the report paints a striking picture of the alarming ecological state of many protected areas in Africa. It identifies critical gaps in ecosystems that are currently unprotected and therefore particularly at risk. Continued degradation would erode their capacity to provide vital goods and services.

GIZ works with partners around the world to develop and implement innovative and transformative solutions to conserve our natural world. Part and parcel of these solutions is to recognize the critical links between nature and development. The AFRICA'S PROTECTED NATURAL ASSETS report is an important vehicle to convey this message. The report shows that nature is not a barrier to economic development, but rather the very foundation upon which healthy societies rely. It is our joint responsibility to conserve and sustainably use our natural assets in Africa and around the world.

Tanja Gönner
Chair of the Management Board,
Deutsche Gesellschaft für Internationale Zusammenarbeit

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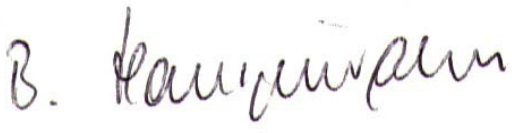
In 2018, the IPBES Regional Assessment for Africa pinpointed a fundamental challenge: The ongoing ecosystem degradation and loss of natural capital in Africa coincides with a rapidly growing societal demand for nature's benefits.

An inclusive natural capital perspective can reveal the multiple ways how societies depend on intact ecosystems. The AFRICA'S PROTECTED NATURAL ASSETS report provides detailed evidence on how the more than 7000 conservation areas on the African continent make substantial contributions to societal welfare and human wellbeing far beyond their boundaries. While the core mandate of conservation is to protect biodiversity, this evidence underlines the additional benefits which conservation areas generate for other policy priorities, such as food security, disaster risk reduction, or secure energy supply. These results emphasize the need to sustain Africa's protected areas and call for action, not only in African countries but also worldwide in order to sustain these global commons.

At the Helmholtz Centre for Environmental Research – UFZ, these results confirm our earlier findings for Germany and for other countries around the globe. Our work at science-policy interfaces teaches us that scientific evidence on natural capital and ecosystem services is of limited use, unless it can inform the co-design of policy reform. For nature conservation in Africa this should mean: Donors and implementing organisations will need to reach out to other sectors and policy areas to tackle the root causes of natural capital loss, to better address the local costs of conservation, and to jointly pursue and promote a mosaic of more sustainable landscapes.



Prof. Dr. Bernd Hansjürgens
Head of the Thematic Area Environment and Society,
Helmholtz Centre for Environmental Research

Executive Summary

Africa's natural wealth underpins the continent's current and future welfare. In addition to natural resources this wealth encompasses a broad range of benefits from nature to society. These 'ecosystem services' include clean water for growing cities, insect pollination for agriculture, medicinal plant products for medication, tourism potential, and others. Yet many African countries are facing urgent development needs and follow pathways which translate into high pressures on their natural environments. Climate change further catalyses socio-ecological instability. This leads to biodiversity loss and ecosystem degradation and, in consequence, puts Africa's welfare and development potential at risk.

Diverse values in African societies have motivated conservation throughout the centuries, and still do today. This report takes on a different perspective: It uncovers the key role of conservation areas in protecting Africa's natural assets. In many regions, conservation areas constitute the 'ecological backbone' of multi-functional landscapes under pressure. A natural capital perspective sheds light on the multiple benefits they provide for African societies, in addition to protecting biodiversity.

This report (i) examines indicators of the state of natural capital in conservation areas; it (ii) analyses their current socio-economic importance for nine different sectors and policy areas, and (iii) explores their future role in satisfying societal needs. The report builds on a review of available evidence, new analyses of satellite imagery and international data sets, as well as six site-level case studies.

This evidence comes at a pivotal moment. The Covid-19 epidemic was caused by viral transmission from wild animals to humans. Its consequences around the world reveal the fragility of today's societies. Anthropogenic ecosystem change is one of the factors driving the risk of zoonotic diseases. In turn, the social and economic impacts of the epidemic threaten development and conservation efforts, particularly in the Global South.

To halt the loss of nature, the world needs to embark on a decade of ambitious action, as envisaged in the new Global Biodiversity Framework of the Convention on Biological Diversity (CBD). The German Federal Ministry for Economic Cooperation and Development (BMZ) commissioned this study as a key component of its Green Value Initiative to accelerate ambition and action for protecting Africa's natural assets.

Key findings include:

I

Africa's prosperity and resilience depend on its vast natural wealth and properly functioning ecosystems. Conservation areas help to maintain these.

A significant proportion of African economies – including agriculture, the energy sector and tourism – relies heavily on resilient natural environments. The diverse benefits of more than 7000 conservation areas in Africa positively influence living conditions and development prospects far beyond their boundaries. About 30% of Africa's total population – more than 370 million people – live within 10 km of a conservation area today. They are affected by conservation areas in one way or another, benefiting from the ecosystem services they provide while also bearing their societal costs.

II

Africa's protected natural capital stocks are dwindling rapidly – and will likely continue to decrease if efforts are not intensified.

African conservation areas are only partially successful in conserving natural capital. Even though

they generally display a better environmental state than their surrounding landscapes, the situation has deteriorated significantly over the past two decades: In 40 African countries at least ¼ of total national protected land area shows signs of degradation. Inside conservation areas 6% of forest has been lost between 2000 and 2018 (deforestation rate outside conservation areas: 9%). And 8,5% of Africa's total cropland is located inside their boundaries (equivalent to 325,000 km²).

Degradation is projected to increase in all African regions. If the current trajectory continues, an additional 4% of total forested land inside conservation areas throughout Africa in 2018 will be lost by 2030 – more than 55,000 km². Total degrading conservation land area would increase by more than 40% between 2020 and 2030.

The eroding natural asset base inside and out- side conservation areas is in stark contrast to the growing demand for provisioning, regulating and cultural ecosystem services.

III

Key economic sectors and policy areas in Africa depend on the ecosystem services provided by conservation areas.

WATER SECURITY: 30% of Africa's population is impacted by water insecurity; by 2050 this figure could double. Conservation areas facilitate ground water recharge, stabilize water flows and ensure better water quality. 40 out of the 50 largest reservoirs in Africa receive their water partly from conservation areas.

AGRI-FOOD SYSTEMS: Conservation areas provide benefits which agricultural landscapes are increasingly lacking, such as pollination, soil erosion control, genetic diversity and regional climatic conditions. More than ¼ of Africa's total cropland area – i.e. 1 million km² – is located inside conservation areas (8.5%) or within 10 km distance to them (20%). In West Africa alone, 226 million agriculturalists live and work within 20 km of a conservation area.

FISHERIES: Fisheries contribute 1.3% to African GDP and are of critical importance for food security. Yet overfishing is becoming prevalent. Marine conservation areas provide important nurseries for the replenishment of fish stocks. Five out of the top 10 African fishing nations prefer to fish closer to marine conservation areas.

HYDROPOWER: 19 African countries rely on hydropower for more than 50% of their total electricity production. Conservation areas across Africa reduce operating costs and prolong the economic life span of dams by limiting sedimentation in reservoirs. Eight of the largest hydropower dams in East Africa benefit from the watershed protection of conservation areas. Just one of them ensures 73% of Mozambique's total electricity production.

CITIES: At least 1240 African cities with 50.000+ inhabitants count on conservation areas. As 'green infrastructure', these (peri-)urban conservation areas make cities more resilient and liveable: They are needed for cleaner air, cooling, drainage, and opportunities for recreation and education.

TOURISM: Nature tourism accounts for 88% of Africa's overall tourism revenue. In 2015 African conservation areas attracted 70 million visitors and spending in excess of US$ 50 billion. They sustained 8 – 10 million jobs in various related sectors. Despite the devastating impact of the coronavirus pandemic on tourism, increased conservation investments could create more than 370,000 additional jobs by 2030.

RESILIENCE TO NATURAL HAZARDS AND DISASTERS: Droughts, floods, sea level rise, storms and coastal erosion are set to worsen under climate projections for Africa. As 'nature-based solutions', conservation areas can address these risks, acting as natural buffers and green belts. For example, 54 million people face significant coastal risks, yet at least 11 million people currently benefit from the coastal protection of mangroves.

GLOBAL WARMING: African conservation areas cover only a fraction of Africa's forests and peatlands – yet they still contain enormous carbon stocks, locking away 14.9 Gt C in woody biomass and 46.1 Gt C in soils. Deforestation and ecosystem degradation

pose a threat to the very existence of these stocks. This implies significant societal costs of climate damage, estimated to be US$ 8.7–10.9 billion annually until 2030 if threats are not reduced.
HEALTHY SOCIETIES: Conservation areas make diverse contributions to human health, including water safety, natural pest control, and the reduction of airborne diseases in arid regions. They also reduce the pandemic risk of zoonotic diseases such as Ebola. They are a source of medicinal plants used in primary healthcare across Africa.

These different benefits of conservation areas for society are not equally accessible, as use rights and tenure over protected natural assets differ from country to country. In addition, benefits accrue at different scales: local, national and global as well as private and public. Differentiating beneficiary groups accordingly can inform policy and finance options and at the same time needs to take into account that benefits are provided in interconnected bundles. While many synergies exist, maximising one benefit can come at the cost of losing others.

IV
It pays off to step up efforts and increase investments in the consolidation and extension of conservation areas.

The return on investment for protecting natural assets in Africa is undisputed. Benefit-cost estimates have been ascertained across the continent: up to 8:1 for Ethiopia's and Zambia's national protected area system, 9:1 for Namibia's. These calculations include only parts of the whole suite of benefits provided.

V
If well adapted to knowledge needs, natural capital assessments at site level help to respond to specific conservation management challenges.

As part of this report, additional natural capital assessments were carried out in collaboration with partners in selected conservation areas in Côte d'Ivoire, Democratic Republic of the Congo, Ethiopia, Madagascar, Mauritania and Morocco. When designed to respond to specific management challenges rather than as general inventories of 'nature's values', such assessments can provide useful insights for tasks such as area planning, conservation funding, or forging alliances for enhanced political support. For example, in Cote d'Ivoire, the Banco National Park was found to improve water quality for 64 % of the city's groundwater – a key argument for strengthening the collaboration of park management with city and water authorities.

VI
Synthesis: An inclusive natural capital perspective calls for an expanded vision for conservation areas.

The natural capital of protected land- and seascapes will erode further, while already high demands for their natural assets will continue to grow. Current conservation approaches need to evolve in order to respond adequately to the speed and scale of environmental and societal change. Conservation will have to become more responsive to society's diverse demands for natural capital and progressively accommodate a broader set of goals, in addition to protecting biodiversity. Conservation actors will benefit from additionally embracing the role of 'stewards of public benefits from nature' in development planning. Their ecological knowledge and their expertise in addressing tensions between competing interests are highly relevant beyond conservation area boundaries. In this vision, they play a key role in renegotiating where and how the multiple societal dependencies on natural capital should be addressed and how practices leading to natural capital loss should be stopped. They will also have to address the environmental injustices related to these practices.

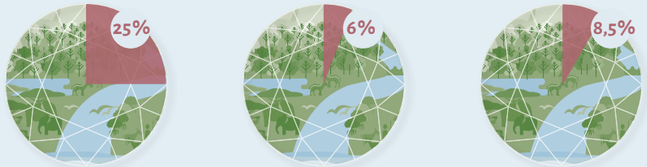
VII
Recommendations

An expanded conservation vision is a necessary response to Africa's sustainability challenges over the coming decade. The aim of the following recommendations is to prepare the ground for this transition:

1. **Make nature's values a crucial factor in politics: Highlight the importance of natural assets for societal prosperity and human well-being.** Healthy landscapes and conservation areas are not an obstacle to development; on the contrary, they contain key assets that support it. More natural capital and ecosystem services assessments are needed to show where these assets are being lost and what the impacts of such losses are. This perspective is critical for elevating nature conservation and protected natural assets in political attention and decision-making.
2. **Connect conservation areas with societal and economic development priorities and establish their role as nature-based solutions.** At least nine economic sectors and societal areas benefit from protected natural assets. An inclusive natural capital perspective equips conservation actors to reach out to relevant sectors. Conservation areas should thereby not only be considered at the level of single sites but become integral to development and sector planning per se. This perspective in addition helps to identify gaps in currently unprotected land and sea areas that are critical for providing natural capital flows to those sectors. Ambitions for expanding conservation area land (as e.g. the 30x30 goal) should consider these gaps.
3. **Enhance the fair governance of conservation areas: Use evidence regarding natural capital in negotiations around the use and management of natural assets.** More plural conservation pathways are better equipped to accommodate and respond to society's multiple demands on a landscape than restrictive protection-based approaches. Recognizing the rights and livelihood needs of all people is at the heart of society-oriented nature conservation, which embraces human rights and social justice as foundational principles. This calls for more flexible conservation area objectives, and more space for crafting solutions regarding how and by whom these objectives are to be pursued.
4. **Link conservation finance more closely with climate, agriculture, infrastructure and post-pandemic recovery finance.** Africa's conservation areas need to be understood as a strategic long-term investment in the future of the continent but underfunding and lack of sustainable finance seriously risk the protection of natural assets. To attract funding from other sources such as climate, agriculture, infrastructure and post-pandemic recovery finance, conservation actors should team up with those entitled to and familiar with the respective funding and better argue their cases.
5. **Shape debates on sustainable development solutions not just within but also beyond conservation areas.** Dramatically changing ecological conditions demand active involvement in policy and planning choices. A democratic re-shaping of society-nature relations is needed, both within and beyond conservation areas: Societies' demands for nature's benefits are rising sharply – yet degrading landscapes will fail to meet them. This trajectory will require transformative changes and bold steps away from past mistakes, for example in agricultural policies. Now is a key opportunity to extend the conservation mission to contribute toward wider societal transformations leading to sustainability. Agri-food systems and urban areas will be principal fields for this transformation. With their ecological knowledge and social expertise, conservation actors can be key players in forging the societal alliances required to meet this challenge.

AFRICA'S PROTECTED NATURAL ASSETS

PROTECTED NATURAL CAPITAL STOCKS ARE AT RISK TODAY...



DEGRADATION:
40 COUNTRIES: ¼ OF CONSERVATION AREA LAND IS DEGRADING.

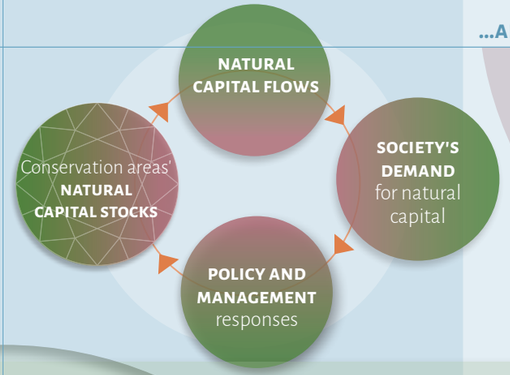
DEFORESTATION:
6% OF CONSERVED FORESTS WERE LOST SINCE 2000.

LAND USE CHANGE:
8,5 % OF AFRICA'S CROPLAND IS INSIDE CONSERVATION AREAS

THE CONSERVATION CHALLENGE

Today, **30% of Africans live close to conservation areas**. While urgent development needs translate into high pressures and threaten their ecological integrity, the multiple benefits they provide are poorly understood, their value as natural asset is hence largely unrecognized.

A **INCLUSIVE NATURAL CAPITAL PERSPECTIVE** ▸ helps to better understand society's dependence on nature:



...AND WILL LIKELY CONTINUE TO DEGRADE IF EFFORTS ARE NOT INTENSIFIED

FOREST LOSS IN CONSERVATION AREAS
WILL INCREASE TO UP TO
10 %.

DEGRADED CONSERVATION LAND AREA
WILL INCREASE BY MORE THAN
40 %.

INVESTING IN NATIONAL PROTECTED AREA SYSTEMS PAYS OFF, **BENEFIT-COST RATIOS** ARE IN THE ORDER OF E.G.:

- **8:1** IN ETHIOPIA
- **8:1** IN ZAMBIA
- **9:1** IN NAMIBIA

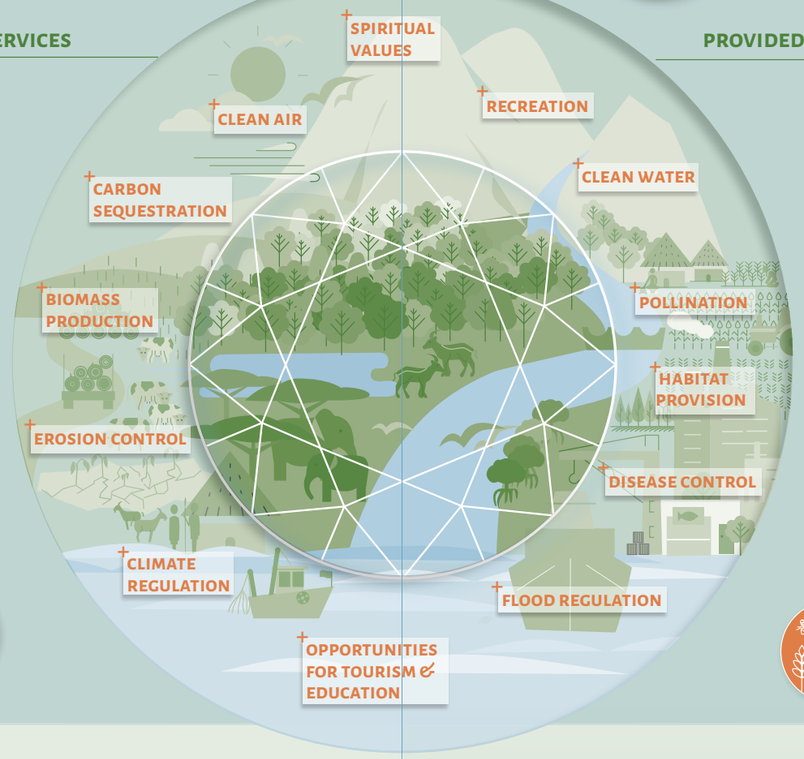
KEY ECONOMIC SECTORS AND POLICY AREAS IN AFRICA DEPEND ON ECOSYSTEM SERVICES

GLOBAL WARMING
African conservation areas lock away carbon stocks in excess of 60 Gt. Reducing deforestation and degradation would avoid social costs of climate damage of US$ 8.7 – 10.9 billion annually until 2030.

TOURISM
Nature tourism generates 50 billion $/year and 10 million jobs. Wildlife tourism accounts for 88% of total annual revenues for trips to Africa.

FISHERIES
5 out of the top 10 African fishing nations prefer to fish closer to marine conservation areas.

DISASTER RISK REDUCTION
More than 11 million people benefit from the coastal protection provided by mangroves – however, only 34% of Africa's mangroves are protected.



PROVIDED BY CONSERVATION AREAS

HYDROPOWER
Conservation areas provide clean and stable water for 8 large hydropower facilities in East Africa, safeguarding up to 73% of national electricity production.

WATER SECURITY
40 of Africa's 50 largest reservoirs receive their water partly from conservation areas.

PUBLIC HEALTH
Conservation areas slow down deforestation, lowering the incidence and spread of Malaria and zoonotic diseases such as Ebola.

RESILIENT CITIES
Conservation areas make more than 1.200 African cities more resilient and liveable by providing clean air and regulating local climate, among other benefits.

AGRI-FOOD SYSTEMS
28.5 % of Africa's total cropland area – i.e. 1 million km² – is located inside conservation areas (8.5 %) or within 10 km distance to them (20 %) benefiting from their services.

APPLYING AN INCLUSIVE NATURAL CAPITAL PERSPECTIVE IN SIX AFRICAN COUNTRIES

MOROCCO: ARGANERAIE BIOSPHERE RESERVE
Land use and water scarcity connect people and ecosystems from the mountains to the coastline

MAURETANIA: DIAWLING NATIONAL PARK
Using evidence from fisheries and other park benefits to position a RAMSAR site within a regional development context

COTE D'IVOIRE: BANCO NATIONAL PARK
Urban national park prevents water pollution and shut down of adjacent wells

ETHIOPIA: BORENA SAYINT, CHEBERA CHURCHURA, BALE MOUNTAINS AND SIMIEN MOUNTAINS NATIONAL PARKS
Investing in Ethiopia's protected natural assets pays off economically and socially

DEMOCRATIC REPUBLIC OF THE CONGO: LOMAMI NATIONAL PARK
Developing the profile of the relatively new park as a source of local livelihoods and other benefits

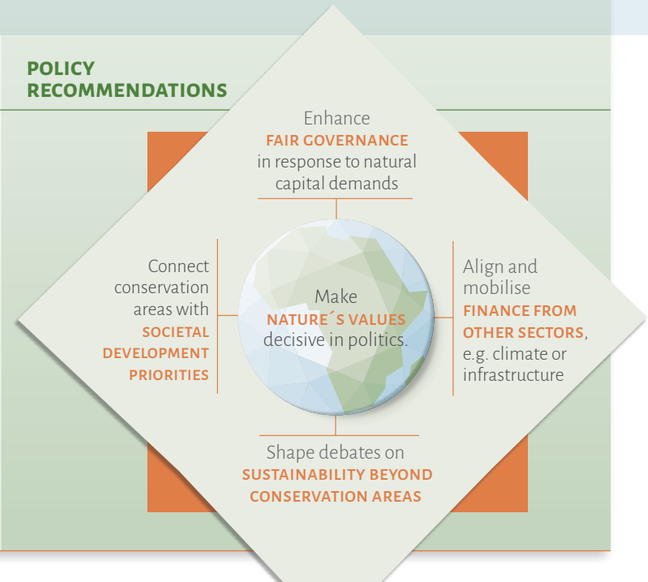
MADAGASCAR: ANKARAFANTSIKA NATIONAL PARK
Modelling erosion and hydrological systems shows how the park contributes to regional water and food security

AN EXPANDED CONSERVATION VISION

CONSERVATION IS POORLY EQUIPPED FOR SPEED AND SCALE OF ENVIRONMENTAL AND SOCIETAL CHANGES. IT WILL HAVE TO EVOLVE FROM AN ENVIRONMENTAL TO A SUSTAINABLE DEVELOPMENT ISSUE:

1. It pursues a broad set of goals – beyond biodiversity – to also ensure the supply of natural capital benefits.
2. Conservation areas are an integral part of multifunctional landscapes with natural assets maintained also beyond their boundaries.
3. This requires diverse combinations of conservation area goals, governance, and management, together with non-area-based approaches.
4. Governments, donors and practitioners promote, fund and pursue these multiple conservation pathways.
5. Conservationists also act as 'stewards of public benefits from nature'.

POLICY RECOMMENDATIONS



1. A SOCIETAL PERSPECTIVE ON CONSERVATION AREAS IN AFRICA

© Pixabay | kmarius

'We need to urgently reach out and clearly articulate to decision makers why biodiversity and the environment should be a priority […]'

Report of the Regional Consultation on the Post-2020 Global Biodiversity Framework for Africa, Addis Ababa, 2–5 April 2019 – Cbd/Post2020/Ws/2019/3/2

Africa's natural wealth underpins the continent's current and future welfare. In addition to natural resources this wealth encompasses the broad range of benefits nature provides to society. However, many countries face urgent development needs, and many responses to meet these needs currently translate into high pressure on their natural environments. This is leading to unprecedented biodiversity loss and ecosystem degradation. Africa's welfare and development potential are increasingly at high risk.

This report seeks to highlight the key role played by conservation areas in protecting Africa's natural assets. Three questions are central to this: What is the socio-economic importance of conservation areas? Are conservation areas today capable of maintaining the natural capital stored within them? Finally, how can conservation areas respond to the growing demands of society on natural capital?

By taking a natural capital perspective, this report casts a spotlight on the socio-economic significance of conservation areas. It focuses on nine economic sectors and policy areas that benefit specifically from conservation areas, examining the status quo, past trends and future prospects based on available evidence and new analyses. It also uses case studies from six African countries to support the analysis and provide examples that reflect different contexts.

This report comes at a pivotal moment in the quest to ensure a healthy and protected planet. The Covid-19 epidemic was caused by viral transmission from wild animals to humans. Its enormous consequences around the world have raised concerns about how societies interact with nature. Anthropogenic ecosystem change is one of the factors driving the risk of zoonotic disease (Settele et al. 2020). In turn, the social and economic impacts of the epidemic threaten conservation efforts in the Global South (Hockings et al. 2020).

To halt the loss of nature, the world needs to embark on a decade of unprecedented ambitious and bold action up to 2030, starting with the new post-2020 Global Biodiversity Framework of the Convention on Biological Diversity (CBD). The German Federal Ministry for Economic Cooperation and Development (BMZ) commissioned this study as a key component of its Green Value Initiative, the aim being to enhance ambition and accelerate action to protect Africa's natural assets in the run-up to CBD COP-15 in China and beyond.

1.1.
7000+ conservation areas: Benefits and disputes

Africa has a rich history of protecting nature (Kwashirai 2012). Long before the first 'modern' nature reserves and national parks had been established, environmental control by African communities was largely sustainable (Schoenbrun 1998, Vansina 1990). Sacred forests, groves and shrines are examples of culture protecting nature – their remnants are present throughout Africa (Decher 1997, Dudley et al. 2012).

Nowadays, too, African governments are taking important steps to enhance biodiversity and ecosystem conservation, e.g. through the establishment and management of conservation areas. However, 'rapid population growth and urbanization, inappropriate economic policies and technologies, poaching and illegal wildlife trade as well as socio-political and cultural pressures have accelerated the loss of biodiversity' (IPBES 2018).

More than 7000 protected areas exist in Africa today. Protected areas are an important instrument of biodiversity conservation and landscape management. The different IUCN categories (Dudley 2008) of protected areas achieve different objectives, including securing livelihoods, species and habitat conservation, sustainable land use, and recreation. The term 'conservation area' covers all protected areas, but is used more specifically in this report to emphasize that in-situ conservation can go beyond the legally defined requirements invoked by an area belonging to one of the (national or international) management categories, such as 'national park'. The term 'conservation area' can be applied to landscapes at any scale where there is explicit concern for the status of its biodiversity and ecosystem conservation. It includes, inter alia, community conserved areas, biosphere reserves, and 'other effective area-based conservation measures' (OECMs)[1].

Conservation areas provide numerous benefits to both local and more distant communities and to society at large. Thus, they are essential components of changing rural and urbanizing landscapes – and

CONSERVATION AREA COVERAGE ACCORDING TO WDPA[2]

According to the World Database on Protected Areas (WDPA), hosted by the IUCN World Commission on Protected Areas and the UNEP World Conservation Monitoring Centre, there are a total of 7020 terrestrial conservation areas in Africa (as at January 2020). They currently cover 4.2 million km², which is 14.2 % of the total terrestrial area in Africa, including inland water bodies. Some countries have a very high proportion of their terrestrial area under conservation status, such as Zambia, Tanzania, Namibia (> 37 %, → technical annex). A total of 819 marine conservation areas currently cover 0.4 million km², which is 3.8 % of the total Exclusive Economic Zone area, with countries such as Gabon and South Africa as frontrunners.

1 OECMs refer to in-situ conservation outside protected areas and were introduced into the CBD under Aichi Target 11 in 2010. They have much interest also in response to more controversial proposals such as 'Nature Needs Half' (Dudley et al 2018)

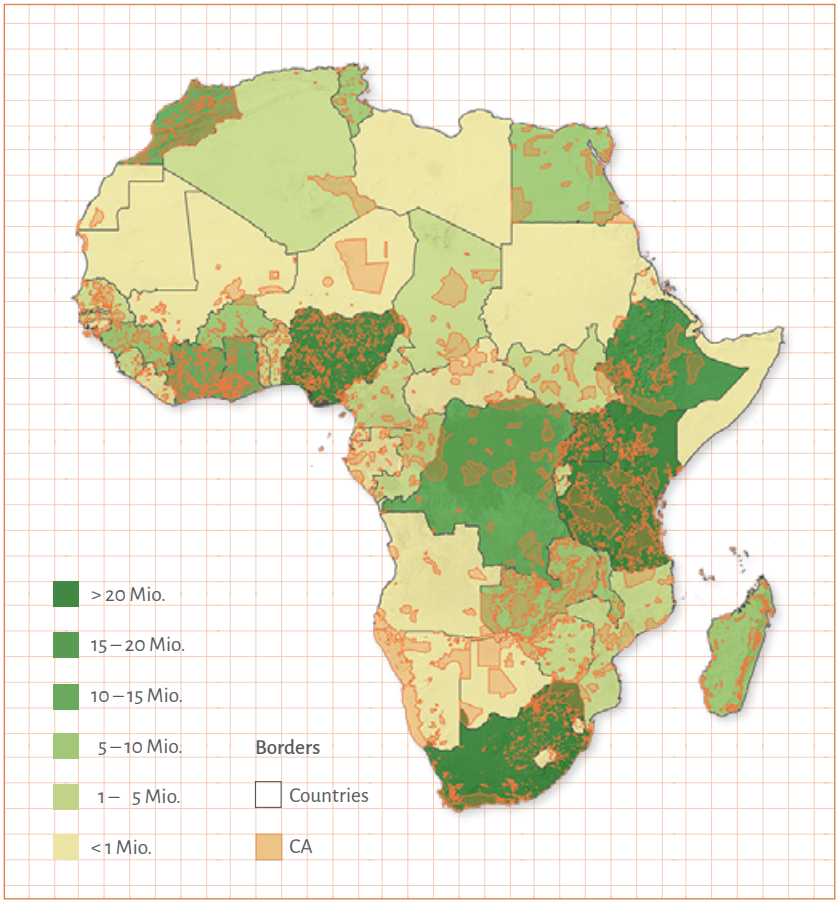
2 Throughout this report we use data for conservation areas that are covered in the WDPA. WDPA applies the IUCN categories. However, countries differ in their national protected area legislation and resulting categories. As this report is based on WDPA data to ensure transparent analysis, discrepancies with national data and reporting cannot be ruled out.

as such are also subject to the fundamental changes African societies are currently witnessing.

Many conservation areas are in previously remote regions, where the societal costs of restricting land use were comparatively low at the time of their establishment. However, regions that were once remote are often no longer so. Population density has increased, and technology (e.g. digital connectivity) as well as infrastructure (e.g. roads) now facilitate access and enhance interactions over greater distances. In addition, global factors such as the global demand for agricultural commodities or global climate change cannot be ignored (Ibisch/Hobson 2014).

Today, about 30% of Africa's total population – more than 370 million people – live within 10 km of a conservation area in Africa. They are likely to be affected by conservation areas in one way or another. In this sense, conservation areas in Africa are a major societal factor today.

People living near a conservation area may benefit from it (e.g. as a provider of wild food, good water quality or local climate conditions favourable to agriculture). They may also be adversely affected, for example by wildlife conflicts, land-use restrictions, or when a conservation area increases the time needed to travel to the nearest town or city. Pure species-focused approaches have often operated by constraining human activity. While this has effectively protected biodiversity in some cases, it has also generated injustices and fuelled conflict and breaches of Human Rights (Dowie 2011, Duffy et al. 2019, Madzwamuse et al. 2020). More inclusive approaches seek to reconcile local use rights and livelihood needs with national development ambi-



MAP 1

AFRICAN CONSERVATION AREAS IN INCREASINGLY POPULATED LANDSCAPES

Number of people living within 10km of a conservation area per country

Source:
Based on the Global Human Settlement Layer by JRC
Data: Natural Earth, GADM & WDPA, LSFE Würzburg University, 2020

tions and global biodiversity goals. Both approaches have seen successes and failures in Africa (Taylor 2009, Sunderland et al. 2007, Sene-Harper et al. 2019). **Thus, conservation areas influence the living conditions and development prospects of a much larger area than the one contained within their boundaries.**

The urgent needs and ambitions of rapidly growing societies mean that conservation may come to be regarded as an 'unaffordable luxury' on African policy agendas. The competition between land set aside for conservation and other uses, such as timber extraction, agro-industrial use or urban expansion, is sure to increase. Globally, the hotspots of conflict between conservation and agriculture concentrate

HUMAN RIGHTS AND CONSERVATION IN AFRICA

Human Rights are universal principles enshrined in national constitutional texts, the UN Declaration on Human Rights, and other international commitments. The realization of numerous human rights, such as the right to food, health or water, depends in many ways on healthy ecosystems. Human rights and conservation management are inextricably linked – respect for human rights can improve prospects for achieving conservation outcomes, while conservation contributes to communities' ability to secure their human rights.

Biodiversity management is a 'human rights issue because people, individually and collectively, can contribute to addressing the challenges that affect biodiversity and ecosystems through exercising a broad range of human rights, such as the right to information, participation, freedom of expression and association' (IPBES 2020). In practice, this requires to complete a turn in conservation action toward those living directly with, and relying on, the natures in question (Fletcher et al. 2020).

Since the 1990s there has been a shift away from restrictive practices of area protection that fail to incorporate the needs of those living near them and towards more inclusive and participatory approaches (prominently enshrined at the World Parks Congress, Durban 2003). However, recent interpretations of rights (and of 'full compliance' with them) have been found in many cases to draw back towards more restrictive framings (Witter and Satterfield 2019). Shocks affecting the population numbers of charismatic species (e.g. elephants in Central Africa and rhinos in Southern Africa) seem to fuel this trend.

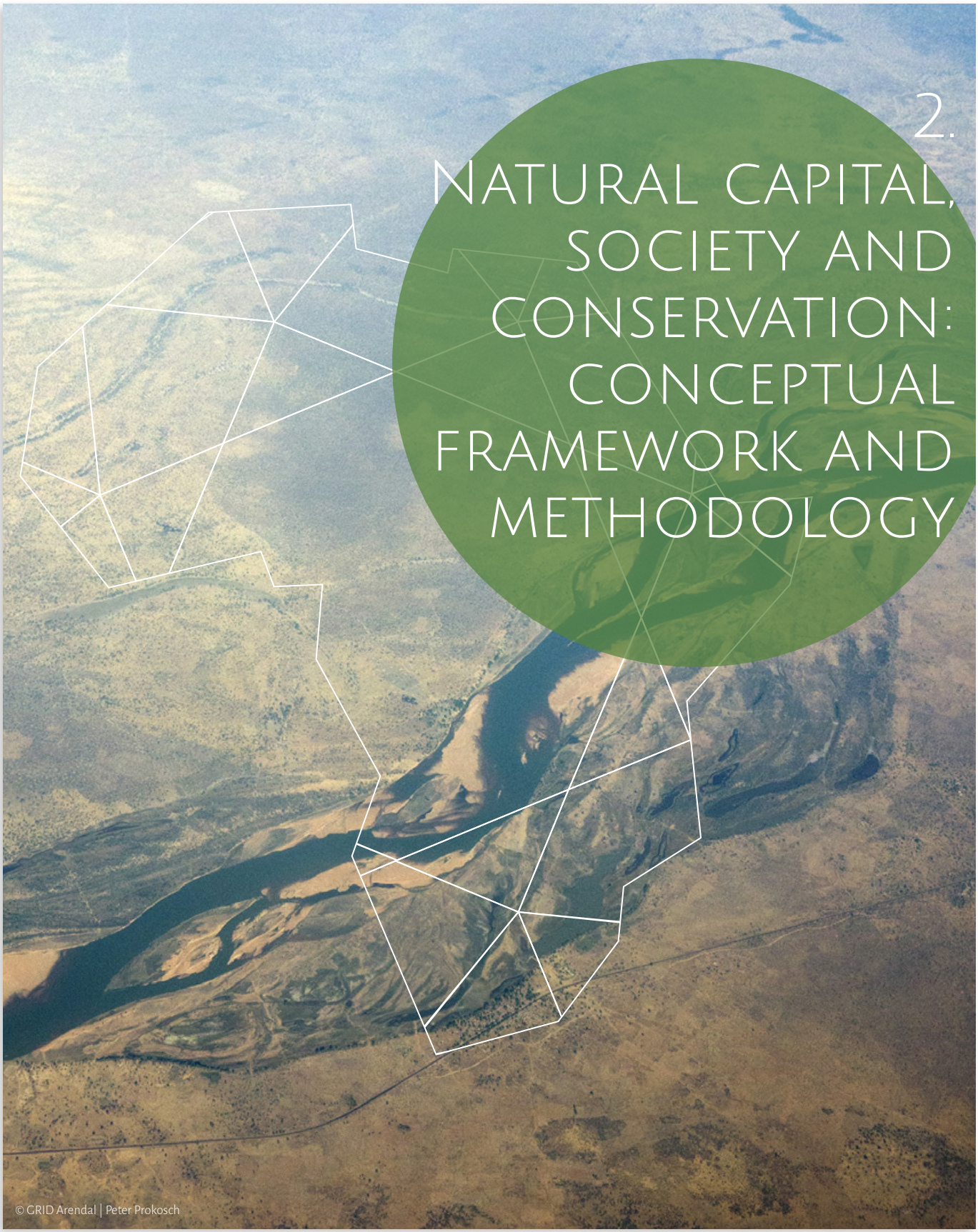
Against this backdrop, situations characterized by weak governance, widespread poverty, poaching and violent conflicts pose challenges to the upholding of human rights in conservation. Recent concern for human rights and reported accusations of their abuse has questioned the coherence of human rights and nature conservation. This has prompted new efforts in conservation and development projects, e.g. in German development cooperation, in order to strengthen criteria and mechanisms for the realization of human rights and prevention of their abuse, more effective local participation and governance structure. Measures are among others the stronger and more effective human rights, social and environmental safeguards systems, starting from the planning of projects, participation and inclusion of local and indigenous communities in and around protected areas, and improved capacities of park rangers, monitoring and disciplinary control systems, and the establishment of local easy access complaint mechanisms.

on Sub-Saharan Africa (Shackelford et al. 2015). The loss of natural systems in Africa and the services they provide will enhance the competition for remaining intact landscapes and seascapes.

The loss of natural systems in Africa and the services they provide will enhance the competition for remaining intact landscapes and seascapes.

Land-use conflicts also mark tensions between societies' short-term versus long-term needs. Short-term needs include food, water and protection from natural hazards. Long-term needs include the capacity of landscapes to retain their ecological vitality and remain multi-functional so that short-term needs can also be met in 10 years' time and beyond. Both types of needs are essential – and societies have to find a balance between them. Conservation areas play a key role because they typically favour long-term over short-term needs. This comes at a cost, however. Conservation-related land-use restrictions often imply costs to neighbouring communities (e.g. by limiting agricultural expansion), while many of the benefits of conservation efforts extend to regional, national and global levels and into the future.

Despite the undeniable challenges and inevitable trade-offs, African conservation areas provide a flow of multiple benefits to wider regions. A natural capital perspective (see next chapter) makes explicit the many different values conservation areas represent, the benefits they generate, and for whom. It brings together a society's needs with the environment's potential to respond to these needs.



2. NATURAL CAPITAL, SOCIETY AND CONSERVATION: CONCEPTUAL FRAMEWORK AND METHODOLOGY

'Nature is a blind spot in economics that we ignore at our peril. (…) Truly sustainable economic growth and development means recognising that our long-term prosperity relies on rebalancing our demand of nature's goods and services with its capacity to supply them. It also means accounting fully for the impact of our interactions with Nature across all levels of society.'

Final Report – The Economics of Biodiversity: The Dasgupta Review. 2021.

Natural capital refers to ecosystems as a 'stock' or 'natural asset' from which 'ecosystem services' flow over time and associated benefits can be obtained (Costanza and Daly 1992). The ecosystem services framework offers a systematic taxonomy of these benefit flows, distinguishing between provisioning, regulating, cultural and supporting services.[3] These include tangible benefits such as wild foods, crops and fresh water (provisioning services) and pollination, local climate regulation and erosion control (regulating services). They also include non-material benefits such as opportunities for recreation, spirituality and inspiration (cultural services), as well as underlying benefits from habitats and biodiversity (supporting services). Another, more recent approach – Nature's Contributions to People – is applied by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which provides an overarching typology of values related to nature and quality of life.

A natural capital perspective can offer insights, evidence and arguments which place conservation efforts in a wider societal context. It helps to reveal the dynamics and socio-ecological interdependencies of landscapes. The concept of natural capital does not replace but rather complements other perspectives on nature as manifested in different societies, cultures and research disciplines.

3 Reports from the Millennium Ecosystem Assessment, TEEB (The Economics of Ecosystems and Biodiversity) and UN SEEA (System of Environmental-Economic Accounting) use different variants of this ecosystem service framework. An alternative and enlarged concept – Nature's Contributions to People – is applied in IPBES assessments.

2.1. An inclusive natural capital perspective on conservation

Considerable controversy exists over how to measure, express and attribute 'value' to nature and to the benefits that flow from it (Pascual et al. 2017). The aggregation of these benefits in estimates of monetary value can be prone to misinterpretation and provides no detailed information (Spash and Vatn 2006). Estimates of monetary value can command considerable public attention ('This mangrove belt has provided coastal protection and thereby prevented flood damage of more than US$ 2 million last year'). However, monetary values often omit critical information for interpreting the estimate ('Who exactly benefits? Who assumes the costs of maintaining (or not using) the mangrove belt? How are human lives at risk considered in the monetary value?'). Also, there is a marked difference between direct financial revenues (e.g. entrance fees from tourism), and monetary estimates of wider economic value (e.g. a park's contribution to tourism value chain) (Waldron et al. 2020). In public debate, this difference is often unclear[4].

Therefore, a combination of different value metrics (e.g. number of people, size of area, scores) and disaggregated results for each benefit along with comparisons (e.g. two sites, or two points in time) offer more useful information than aggregate monetary estimates of value alone. Furthermore, in many settings it has been questioned whether single value metrics ('value monism') are culturally appropriate and politically legitimate (IPBES 2016).

THE WORLD BANK'S GLOBAL PERSPECTIVE ON AFRICA'S PROTECTED NATURAL CAPITAL

A natural capital perspective was used in the World Bank's recent report on the Changing Wealth of Nations. It aggregates several components of national wealth, including produced, natural and human capital (Lange et al. 2018). 'Protected area assets' are a sub-category of 'natural capital' in this study. Their monetary value is constructed on the basis of the opportunity cost of the agricultural value of surrounding landscapes. This method excludes most of the aspects explored in this present report. According to the World Bank, in Sub-Saharan Africa 'protected area assets' constitute 4% of the total wealth per capita (defined as including various types of capital minus foreign debt). In all other global regions, protected area assets range between 0.2% – 2%. This higher percentage indicates that Africa is richly endowed with protected natural assets per capita. Equally, it means that Africa is comparatively poor in other types of capital. For meaningful interpretation, such aggregate estimates need to be substantiated with more nuanced information.

4 The 'money value' of 1t of carbon is much higher in a climate damage cost estimate compared to its price on an emission reduction certificate market. Thus, many protected forests stock tons of carbon worth millions of US$ of avoided damage cost, yet only very few succeeded to tap into carbon certificate markets as a reliable source of income (Gizachew and Duguma 2016).

Throughout this report, the terms 'natural capital' and 'natural assets' are used in a broad sense as a metaphor for 'society's dependence on nature' and its interdependencies with nature. This perspective makes it possible to describe the economic and social magnitude of conservation area benefits for various sectors and policy areas. Protected natural capital is examined here in a more disaggregated manner: a combination of maps and different metrics is pursued in addition to single stock values.

Some natural capital studies calculate aggregate proxies for natural capital stocks. Such information is difficult to interpret for policy-making purposes. Therefore, this report pursues four foci which complement each other (→ see Figure 1 below) to provide a more policy-relevant picture: In addition to examining the state of stocks (expressed in biophysical terms → Chapter 3), the benefit flows and corresponding societal demands are explored (expressed in diverse qualitative descriptions and quantitative proxies → Chapter 4). This then informs the search for options to manage conservation areas as part of wider landscapes (→ Chapters 5 and → 6).

A broader conceptual interpretation of natural capital as society's interdependence with nature also indicates the normative stance and basic assumptions of this report (→ see box page 26).

We believe that an inclusive natural capital perspective can help us rethink current paradigms and approaches and thereby contribute to necessary change processes. Expressing the interdependencies societies have with nature enables a different view on conservation goals and practices. It draws atten-

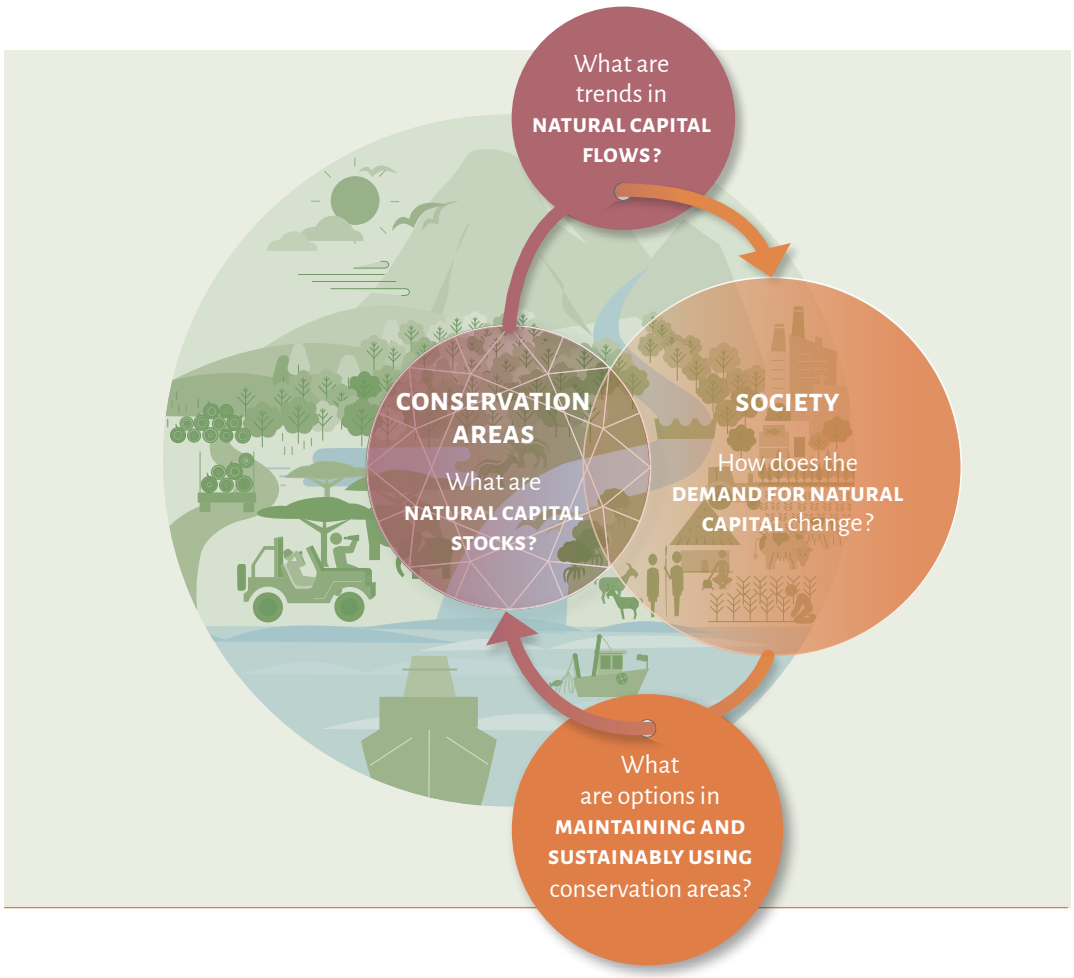


FIGURE 1
AN INCLUSIVE NATURAL CAPITAL PERSPECTIVE: FOUR QUESTIONS FOR EXAMINING HOW SOCIETY DEPENDS ON NATURE.

This report uses literature, a combination of different datasets (including the IUCN & UNEP's WCMC World Database on Protected Areas), satellite imagery and case studies. For details, see technical annex.

tion to the assets provided by healthy ecosystems, both inside and outside conservation areas, which societies require in order to be prosperous, and to the trade-offs involved in how these assets can be used. It also draws attention to the distribution of costs and benefits in society relating to changes in natural capital. **In this way, an inclusive natural capital perspective illuminates issues that support and inform conservation and development debates,** such as:

- How can conservation approaches evolve to provide critical natural capital in view of society's demands, without compromising either human needs or the conservation of biodiversity?
- How can we foster acceptance for and reach agreement in society on balancing short-term with long-term needs in actionable policies that respect people's diverse needs and values?

BASIC ASSUMPTIONS FOR AN INCLUSIVE NATURAL CAPITAL PERSPECTIVE ON CONSERVATION AREAS

An inclusive natural capital perspective offers important insights about conservation and development challenges, based on the following assumptions:

- Society should be the starting point: **Societal dependence on healthy ecosystems is multiple and substantial.** This dependence is not only local (as rights-focused approaches would suggest) but national or even global (e.g. in the case of GHG emissions).
- Trade-offs between competing needs, interests and policy priorities exist: **Environmental justice needs to be placed centre-stage**. An inclusive natural capital perspective should prompt questions that stimulate broader negotiations: Who are the beneficiaries, who the polluters/degraders? Who is held responsible? And who bears the costs of conservation?
- A long-term perspective: **Conservation efforts are investments in diverse and resilient landscapes** and ecosystem degradation is an asset loss (rather than 'development progress'). Preventing such asset loss means preventing negative impacts on people who rely on these assets now or will rely on them in the future.
- Value plurality: **Diverse values and value systems co-exist which people attribute to nature.** An inclusive natural capital perspective should aim to enrich other ways of viewing nature and societal debates on sustainability.
- Attention to complementarity: **Strong culturally rooted or intrinsic motivations for conserving nature should be complemented and strengthened** – not substituted or weakened – **by natural capital arguments.**

Such societal dependence on nature does not tell the full story, though. A fundamental motivation for protecting nature against degradation is intrinsic to us as human beings, namely, to maintain a vital human kinship with nature - a central characteristic of all societies. Traditions, arts, foods, religions and collective identities are closely linked to the landscapes people live in, to their natural heritage. This report therefore provides arguments and evidence intended to complement rather than replace the underlying ethical consensus that nature deserves to be protected in and of itself.

Expressing the interdependencies societies have with nature enables a different view on conservation goals and practices. It draws attention to the assets provided by healthy ecosystems, both inside and outside conservation areas, which societies require in order to be prosperous, and to the trade-offs involved in how these assets can be used.

2.2. Methodology: Macro analyses and case studies

This report combines two levels of analysis: An overview of the entire African continent, at times combined with changing foci on different regions, with a zoom-in on the level of individual conservation areas.

At continental level, geospatial data on conservation areas is combined with different data sets from other studies as well as remote sensing data based on satellite sensors. An extensive literature and data review was conducted for the different sectors and policy areas addressed in Chapter 4, so as to combine satellite imagery with further data sets and to qualify and meaningfully interpret the results of the GIS analyses. Preliminary findings were presented for discussion at two expert workshops (January and December 2020), and two rounds of reviews were organised with a total of 27 reviewers. Detailed explanations about both data and analyses are provided in the technical annex.

The report also draws on six case studies, from Cote d'Ivoire, Democratic Republic of the Congo, Ethiopia, Madagascar, Mauritania and Morocco. Since its launch in 2019, the Green Value Initiative has collaborated with each of these partner countries of German development cooperation to carry out natural capital assessments in selected conservation areas. The local assessments were conducted to gather more detailed evidence and complement the continental level analyses.

The case studies also sought to put the inclusive natural capital perspective into practice at the level of conservation areas in order to leverage policy ambition and action on the ground. Thus, the studies were carried out as participatory processes, driven by the knowledge needs of key stakeholders, so as to ensure policy relevance and uptake.

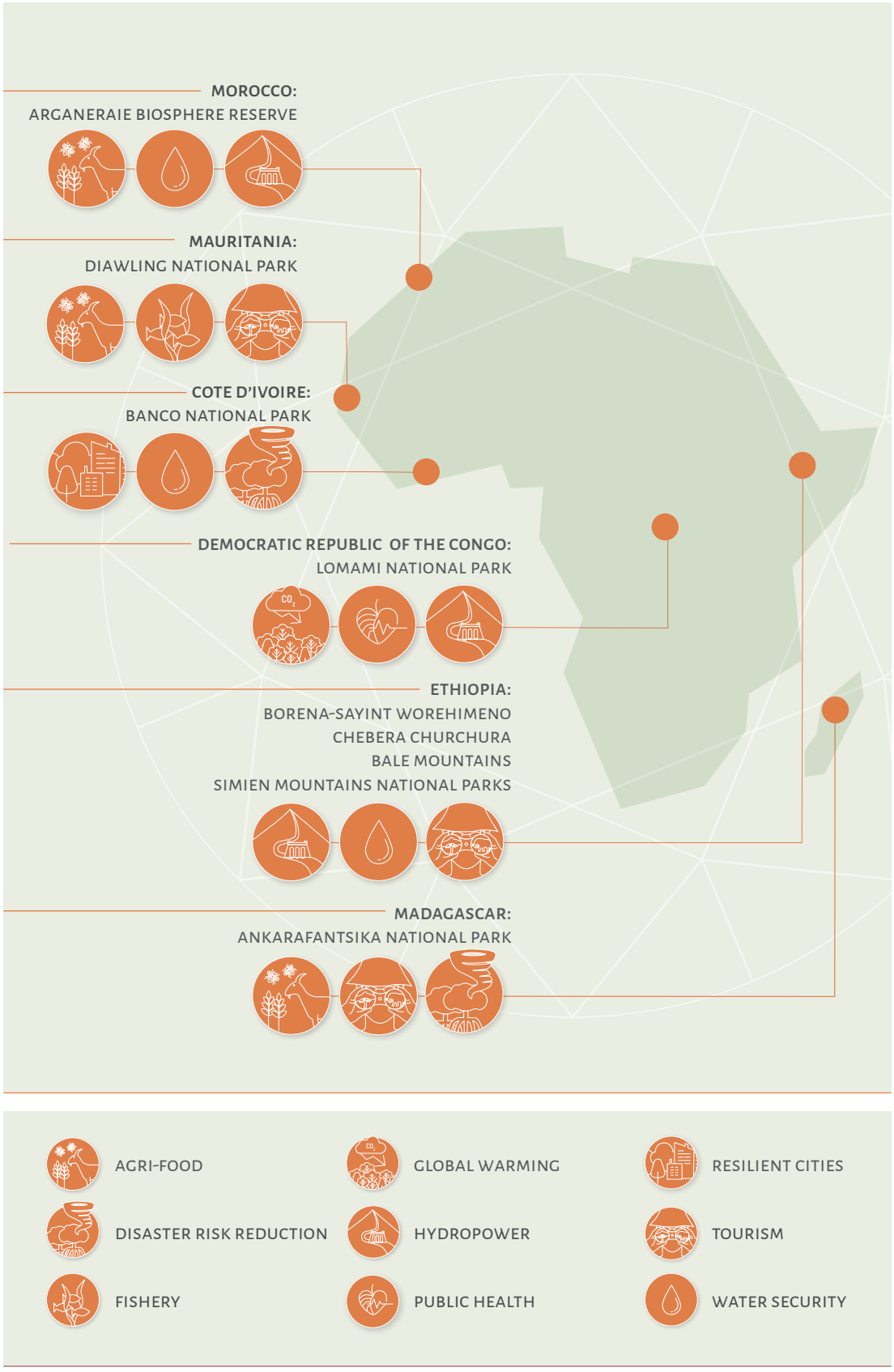


FIGURE 2

NINE CONSERVATION AREAS IN SIX COUNTRIES SERVED AS GREEN VALUE CASE STUDIES TO PUT THE INCLUSIVE NATURAL CAPITAL PERSPECTIVE INTO PRACTICE.

This figure shows some of the benefits analysed in each case study.

The **scoping phase** introduced stakeholders from government, economic sectors and civil society to key concepts of natural capital. Conservation area challenges were jointly explored, and the possible contribution of an inclusive natural capital perspective were scoped. How might this perspective inform solutions to specific problems, e.g. land-use conflicts and encroachment due to limited social acceptance and political backing? For this, participants identified natural capital flows, beneficiaries and impacts in the wider landscape. Scoping also included a search for strategic opportunities to respond to the problems identified and determined the kind of evidence and arguments which would be useful for seizing such opportunities.

In the **assessment phase,** a core group consisting of conservation area management staff, researchers and, at times, local representatives translated the scoping results into tailor-made study designs with specific research questions and corresponding methods. Blueprints were considered inappropriate in view of differing knowledge needs and contexts[5]. The assessments comprised a combination of desktop research, field work and the integration of diverse data. They resulted in independent case study reports.

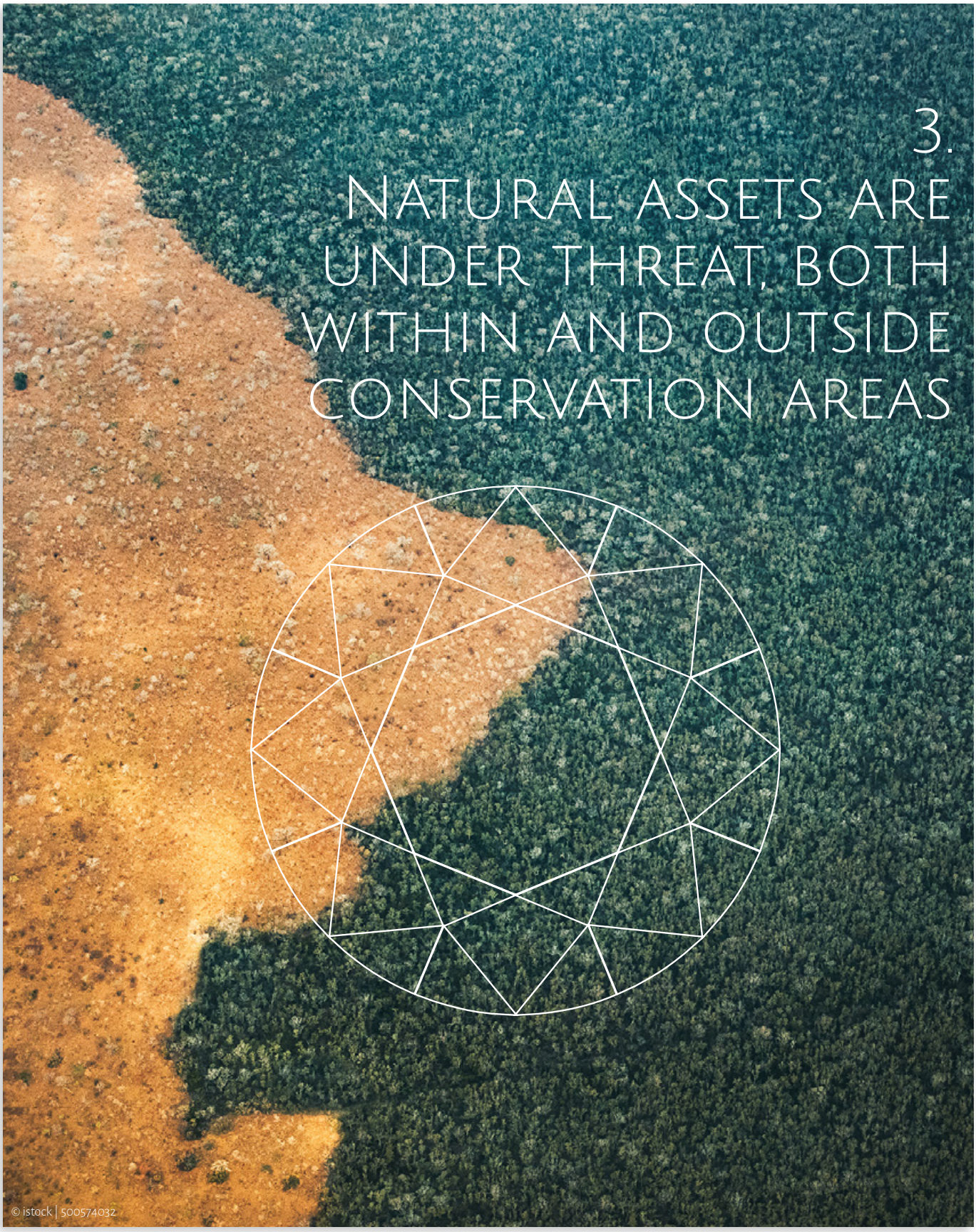
The **validation** workshops with key stakeholders ensured a shared in-depth understanding of the results. They also prepared for the further **use of study outcomes** in different policy arenas. This includes raising awareness of the societal role of conservation areas; informing conservation management options to expand efforts to the social realm; reaching out to sectors that benefit from protected natural capital; engaging with regional development strategies and funds.

The assessments at conservation area level confirm the diversity of interlinkages between protected ecosystems and surrounding landscapes. However, information alone cannot be a driver of change. In order to leverage discussions and generate momentum, assessments – such as these natural capital case studies – can be facilitated as social processes, responsive to political windows of opportunity (al. 2014).

The assessments at conservation area level confirm the diversity of interlinkages between protected ecosystems and surrounding landscapes. However, information alone cannot be a driver of change.

Applying a natural capital perspective to conservation areas can serve several different purposes, such as developing arguments in favour of 'defending' nature, building alliances, fundraising, or better integrating socio-economic considerations into management tasks. Knowledge needs differ according to the purpose at hand: in many cases, *inventories* of natural capital stocks and flows provide less useful information than, say, examining the *causal links* between ecosystem states and benefits or changes in supply or demand for natural capital (Berghöfer et al. 2016).

5 Assessment teams had to strike trade-offs between practical feasibility (data gaps, Covid-19), policy relevance and scientific robustness.



3. Natural assets are under threat, both within and outside conservation areas

African conservation areas are stores of natural wealth. Ecosystems generate a range of benefits, also known as 'ecosystem services' or as 'nature's contributions to people'. This capacity of ecosystems can be understood as a stock of natural capital. What is the current state of ecosystems inside African conservation areas? Is this natural asset base eroding? This chapter (i) summarizes new evidence from analyses of satellite data, (ii) briefly reflects on the reasons for natural capital loss, (iii) summarizes the main IPBES (2018) findings on African trajectories, and (iv) compares business as usual with an 'ecological consolidation' scenario, based on an extrapolation of past trends. Details of the analyses are given in the technical annex.

3.1. Conservation areas in Africa are losing natural capital

Ecosystems are complex. Many methods exist for measuring changes in biodiversity and ecosystem functioning, each focusing on different aspects (see geobon.org). This report draws on three rather general, yet powerful, indicators for approximating changes in terrestrial ecosystems within conservation areas across Africa: (i) The Normalized Difference Vegetation Index (NDVI), (ii) forest cover loss, and (iii) land-use change. All three indicators process remote sensing data (satellite imagery) for approximating status and trends of ecosystems. They do not offer detailed insight into biodiversity and ecosystem dynamics, but allow for comparison at the macro-scale.

The following results indicate that conservation areas are only partially successful in conserving natural capital, and that the situation has significantly deteriorated over the past two decades.[6]

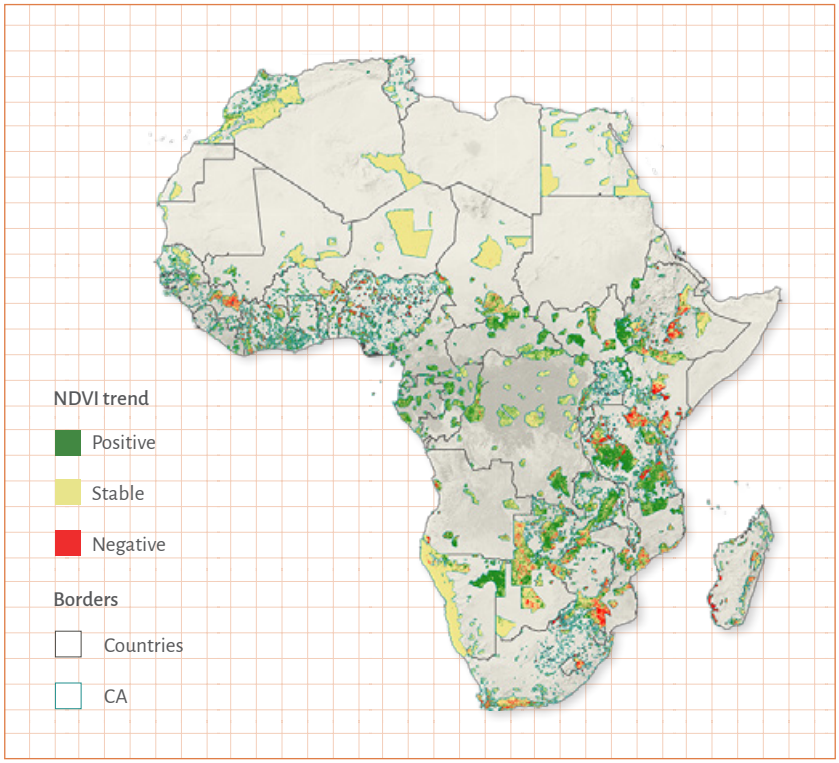
NDVI index: This index measures the 'greenness' of an area based on processed satellite imagery. We compare NDVI data for 2001 and 2018 to identify increases or reductions in greenness of vegetation cover.[7] In Africa, changes in land use and in precipitation are main causes for reduced greenness (Higginbottom and Symeonakis 2020). A negative NDVI trend means a reduction in average greenness of an area. This is widely applied as a rough indicator for ecosystem degradation, despite several limitations (Yengoh et al. 2015).

6 Our analysis examines those areas which were included in the UNEP-WCMC WDPA as of January 2020. Over the past two decades many new conservation areas have been gazetted. This means that not all of the 7000+ areas analysed were under formal conservation status in 2000 or 2001, which is our first data point for the trend analyses. In consequence, the results are less precise for countries that have significantly increased their conserved land areas in recent years.

7 The NDVI trend is determined per pixel (i.e. land area). The indicator requires a minimum vegetation cover and cannot reveal ecosystem degradation in desert regions. NDVI allows for rough approximation only. The actual degree of loss in greenness per pixel is not reflected. An increase in greenness can also mean that savannah has been converted into cropland. See also the technical annex.

Our analysis reveals:

- **In 40 countries, at least ¼ of the total conservation land area shows a negative NDVI trend, indicating degradation.** In Lesotho, Kenya, Madagascar and Guinea, more than 60% of total conserved land area is degraded (according to NDVI). In only 14 out of 57 African countries is less than 20% of conserved land area without signs of degradation (according to NDVI).
- A comparison of NDVI trends in conservation areas and in their buffer zones reveals: In **38 countries, ecosystem degradation within conservation area boundaries is less pronounced than in the 20 km buffer area around them.** This indicates that their conservation management was effective in preventing the degradation which was happening in surrounding areas.



LAND DEGRADATION INSIDE CONSERVATION AREAS IN AFRICA

PERCENTAGE OF CONSERVATION AREA LAND PER COUNTRY THAT HAS SUFFERED SOME LEVEL OF DEGRADATION	NUMBER OF COUNTRIES
0 – 20 %	14
> 20 – 40 %	21
> 40 – 60 %	18
> 60 – 80 %	1
> 80 – 100 %	3

MAP 2

ECOSYSTEM DEGRADATION AND IMPROVEMENT ACCORDING TO CHANGES IN NDVI INDEX IN CONSERVATION AREAS ACROSS AFRICA

Linear NDVI trend based on MODIS data between 2001 and 2018 within conservation areas across Africa by using annual median NDVI images. Red indicates ecosystem degradation in terms of loss of 'greenness' between the two points in time. Green indicates a grown density of green vegetation cover. Yellow indicates no change between 2001 and 2018. Desert regions with no vegetation cover also have a stable NDVI.

Source:
Based on the World database on Protected Areas by UNEP

Forest loss: Forest assets provide critical benefits such as local climate regulation, water regulation, carbon sequestration and many more. This analysis compares high resolution remote sensing data for forest cover in 2000 and in 2018 across Africa.[8]

The data reveals:

- In 2018, **19% of Africa's total forest area was located inside conservation areas** – 1.4 m of a total 7.2m km².
- **Forest loss inside African conservation areas 2000 – 2018 was almost 6% (83,500 km²).** This constitutes ~12% of total forest loss in Africa during that period (equivalent to 687,300 km²).
- **Deforestation rates within conservation areas are significantly lower than outside them – 5.75% as opposed to 9.31%.** This can be linked to conservation effectiveness, but also to the remote location and limited access of many conservation areas.
- **Six countries account for 69% of Africa's total forest loss inside conservation areas:** DRC, Cote d'Ivoire, Tanzania, Madagascar, Mozambique and Zambia.

Other studies confirm these findings, even though the situation is highly heterogeneous across Africa (Mayaux et al. 2013). In DRC, small scale forest clearance linked to a growing population, is by far the largest pressure on forests, while selective logging and agro-industrial forest clearance is more prevalent in oil-rich Gabon and Equatorial Guinea (Tyukavina et al. 2018). *Protected* forest loss is a global phenomenon happening across all IUCN categories, with forest loss actually accelerating (Leberger et al. 2020).

The following figures provide a more detailed breakdown of total and relative forest losses, both within and outside conservation areas.[9]

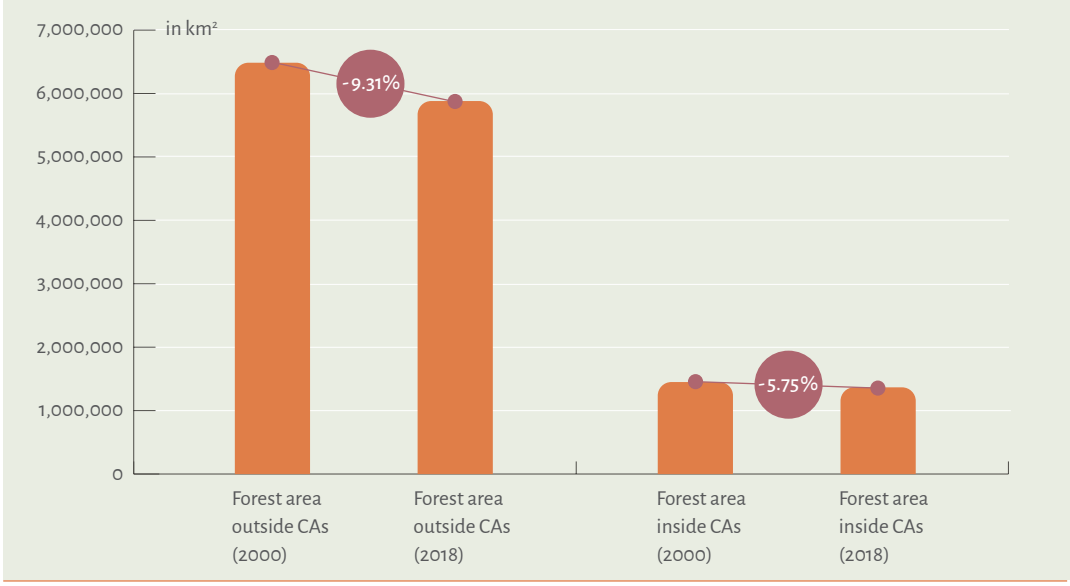


FIGURE 3
FOREST LOSS BETWEEN 2000 AND 2018

Comparison of forest area and forest loss rates inside and outside conservation areas (CAs) between 2000 and 2018, based on satellite imagery. For details see technical annex.

Source:
Authors' analysis.

8 If canopy density in one area falls below a 20% threshold, this is defined here as forest loss. This does not take account of below canopy forest clearance and degradation. See also technical annex.

9 Note that the analysis cannot distinguish between different types of deforestation. From a conservation point of view, there are also 'desirable types of deforestation', such as the removal of exotic plantations or the clearance of bushland in Savannah areas. Their spatial extent or share in total forest loss is not identified.

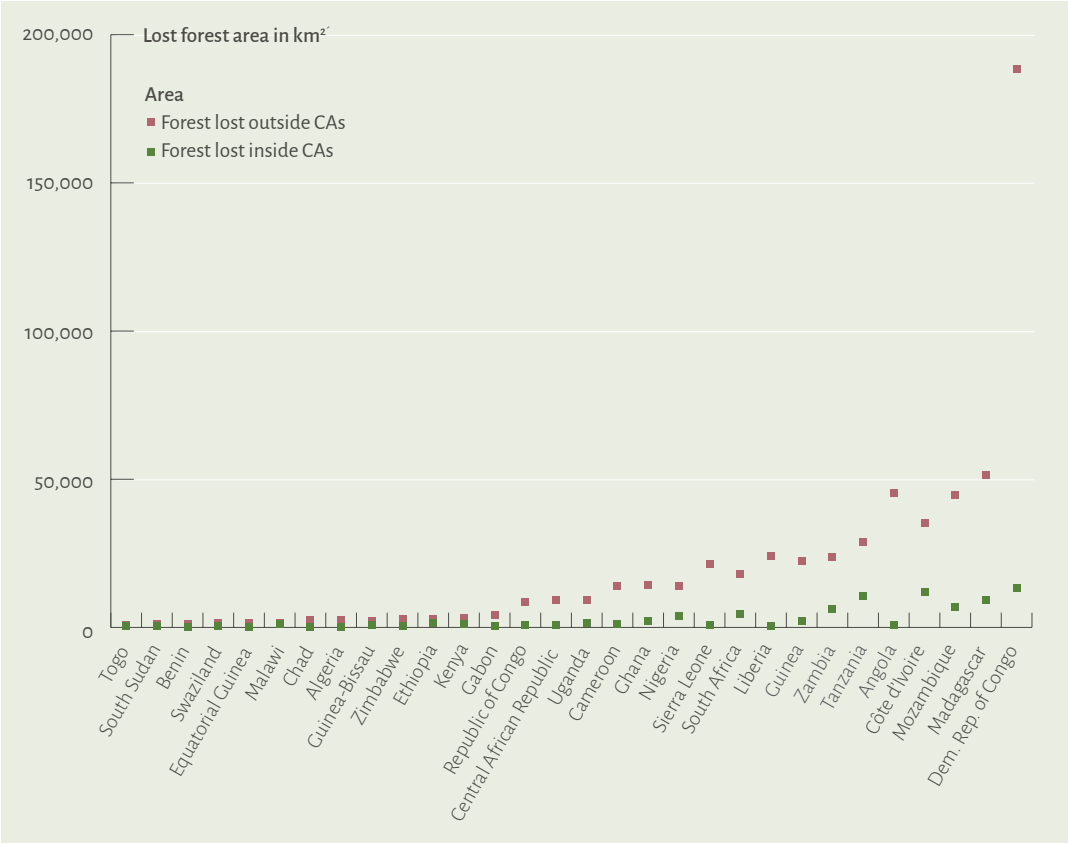


FIGURE 4

ABSOLUTE FOREST LOSS BETWEEN 2000 AND 2018 INSIDE AND OUTSIDE CONSERVATION AREAS FOR THE 30 MOST AFFECTED COUNTRIES.

High forest loss countries (in terms of absolute loss area) are spread across sub-Saharan Africa. Among them, Tanzania and Côte d'Ivoire have high shares of protected forest loss: Between ¼ – ⅓ of total national deforested area is within conservation areas.

Source: Authors' analysis

Land cover change inside conservation areas. Another strong indicator for approximating the state of ecosystems and natural capital stocks inside conservation areas is the relative absence of human land use and encroachment. Human activities can be compatible with conservation management if the land is sustainably managed. Biosphere reserves are good examples of where conservation and local sustainable development are jointly pursued in different zones of the area. In addition, many conservation areas were inhabited and used prior to their establishment, so that land use on conserved land is often in line with local rights. On the other hand, significant increases in land use can be a pointer for 'paper parks', especially if there is no detectable difference between land use inside and outside conservation area boundaries.

The presence of cropland inside conservation areas is examined here, being a conservative proxy for human land-use intensity.[10] Sentinel 2 data (2016) for all Africa is considered for the status quo analysis. A comparison of USGS data (2000 and 2013), only available for West Africa, is used for trend analysis.

The analysis of 2016 Sentinel 2 data reveals:

- **325,000 km² of cropland – 8.5% of Africa's total cropland area – is located inside conservation area boundaries.**
- Croplands cover a significant share of total conserved land area: 16 countries have more than 10% of conserved land as cropland. In **Senegal, Nigeria and Mali, croplands cover 25% – 30% of total terrestrial conservation area.**

10 Other human activities, which cannot be precisely detected by satellite data, include life-stock raising, transhumance, wild food harvesting, medicinal plants collection, artisanal mining.

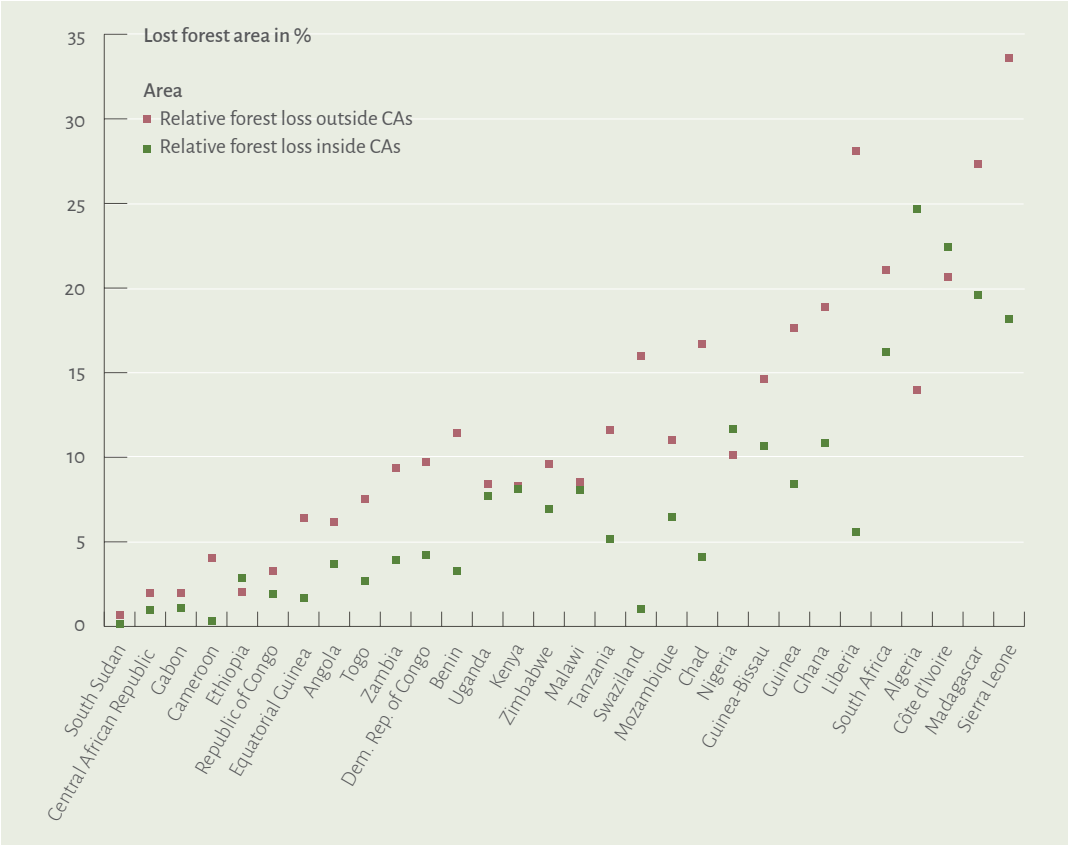


FIGURE 5
ABSOLUTE FOREST LOSS BETWEEN 2000 AND 2018 INSIDE AND OUTSIDE CONSERVATION AREAS FOR THE 30 MOST AFFECTED COUNTRIES.

This is not only influenced by deforestation activities but also related to the share of total forest area that is formally protected. For example, Algeria has significantly higher deforestation rates inside CAs than outside which is linked to the fact that almost all remaining forests are formally protected.

Source: Authors' analysis

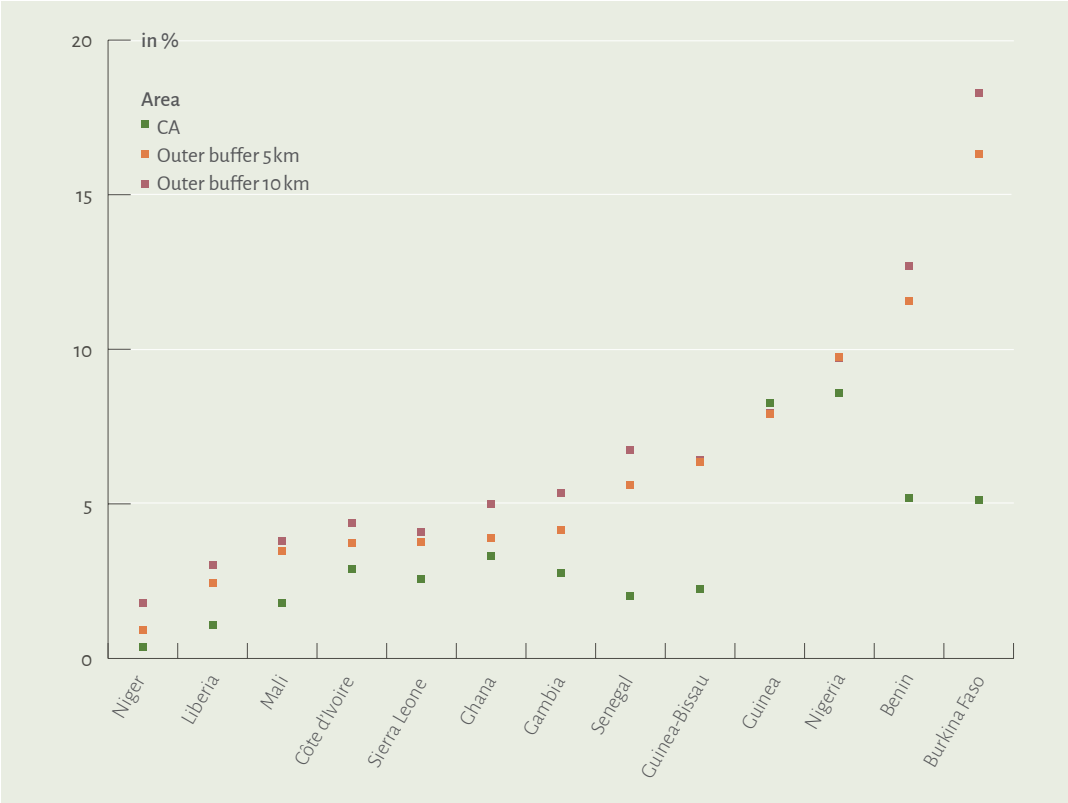
- **Only a few countries – such as Malawi, Rwanda, Burundi and Benin – show significantly lower agricultural activity inside conservation areas compared to their intensively used buffer zones** (cropland < 10% of total CA area versus cropland >30% within 10 km buffer zone). This points to ecologically effective conservation regimes in these countries and confirms the findings on forest loss.

Past trends in land-use change can be inferred from data (2000 and 2013) for West Africa[11], processed by USGS, USAID and CILSS:

- **More than 2100 km² of protected wetlands have been lost in West Africa (2000 – 2013)**, most of them within Nigeria (1,200 km²).
- **In West Africa, more than 24,000 km² of natural vegetation cover within conservation area boundaries have been converted into agricultural land (2000 – 2013).** While for most countries this is equivalent to less than 5% of total conserved land, the pressure on conservation areas is increasing: Within the 20 km buffer zone around conservation areas, agriculture has converted an additional 166,000 km² of land, with the highest expansion rates in Burkina Faso (19%), Benin (13%) and Nigeria (10%).

The following figures show total and relative conversion into croplands inside conservation areas and for different buffers:

11 13 countries: Niger, Nigeria, Benin, Ghana, Burkina Faso, Mali, Côte d'Ivoire, Liberia, Sierra Leone, Guinea, Guinea-Bissau, Senegal, Gambia.



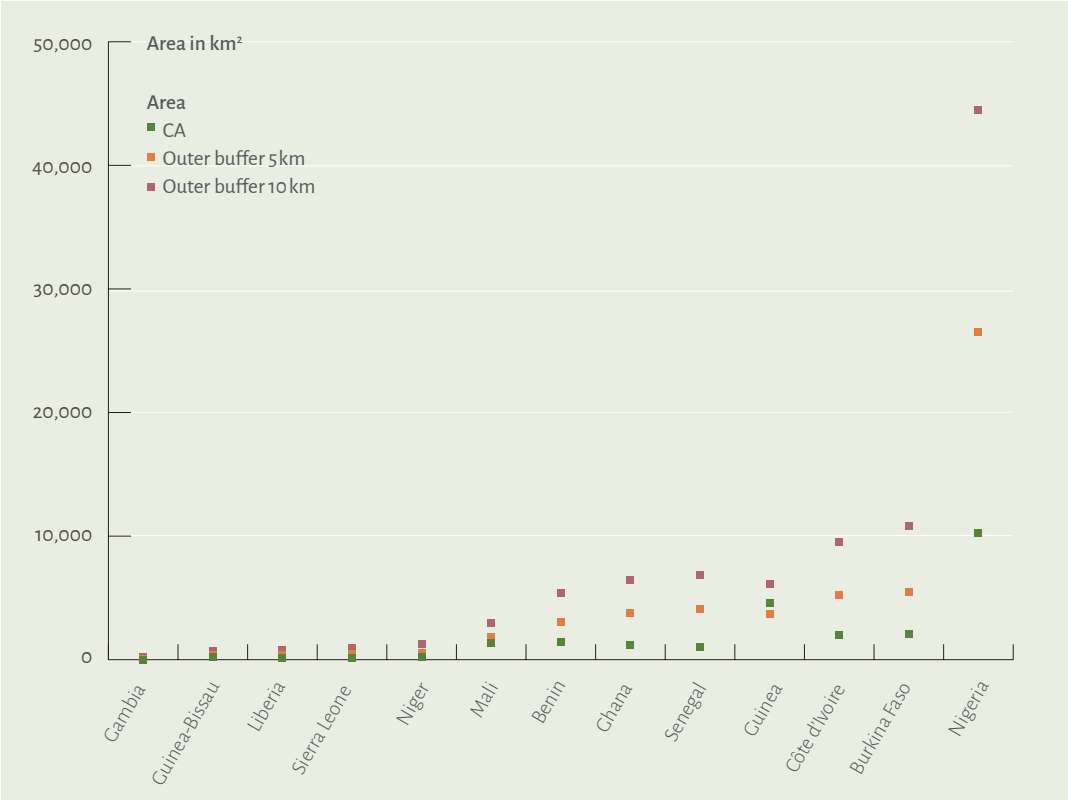


FIGURE 6

TOTAL AND RELATIVE CONVERSION INTO CROPLANDS INSIDE CONSERVATION AREAS AND FOR DIFFERENT BUFFERS IN 13 WEST AFRICAN COUNTRIES (2000–2013).

Percentage and total area of agricultural expansion within and around PAs for West-African countries.

Source:
Authors' analysis

3.2.
Why are African landscapes losing natural capital? Drivers and pressures

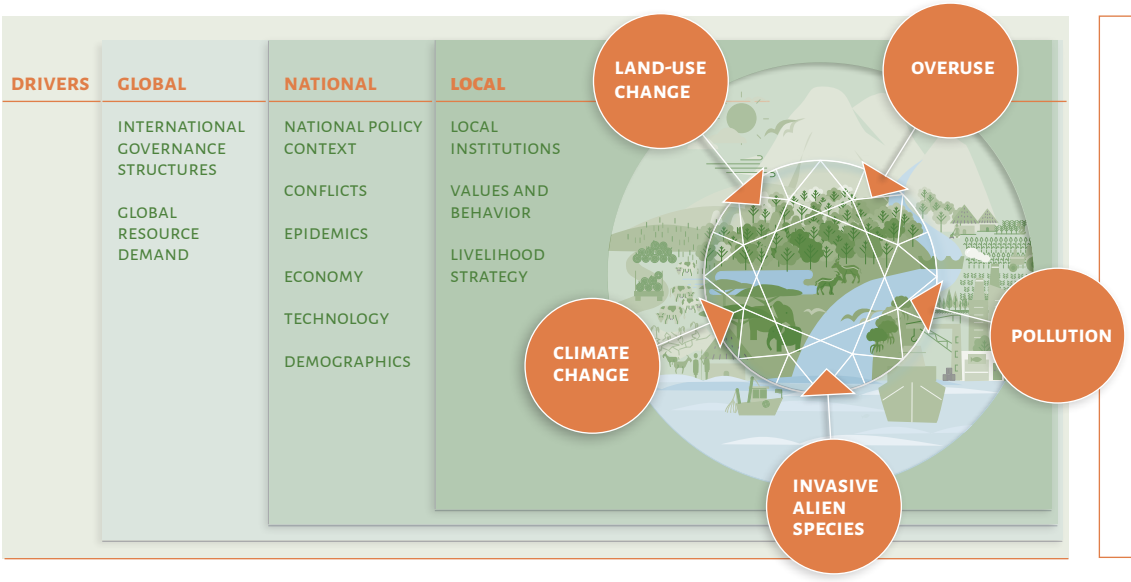


FIGURE 7
DISTANT AND PROXIMATE DRIVERS TRANSLATE INTO PRESSURES ON ECOSYSTEMS IN GENERAL AND ON CONSERVATION AREAS IN PARTICULAR

African landscapes are under direct pressure from climate change, habitat conversion (i.e. land-use change leading to land cover change), overharvesting, pollution, the spread of invasive alien species, and the illegal wildlife trade (IPBES 2019).

These direct pressures are driven by various factors located at global, national and local levels. The nature of their interplay differs from setting to setting.

Underlying macro trends and drivers at national and international scale include climate change, international policy and global demand for resources, national level policies, changes in technology, and the outbreak of epidemics. These are but some of the influencing factors. National economic pathways (e.g. unsustainable growth strategies), policy neglect (e.g. inappropriate spatial planning), and direct human influences (e.g. rapid urbanization) form various combinations. In turn, local institutional structures, livelihood strategies and cultures have an influence on how these more distant factors are dealt with at local scale and impact on local ecosystems.

Some pressures can be clearly identified. For example, armed conflicts, even low-grade, infrequent conflicts which are a common challenge in Africa, have strong impacts on conservation areas (Daskin and Pringle 2018). Likewise, global interest in Africa's non-renewable assets poses severe risks to its natural wealth: 25 out of Africa's 41 World Natural Heritage sites are threatened by extractive industries. Currently, 196 mining and 30 oil/gas concessions have been granted within their boundaries. The spatial overlap of leased oil and gas concessions with protected areas for the whole of Africa is estimated at 26.65% (WWF 2015).

Other pressures result from more interlinked factors across different scales. Thus, the recent elephant and rhino crises are not only linked to demand for wildlife products in distant markets, to criminal international networks and to poor local income alternatives. Political indifference and low levels of awareness on all sides (i.e. in Africa, Asia and Europe) exacerbate the situation (EU 2016). Likewise, climate change catalyses ecosystem

change in Africa by extreme weather events (Dasgupta et al. 2011), but also by affecting agricultural systems (Pereira 2017). It destabilizes African societies by a range of impacts (Serdeczny et al. 2017). For example, African coastal countries have to expect high damages caused by flooding, forced migration, or increased salinity linked to sea-level rise (Hinkel et al. → 2011).

One universal underlying factor is the low visibility and recognition of nature's benefits to people (TEEB National 2011). This has long been neglected in economic plans, development strategies, policies and investments. Only once the full environmental consequences of these are taken into account will public decisions and private sector activities be able to achieve more sustainable outcomes (Dasgupta 2021).

3.3 IPBES trajectories for Africa

The next decade will shape Africa's development prospects in fundamental ways. Terms of trade, technology, population growth, urbanization and climate change will create living and development conditions that are likely to be radically different from today. Among these factors is the loss of natural capital. Various scenarios describe potential development trajectories for the African continent (IPBES 2018).

A recent review and synthesis of scientific knowledge indicates that all direct drivers of ecosystem change are expected to increase further – in all African regions (IPBES 2018 → see Figure 8 on the right side).

For Africa as a whole, drivers related to population, natural resource use and climate change are expected to increase under all the imagined societal trajectories described in the IPBES Regional Assessment for Africa (IPBES 2018).

- **Population growth:** Africa's population is expected to double by 2050, to 2.5 billion people.
- **Natural resource use:** Projections draw a mixed picture for Africa. Increases in national cropland will range between 19 %–120 % across Africa. This might lead to further environmental pressures, but could also prompt a decrease of 27 % in certain scenarios. A proliferation of cash crops for global markets would increase land conflicts.
- **Climate change:** Africa is one of the continents most vulnerable to climate change, raising concerns around water stress and future prospects for food production. Even in a low emissions scenario, average temperatures are expected to increase between 1.1 °C and 2.6 °C.

The next decade will shape Africa's development prospects in fundamental ways. Terms of trade, technology, population growth, urbanization and climate change will create living and development conditions that are likely to be radically different from today.

SUBREGIONS	ECOSYSTEM TYPE	CLIMATE CHANGE	HABITAT CONVERSION	OVER-HARVESTING	POLLUTION
CENTRAL AFRICA	Terrestrial/ Inland waters				
	Coastal/Marine				
EAST AFRICA AND ADJACENT ISLANDS	Terrestrial/ Inland waters				
	Coastal/Marine				
NORTH AFRICA	Terrestrial/ Inland waters				
	Coastal/Marine				
SOUTHERN AFRICA	Terrestrial/ Inland waters				
	Coastal/Marine				
WEST AFRICA	Terrestrial/ Inland waters				
	Coastal/Marine				

FIGURE 8
EXPECTED TRENDS IN DIRECT DRIVERS OF ECOSYSTEM CHANGE IN DIFFERENT AFRICAN REGIONS

Based on the IPBES review of scientific knowledge. Width of arrows indicates robustness of evidence or degree of agreement on the trend.

Source: IPBES 2018

There is broad agreement that terrestrial food, fodder and biofuel production will increase, while biodiversity, various regulating ecosystem services and habitat characteristics will generally deterio rate. In fact, by 2030 Africa is projected to have the highest proportion of land globally that is crucial to conservation but will be converted to other uses (Allan et al. 2019).

3.4
NDVI change and forest loss: Prospects for conservation areas in 2030

How do these macro-projections shape the future of African conservation areas? Global scenario analysis indicates that expanding the world's conservation areas to 30% of land and sea area would, in the long run, generate higher overall output and revenues than non-expansion. At the global level the benefits could exceed the costs by an order of at least 5:1 across different implementation scenarios (Waldron et al. 2020).

However, lower-income countries often lack the necessary infrastructure and market access to realize the revenue potential – for example through tourism – from such an expansion. In addition, effective implementation and management of the already existing conservation areas remains a key challenge for many countries (Lindsey et al. 2017, Watson et al. 2014). This section therefore elaborates projections about the state of protected natural assets for the existing land area under protection.

National contexts are highly divergent across Africa. However, it is plausible to extrapolate from past trends in order to describe what might happen if things do not change. Two scenarios for African conservation areas in 2030 are considered here in a rough approximation: a 'business-as-usual' scenario and an 'ecological consolidation' scenario:

- **Business-as-usual (BAU scenario):** Past degradation and forest loss trends (described in section 3.1) inside conservation areas continue unchanged and are extrapolated to 2030.
- **Ecological consolidation (EC scenario):** Past degradation and deforestation trends inside conservation areas can be effectively halted at 2020 levels. Further losses are either halted or offset by ecosystem restoration efforts.

Based on available data, these scenarios can be compared for NDVI trends and forest loss trends.

SHARED ASSUMPTIONS IN THE 'BUSINESS-AS-USUAL' AND 'ECOLOGICAL CONSOLIDATION SCENARIOS

- It is assumed that the overall situation will continue to evolve at the same speed. On average, the macro factors (population growth, climate change, natural resource consumption) that accelerate environmental degradation will be mitigated sufficiently by public and private responses to keep overall environmental change trends stable or on their current trajectory. This is optimistic given the IPBES judgement that the drivers of ecosystem change will increase.
- For methodological purposes we also assume that the size and location of conservation areas will not change. This is highly improbable: new areas are likely to be established, and some existing ones will change their borders or be de-gazetted.

These assumptions limit the validity of the scenario comparison – precise results should not be taken at face value. However, the results can convincingly approximate the magnitude of possible gains or losses.

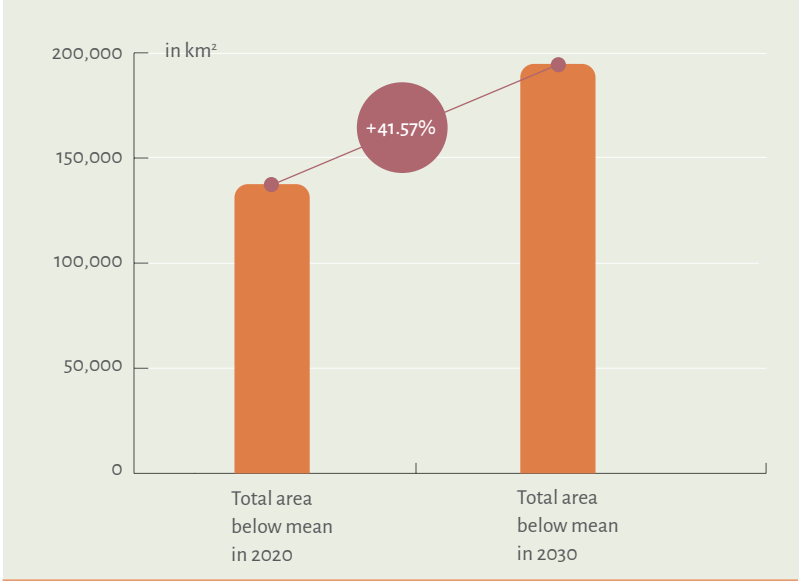


FIGURE 9
PROJECTED CA LAND DEGRADATION IN 2020 AND 2030

Projected extension of degraded conservation land according to NDVI index - compared to NDVI mean 2001 – 2003.

Source:
Authors' analysis

Comparison of scenarios for ecosystem degradation (NDVI index): This index measures landscape 'greenness' and is used as an indicator for ecosystem change. For scenario comparison, past changes (2000-2018) per country were extrapolated for 2020 and 2030.[12]

- BAU scenario for ecosystem degradation: If past degradation trends continue unchanged, a total of **195,000 km² of conservation land will show significant signs of degradation** (i.e. below country-specific NDVI thresholds from 2001 – 2003). **This is an increase of more than 40% of total degraded conservation land in Africa.** Half of this degradation will take place in just seven countries: Tanzania, Mozambique, South Africa, Kenya, Zambia, Zimbabwe and Botswana. As Africa's total conserved land area extends to 4.2 million km², this figure appears small. However, it should be noted that large conserved land areas are located in arid or desert regions, for which the NDVI index does not capture degradation.
- **EC scenario for ecosystem degradation:** If degradation inside conservation areas can be halted at 2020 levels, the land area saved from degradation will exceed 57,000 km² (i.e. the difference in affected land area for the two scenarios).

Comparison of scenarios for forest loss: Forest loss is determined by measuring changes in canopy density via remote sensing data. For our scenario comparison, past trends are extrapolated:

- **BAU scenario for deforestation:** An additional 46,000 km² of forest area inside conservation areas will be lost between 2020 and 2030. This is an additional 40% increase on today's deforested area inside conservation areas (that has been lost between 2000 and 2020). Half of this area will be lost in just four countries: DRC, Tanzania, Cote d'Ivoire and Madagascar.
- **EC scenario for deforestation:** If deforestation can be halted at 2020 levels, this forest area of

12 The mean NDVI value (2000-2003) in conservation areas per country was determined as the threshold value. Changes up to 2018 were determined on the basis of satellite data. The area found to be below the threshold was calculated. Trends were then extrapolated for 2020 and 2030. Only areas with vegetation were compared.

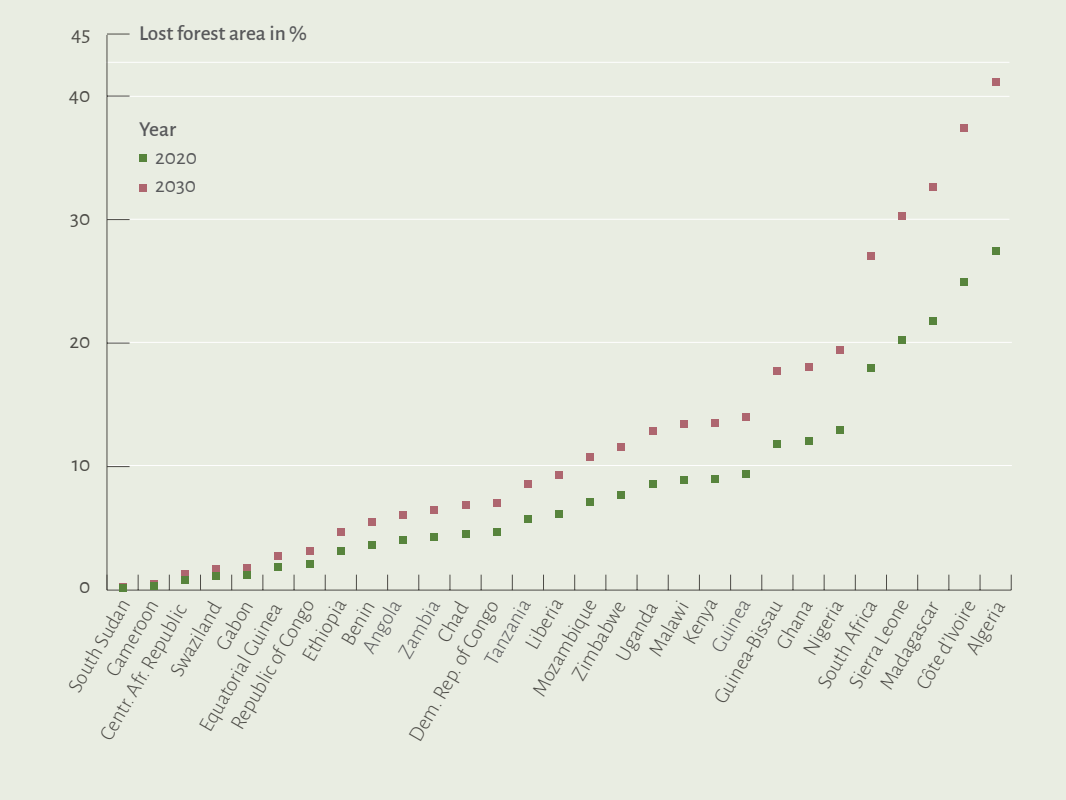


FIGURE 10
PROJECTED RELATIVE FOREST LOSS INSIDE CONSERVATION AREAS BETWEEN 2000 AND 2020/2030 FOR THE 30 AFRICAN COUNTRIES MOST AFFECTED BY FOREST LOSS.

Comparison of forest losses inside conservation areas up to 2020 and in a BAU scenario up to 2030, based on past forest loss trends. 2020 values represent the EC scenario for 2030 ('All further deforestation is halted at 2020 levels'). Percentages represent share of deforested area compared to protected forest area in 2000.

Source: Authors' analysis

46,000 km² – larger than the national territories of Burundi and The Gambia put together – can be saved.

Figure 10 provides details on the relative forest loss inside conservation areas, i.e. the share of total protected forest area in 2000 that is lost in 2020 and in 2030. **In the ecological consolidation scenario, at least five countries will be able to save 10 % or more of their total forests inside conservation areas – within the next decade.** In view of the even higher forest loss rates outside conservation areas, manifest in many African countries, these projections underline the need to rapidly step up conservation and reforestation efforts.

These prospects for losses in vegetation density (NDVI) and for forest loss inside conservation areas are very conservative estimates: They do not consider the likely increases in pressures on ecosystems resulting from climate change, population growth and other macro drivers. Thus, the differences between the two scenarios may well be much greater. Further, the rate of ecosystem change and natural capital loss in unprotected landscapes (i.e. outside conservation areas) will very likely be even higher in many countries. As there are dozens of influencing factors and forces (including the Covid-19 pandemic), neither scenario provides a forecast. Yet the difference between them reveals the magnitude of what is at stake and might be lost – or gained – within the coming decade. This highlights the urgency of stepping up efforts to protect the ecological integrity of ecosystems – inside conservation areas at the very least.

The case of Ethiopia illustrates the huge social and economic benefits of consolidating existing conservation areas, with benefit-cost ratios of 6:1 and more (see box below). The more specific socio-economic implications of past trends and the consequences of these potential ecosystem changes are explored separately for each policy area/sector in the following chapter.

CASE STUDY

BORENA-SAYINT WOREHIMENO, CHEBERA CHURCHURA, SIMIEN MOUNTAINS AND BALE MOUNTAINS NATIONAL PARKS, ETHIOPIA

Investing in Ethiopia's protected natural assets pays off economically and socially

STATUS: All four parks are national parks.

SIZE: Ranging from 15,000 to 220,000 ha/park.

ECOSYSTEMS: Diverse mountainous landscapes, including wooded grassland and montane woodland.

KEY ECOSYSTEM SERVICES: Watershed protection, erosion prevention, carbon sequestration, habitat, recreation, fodder, pollination, genetic resources.

NEARBY POPULATION AND INFRASTRUCTURE: All parks are in relatively rural mountain areas with rural population living in their buffer zones. Chebera Churchura and Bale Mountains national parks are located in proximity to hydropower infrastructure.

LAND-USE: The parks' buffer zones are characterized by agriculture and livestock grazing which in some locations extends into the parks' boundaries.

CHALLENGES: Challenges differ by site but include encroachment and expansion of agricultural lands, human wildlife conflicts and new settlements and infrastructure as well as underfunding.

Ethiopia is home to a rich diversity of ecosystems and species and its gene pools are one of the world's most important sources for crops such as coffee. Currently approximately 14% of the country's territory has been designated as protected areas. However, these areas are operating substantially below their potential. This is partially due to severe funding shortages for their management. This raises an interesting question for an assessment: *What are the socio-economic benefits of an improved management funding scenario for Ethiopia's protected areas?*

Borena-Sayint Worehimeno National Park is an important religious, cultural and natural site, and it provides crucial watershed protection, pollination and pest control services.

CASE STUDY
ETHIOPIA

APPROACH OF THE ASSESSMENT

To answer this question, an ecosystem services assessment (GIZ 2021) was conducted for Borena-Sayint Worehimeno and Chebera Churchura National Parks, while existing information on the value and potential of protected areas in Ethiopia (see Van Zyl 2015) was updated for Simien Mountains and Bale Mountains National Parks. The aim was to demonstrate how additional investment in protected areas would result in increased benefits from and better conservation of ecosystem services. The range of benefits which were considered included grazing, harvesting of natural products and medicinal plants, watershed protection and water provision, carbon sequestration, pollination, pest control, tourism and cultural values.

Simien Mountains: Group of tourists with local guides

SOME KEY FINDINGS

The 2015 study estimated the financial costs of an improved management scenario over 20 years. These costs were then compared with likely benefits in terms of increased ecosystem services values. The wider economic importance of these benefits was approximated by monetary value estimate:

- Adjusting the findings of the study for inflation since 2015, improved management would require annual system-wide budgets to increase more than four-fold (from approximately US$3 to US$5 million/yr to US$15 to US$20 million/yr). Benefits in terms of increased ecosystem services values would then increase gradually from approximately US$350 million/yr to an enhanced value of US$540 million/yr over the 20-year period.

- This translates into a benefit:cost ratio of between 6:1 and 8:1 (depending on different discount rates for future benefits).

CASE STUDY
ETHIOPIA

The 2021 assessment concluded that the four selected protected areas are substantially under-funded, requiring an average of 4.2 times more for basic management than is currently available (see summary of results below).

- The results of the cost-benefit analyses of increased funding for a basic funding scenario were significantly positive for all of the parks. In addition, the benefit:cost ratio of the scenario averaged 19:1 for all parks and varied substantially from 4:1 to 51:1. This variation should not be overly surprising given the significant differences between the parks.
- Accordingly, an increased budget for these protected areas would have a positive impact and can be clearly justified. More funds invested in the management of these areas would generate economic and social benefits which considerably exceed the costs.
- The delay of the required investments may result in significant risks, such as the high costs of ecological restoration in the future and potential irreparable loss of ecosystems.

CONSERVATION AREA	CURRENT ANNUAL VALUE OF ECO-SYSTEM SERVICES (ETB MILLIONS)	BASIC FUNDING SCENARIO (FUNDING NEEDS AS A MULTIPLE OF BUSINESS-AS-USUAL FUNDING AVAILABLE)	NET PRESENT VALUE OF INVESTMENT IN BASIC FUNDING SCENARIO (ETB MILLIONS)	BENEFIT-COST RATIO OF INVESTMENT IN BASIC FUNDING SCENARIO
BORENA-SAYINT WOREHIMENO (18,858 HA)	149	x 2.65	134 – 201	5:1
CHEBERA CHURCHURA (126,453 HA)	648	x 1.6	1,597 – 2,396	51:1
SIMIEN MOUNTAINS (41,200 HA)	602	x 5	323 – 485	5:1
BALE MOUNTAINS (220,000 HA)	1,866	x 7.5	1,843 – 2,765	17:1
AVERAGE	816	x 4.2	975 – 1,462	19:1

FIGURE 11
SUMMARY OF CURRENT ECOSYSTEM SERVICES VALUES, FUNDING NEEDS AND COST-BENEFIT ANALYSIS OF BASIC FUNDING SCENARIO RELATIVE TO BAU FUNDING SCENARIO

Source:
GIZ (2021):
Ethiopia's Protected Natural Assets: Creating Value and Supporting Development.

In addition to the strong economic rationale that recommends a significant increase in budget allocation for the management of protected areas, the results show the need for a better integration of the multiple benefits of protected areas and surrounding landscapes and the real costs of their degradation in development decisions.

Source: Authors' analysis

4. AFRICA BENEFITS IN MANY WAYS FROM PROTECTED NATURAL ASSETS

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Protected natural assets contribute to meeting the direct needs and the development ambitions of African societies.

Protected natural assets contribute to meeting the direct needs and the development ambitions of African societies. Nine economic sectors and policy areas are addressed in the following: water security, agri-food systems, fisheries, hydropower, tourism, resilient cities, disaster risk reduction, global warming and public health.

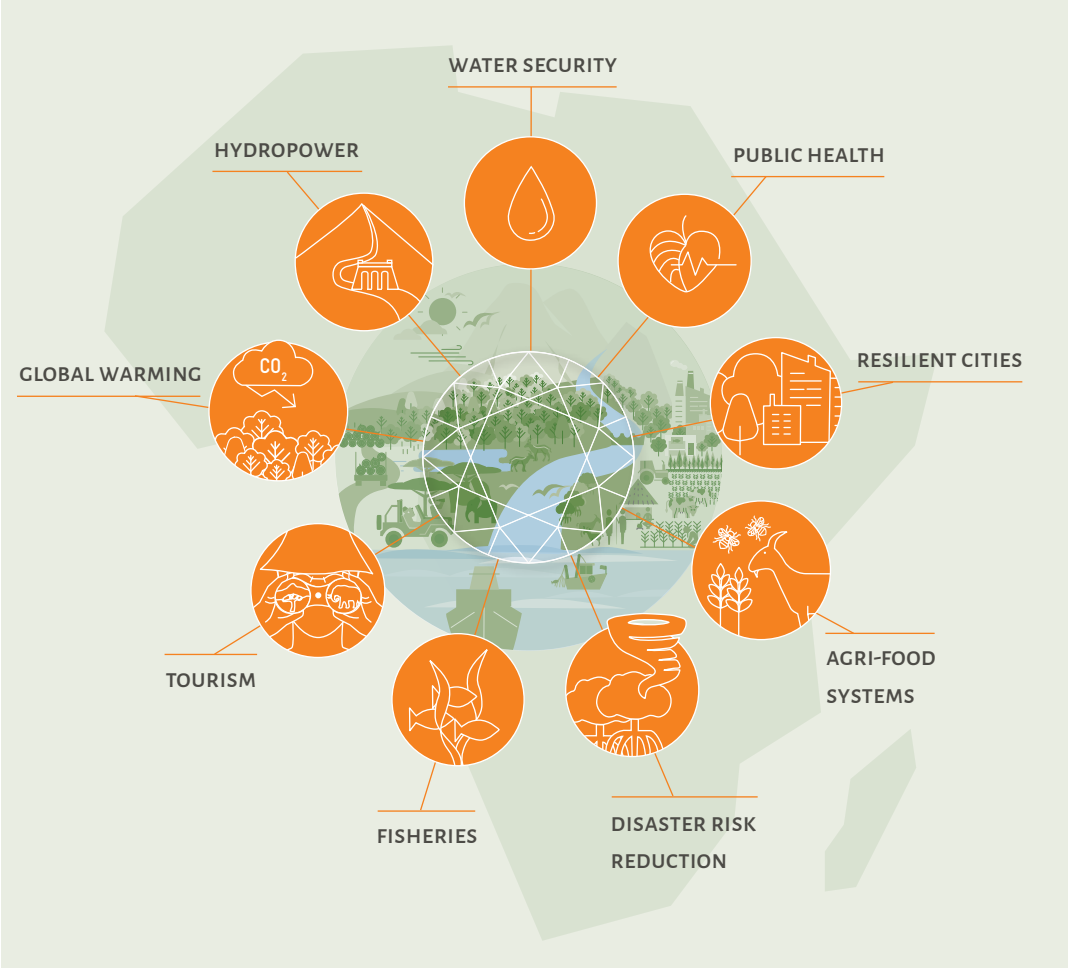


FIGURE 12
OVERVIEW OF POLICY AREAS AND ECONOMIC SECTORS TO WHICH PROTECTED NATURAL ASSETS CONTRIBUTE, AND WHICH ARE ADDRESSED IN THIS CHAPTER.

CONSERVATION AREAS GENERATE INTERDEPENDENT BUNDLES OF PUBLIC AND PRIVATE BENEFITS ACROSS ALL SCALES

Even though different sectors benefit from conservation areas, these benefits are not generated separately from each other. The services of (protected) ecosystems to society come in interconnected bundles. While many synergies exist, the maximisation of one benefit often comes at the cost of losing other benefits. This is typically the case if provisioning services are maximised at the expense of regulating benefits. Therefore, the assessment of benefits also needs to account for different beneficiary groups at different scales.

This information has potential relevance for informing conservation finance and policy options: **Typical global benefits** (for all mankind) include carbon sequestration, the maintenance of genetic diversity, or the protection of charismatic endangered species. They offer suitable arguments for international conservation finance. **Typical national benefits** include water supplies for stable hydropower, or favourable conditions for cash crops that generate significant tax or trade income for governments. These benefits can motivate financial mobilisation from other sectors and national budget lines. **Typical local or regional benefits** include all services that sustain nearby livelihoods or local safety against hazards. Here, local support for conservation, and partial acceptance of opportunity costs are important in-kind contributions.

A forest area can be used for growing shade coffee and for protecting wildlife habitat (e.g. for intrinsic reasons and for tourism). Yet, if management strongly favours one service, the balance with the others will be lost. Often the maximisation of agricultural productivity is to the detriment of regulating public benefits. In turn, pursuing a strict conservation regime can result in excluding local access to critical conservation area benefits (e.g. medicinal plants). Finding a sustainable balance between local, national and global benefits, between private and public benefits from conservation areas, requires strong cross-sector collaboration and awareness of diverse (local) dependencies on intact ecosystems

4.1. Conservation areas contribute significantly to water security in Africa

Tackling water insecurity is pivotal for the future development of Africa. Conservation areas play a key role here, which is why the SDG Clean Water and Sanitation formulates the specific target of protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes by 2030 (UN 2015).

4.1.1 WATER INSECURITY IS A SERIOUS CHALLENGE IN LARGE PARTS OF AFRICA

400 million people, representing 30 % of Africa's population, are affected by water insecurity (IPBES 2018). This number is expected to double by 2050 (Gosling and Arnell 2016). It will strongly affect (rural) poor people, even in countries with a high coverage of basic drinking water infrastructure (United Nations 2018).

Access to safe drinking water and sanitation are not only essential for health. Water shortages and water quality problems can seriously constrain food production, with implications for food security (see following section). Water scarcity also presents serious challenges to economic growth. Economic losses associated with inadequate water supply and sanitation have been estimated at a minimum of 4% of GDP in sub-Saharan Africa (Hutton, Guy & World Health Organization 2012). Entire economic sectors would collapse or shrink dramatically if they lost access to sufficient water. These include irrigation agriculture, pulp and paper manufacturing, the garment industry and the energy sector. Furthermore, international conflicts over water are expected to occur or intensify where scarcity of water, high population density, power imbalances and climatic stressors coincide – such as in the upper Nile basin (Farinosi et al. 2018).

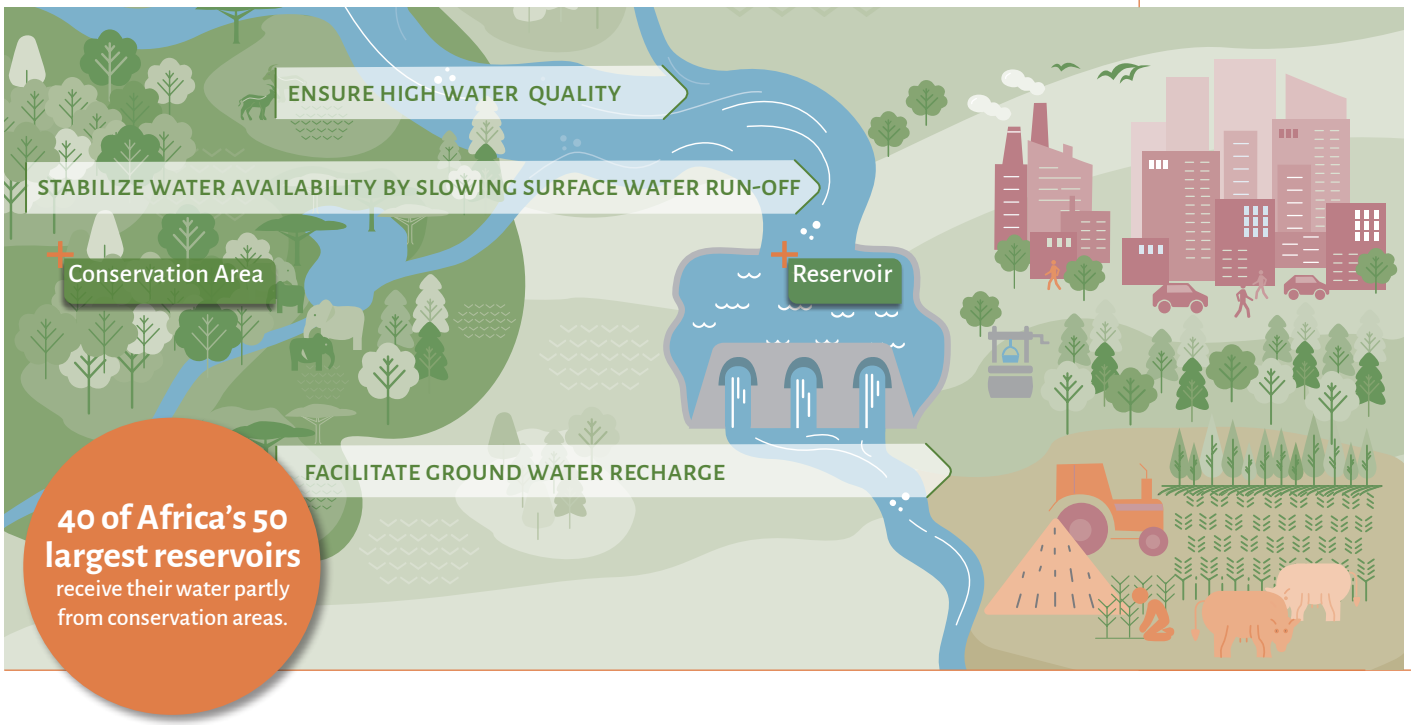
A global review comparing national water supply with water abstraction levels reveals that Libya, Eritrea, Botswana and Morocco are among the top 25 countries currently facing high or extreme water stress (WRI 2019).

4.1.2 CONSERVATION AREAS ARE NATURE-BASED SOLUTIONS TO WATER INSECURITY

Conservation areas protect watersheds, but **only about 14% of Africa's total freshwater volume originates from conservation areas** (Harrison et al. 2016). Thanks to their comparatively intact vegetation cover, conservation areas facilitate ground water recharge and stabilize water flows by slowing surface water run-off. Intact riparian vegetation also ensures lower levels of sedimentation and thereby maintains water quality (see graphic below). This constitutes a critical natural asset that, if lost, would jeopardize the supply of clean water across Africa.

40 out of Africa's 50 largest reservoirs receive their water partly from conservation areas. They enable the irrigation of more than 4.2 million hectares of land. 12 of these reservoirs have more than 25% of their watersheds conserved, indicating comprehensive legal protection. Reductions in sediment loads from these nature-based water facilities have significant benefits, such as extending the useful lives of dams and irrigation canals while reducing the need for water treatment.

FIGURE 13
OVERVIEW OF CONSERVATION AREAS' CONTRIBUTIONS TO WATER SECURITY



- Sediment yields in South Africa's Kruger National Park are six times lower than yields in 'average', relatively more degraded landscapes characterized by agricultural and other non-conservation land uses (Baade et al. 2012).

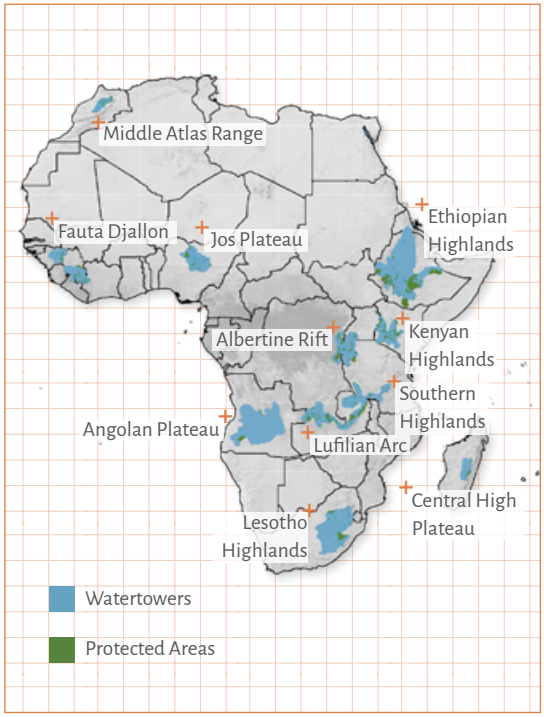
Healthy ecosystems also regulate or even out water flows over time: This ensures greater water availability, particularly during dry seasons or droughts, and reduces flood risks. The upper reaches of watersheds, often in mountainous areas, are relatively more important in the provision of watershed services.

- In southern Africa, strategic water source areas represent only 8% of total land area but ensure water for more than 50% of the population and 64% of the local economy in South Africa (Nel et al. 2017).

- Some of these areas have also been identified as 'water towers': They are key water source areas, often feeding transboundary rivers and multi-national watersheds, serving the water needs of millions of people (UNEP 2010). Map 3 shows that all African 'water towers' have some share of their land under conservation status, although the proportion is rather small, ranging between 1% and 20%.

Even single conservation areas can be highly significant for national and regional water security and for national economies:

- More than 40 springs and five major rivers emerge from the Bale Eco-Region (BER) in Ethiopia, the majority of which is conserved within the Bale Mountains National Park (BMNP), **providing year-round water for up to 12 million people in Ethiopia, Northern Kenya and the Republic of Somalia** (FZS 2007).



MAP 3

UNEP 'WATER TOWERS' (KEY WATER SOURCE AREAS OF INTERNATIONAL IMPORTANCE) AND THE PROPORTION OF THEIR LAND AREA COVERED BY CONSERVATION AREAS IN 2020

Source:
According to UNEP-WCMC WDPA

CASE STUDY

ARGANERAIE BIOSPHERE RESERVE, MOROCCO

Land use and water scarcity connect people and ecosystems from the mountains to the coastline

STATUS: Biosphere Reserve

SIZE: 2,568,780 ha

ECOSYSTEMS: Semi-arid and arid mountains and coastal plains, endemic Argan forests

KEY ECOSYSTEM SERVICES: Erosion prevention, water provision, provision of natural resources

NEARBY POPULATION AND INFRASTRUCTURE: The region's population is 3.5 million, 60 % of which is rural population living across the reserve

LAND-USE: Traditional terrace-based agriculture and livestock in mountain areas, irrigation-based agriculture and horticulture in coastal plains.

CHALLENGES: Infrastructure development in vulnerable areas, water overuse, abandonment of traditional land-use practices

The Argan Biosphere Reserve (recognized by UNESCO in 1998) stretches across several provinces in South-Western Morocco, with a total extension of 2.5 million ha. It comprises 18 core zones and buffer and transition zones which extend from the remote Atlas mountains to the intensively used and inhabited coastal plain. Having at one time been well established and equipped with a governance structure, its de facto role in drawing together diverse actors in implementing sustainable land use currently needs to be strengthened. Water scarcity, agriculture and coastal tourism are closely intertwined in the region.

PURPOSE AND APPROACH OF THE ASSESSMENT

Arguments and evidence relating to natural capital are sought in order to raise awareness among private sector and public administration actors for the causal connections between land use, ecosystem degradation and wider socio-economic impacts. It should be possible, on this basis to mobilize better coordinated efforts in the landscape surrounding the reserve. The main component of the assessment is a literature-based overview of the various benefit flows from the biosphere reserve's ecosystems.

The Argan fruit and its oil have multiple uses in cooking, medicines and cosmetics.

CASE STUDY
MOROCCO

SOME KEY FINDINGS

- Intensive agriculture in the coastal plain, namely citrus and almond production for export, causes water abstraction to significantly exceed sustainable water supply levels. Agriculture requires more than 80 % of total water consumption in the region, even though one third of national tourism is concentrated in the area. Deep water aquifers are tapped into while significant volumes of additional water from desalination plants, which could fill the gap, are not expected to be available until 2030.

- Linked to water scarcity is the pre-eminent importance of terrace-based traditional agriculture in upstream areas: these terraces, combined with intact vegetation cover, control the level of soil erosion and resulting sediment loads in the region's dams and reservoirs.

- The (upstream) Argan forest areas inside the biosphere reserve provide a number of benefits which sustain at least 20,000 households. Argan nut, fodder for livestock, and fuelwood constitute the main sources of livelihood. They are roughly of equal importance to the local economy. However, they are also a cause of conflict among competing users. The high export value of Argan oil is generated only further down in the value chain, and the benefits do not flow back to the region. The traditionally extensive use of the Argan forest is losing ground for economic and socio-cultural reasons.

These findings are being further examined in ongoing analyses. Notably, the connections between terrace-based traditional agriculture, erosion control and water supply (as well as avoided flood damage) are to be further specified. This may serve to inform more integrated land-use planning across the provinces of the biosphere reserve. It may also provide an incentive to downstream water beneficiaries to co-finance the maintenance of upstream traditional land-use systems.

The Arganeraie Biosphere Reserve conserves Argan forests (left) which constitute the main source of local livelihood.

Source: Authors' analysis

4.1.3. PROSPECTS FOR 2030: CONSERVATION AREAS AND WATER SECURITY

Africa's demand for water will increase. Its water security prospects are closely linked to ecosystem degradation. Conservation areas play a key role here (Mafuta et al. 2011).

Several countries will see their water scarcity challenges more closely related to the state of their conservation areas than others. Those which face high water stress and still maintain significant protected land cover in key water source areas will face significant impacts in a **BAU scenario** (see Chapter 3). Such countries are mostly located in eastern and southern Africa. In turn, they are likely to benefit significantly from restoration and conservation efforts toward enhanced water supplies, as assumed in the **ecological conservation scenario**. Other countries will either continue to have enough water (those in tropical central Africa), or else they will face a level of water stress that requires much larger efforts and for which current conservation areas are only a small part of the solution (Mediterranean and sub-Sahel countries). In any case, the drivers of pollution, ecosystem degradation and deforestation will exacerbate water stress in some areas and flooding and soil erosion in others. Climate change will have regionally variable effects but is expected to further aggravate this situation (WRI 2019).

The benefits of ecosystem restoration for enhanced water security are well established but need to be scaled up. Such efforts can achieve benefit:cost ratios of more than 20:1, particularly among those focused on inland wetland, forest and woodland restoration (de Groot et al. 2013).

4.2. African agri-food systems are closely connected to conservation areas

As agricultural landscapes degrade, the 'ecological spill-over effects' from conservation areas become an important factor in agri-food systems.

4.2.1. AGRICULTURAL SYSTEMS AT RISK FROM ECOSYSTEM CHANGE AND INCREASING LAND DEGRADATION

Agriculture across Africa is mostly composed of traditional and mixed agri-food systems. Industrial farming has been expanding, but still covers a relatively small proportion of agricultural land. Agricultural outputs are unstable and agri-food systems are becoming more fragile. Low input usage, declining soil fertility, erratic climatic conditions and low government funding in the sector have driven Africa's decline in production of major cereal crops over the past several years (IPBES 2018).

Natural capital is the foundation that sustains agri-food systems; three other types of capital influence their trajectory, namely, human, social and pro duced capital (→ see Figure 14).

Agriculture is a principal driver – and a prime victim – of natural capital degradation, which jeopardizes governments' capacity to meet the rapidly growing need for food and animal fodder. Two thirds of productive land in Africa are already affected by land degradation (UNCCD 2013, UNCCD 2017). For example, soil erosion and depletion of soil nutrients

cause annual losses in excess of 250 million tons of cereals per year across 42 countries in Africa (ELD & UNEP 2015). Climate change may cause further crop yield decline of up to 8% in sub-Saharan Africa (Dale et al. 2017), while the resulting water scarcity will affect agriculture particularly in the Mediterranean countries and Southern Africa (TEEB AgriFood 2018).

This exacerbates food insecurity. The poorest households rely most directly on farming and agricultural labour for their income and subsistence (IFAD 2011). In sub-Saharan Africa, for example, 22.7 % of the population suffered from undernourishment in 2016 (FAO et al. 2017).

Conservation areas generate ecological spill-over effects and create favourable farming conditions (→ see Figure 15 on page 56). At the same time, wildlife conflicts and human encroachment on strictly protected lands create tensions between agriculture and conservation.

Conservation areas generate ecological spill-over effects and create favourable farming conditions.

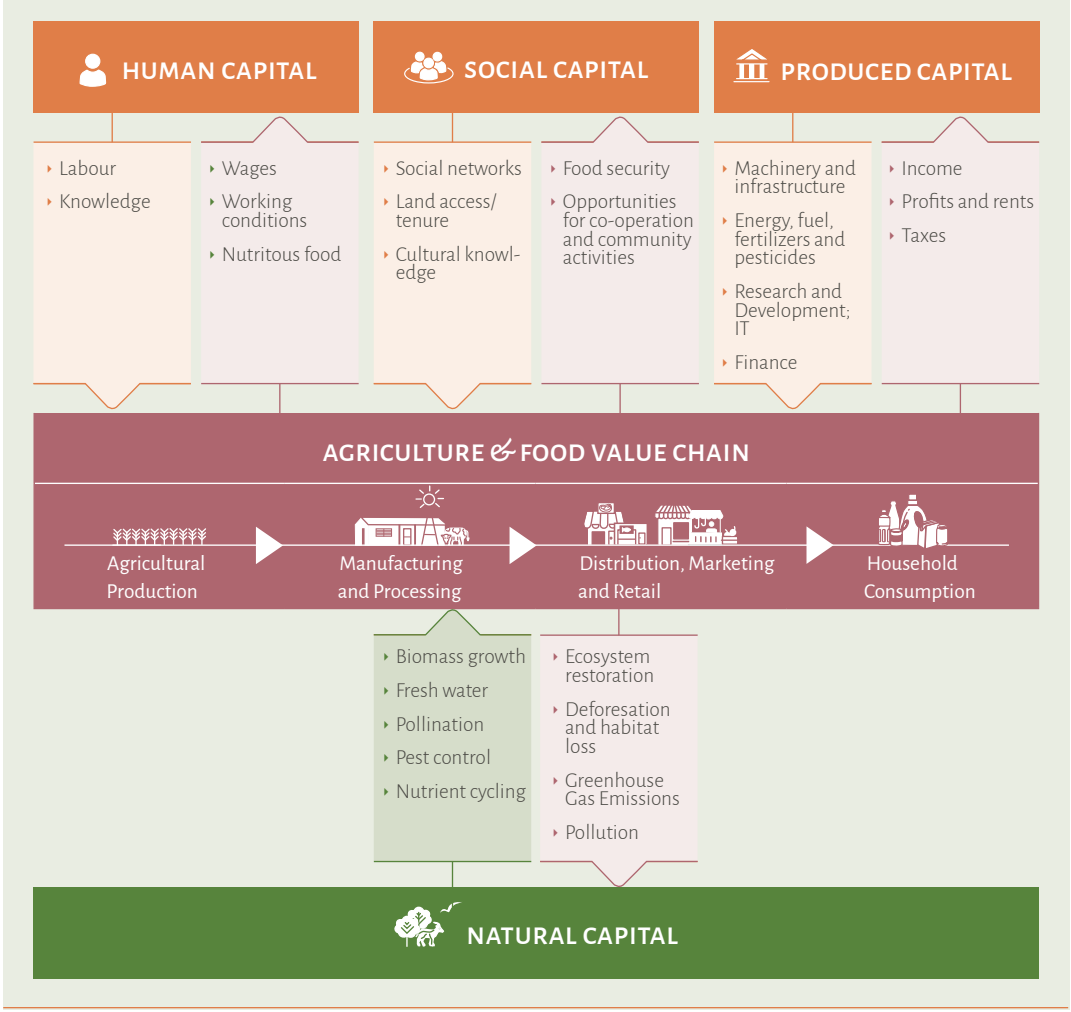


FIGURE 14
NATURAL CAPITAL SUSTAINS AGRI-FOOD SYSTEM – BUT OTHER TYPES OF CAPITAL DETERMINE HOW SUSTAINABLE THESE SYSTEMS ARE.

There are many entry points for influencing the sustainability of the value chain.

Source:
TEEB AgriFood 2018

4.2.2. AGRI-FOOD SYSTEMS RELY ON CONSERVATION AREAS

The principal input of natural capital to agri-food systems is the land's capacity to grow biomass in the form of crops, pastures and wild foods. Spill-over effects in the form of different ecosystem services affect and benefit millions of farmers. For example, about 226 million people live on ~600,000 km² of agricultural land just within the 20 km buffer zones around conservation areas in 13 West African countries (→ see Figure 15 next page).

Farming and livestock raising depend on several important benefits from wild habitats. The geographic range of ecological spill-over effects differs from ecoregion to ecoregion and depends on topography, watershed locations, regional climate, adjacent land cover, farming systems, and the specific ecosystem service concerned. However, the closer a conservation area to human habitation, the more likely it is that spill-over effects will play an important role in regional agri-food systems. With intensifying land use, agriculture relies ever more greatly on conservation areas to provide ecosystem services to surrounding farming landscapes. At the same time, agricultural activity in the vicinity of conservation areas increases the probability of human-wildlife conflicts or pollution from agro-chemicals.

On average, the following ecosystem services from conservation areas **can be assumed to benefit farming and pastoralism within a 5–20 km range (or more) beyond their boundaries:** Pollination and soil erosion control services, enhanced water provisioning and genetic diversity (crop wild relatives), regional climate regulation from forests, and pest control (e.g. from vultures). Some examples:

Enhanced insect pollinator diversity and abundance significantly increases yields in a large variety of (cash) crops in West Africa (Stein et al. 2017). This has been confirmed for small farm plots across the globe, including mangos (Ghana), sunflowers (South Africa) and French beans (Kenya) (Garibaldi et al. 2016). As the agricultural application of pesticides, specifically insecticides, intensifies (FAO 2020b), the presence of protected wild habitats as refuges for pollinator populations gains greater importance for pollination in African farming.

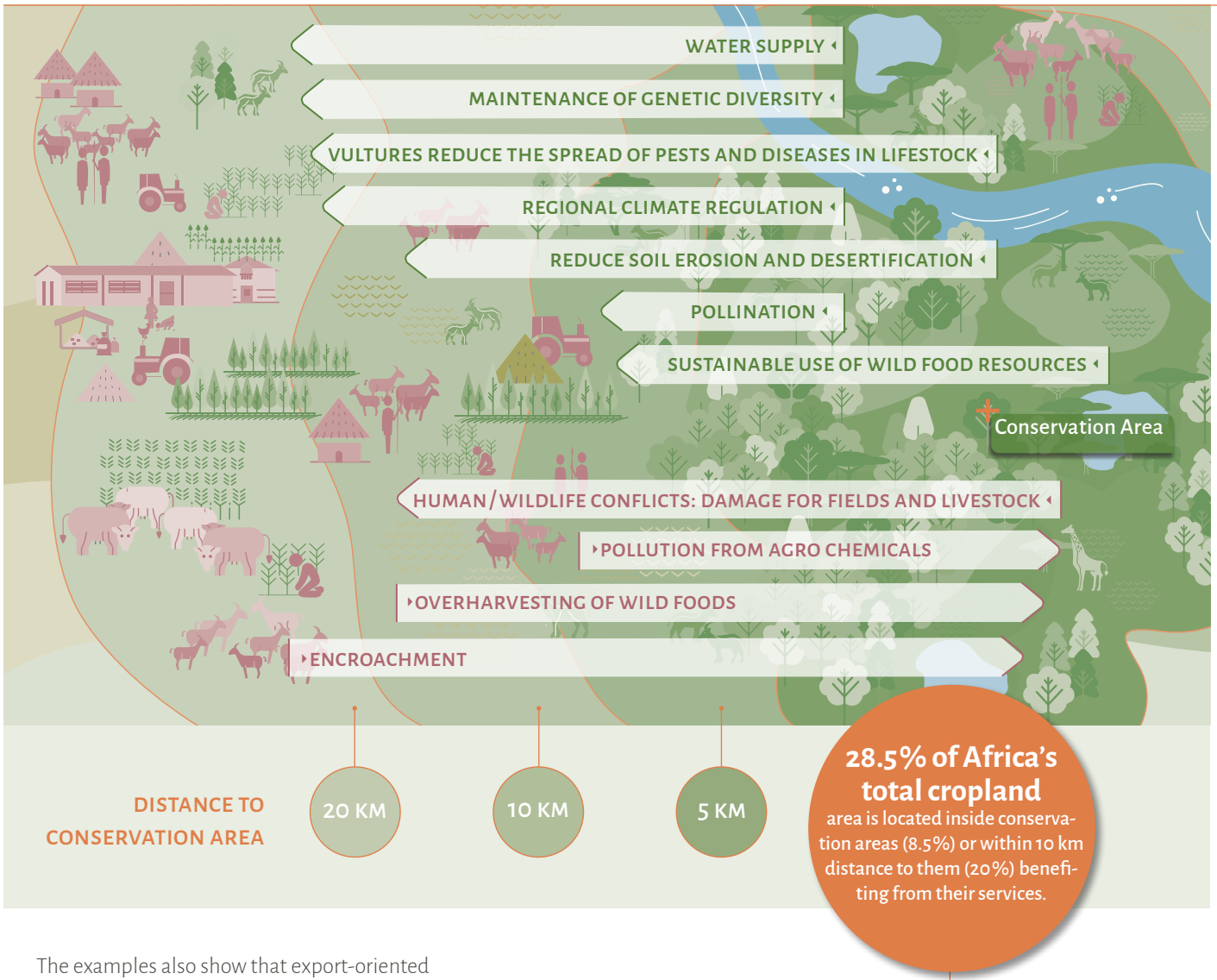
Genetic information from crop wild relatives is important for breeding enhanced cultivars, such as for pest and disease resistance, and increasing yields.

- Yayu and Kafa Biosphere Reserves in Ethiopia's highland forests host large genetic diversity of wild arabica coffee plants used by local breeders. With deforestation and below canopy forest clearance, coffee genetic resources are dwindling at alarming rates in Ethiopia – which makes their in-situ conservation in protected forests all the more important (Labouisse et al. 2008).

Protected forests contribute to regional climate regulation, regular rainfall and enhanced water security for agricultural landscapes.

- In Cote d'Ivoire, the Taï National Park is the largest remnant of rainforest in West Africa. All non-protected forest near the park has been converted to agriculture. In the cocoa sector alone, the **climate regulation effects from the park's forest secure more favourable conditions for about 176,000 farming households within a 50 – 75 km radius,** which harvest 40 % of the national cocoa production (worth 3 % of national GDP) (Berghöfer et al. 2018).

Many benefits from conservation areas for farming cannot be replaced by agricultural technologies – or these would be prohibitively expensive – if such benefits were lost.



The examples also show that export-oriented agriculture in mixed and modern farming systems (as in the cases of cocoa, coffee and mango production) depends just as much on protected natural assets. Many benefits from conservation areas for farming cannot be replaced by agricultural technologies – or these would be prohibitively expensive – if such benefits were lost.

FIGURE 15
INTERACTIONS BETWEEN CONSERVATION AREAS AND ADJACENT AGRI-FOOD SYSTEMS: BENEFITS FROM PROTECTED NATURAL ASSETS AND IMPACTS ON THEM

CASE STUDY

ANKARAFANTSIKA NATIONAL PARK, MADAGASCAR

Modelling erosion and hydrological systems shows how the park contributes to regional water and food security

STATUS: National park

SIZE: 130,026 ha divided into a core protection zone of 42,878 ha and a buffer zone of 93,635 ha

ECOSYSTEMS: Tropical dry forest, the last continuous forest of its kind in the region

KEY ECOSYSTEM SERVICES: Erosion prevention, carbon storage, opportunities for nature tourism

NEARBY POPULATION AND INFRASTRUCTURE: Rural population in buffer zone, important national road cuts through the park

LAND-USE: Sustainable land-use practices allowed in buffer zone

CHALLENGES: Encroachment and expansion of agricultural land, erosion

Ankarafantsika National Park (ANP) is a well-established national park of 130,026 ha with a buffer zone where certain sustainable land-uses are allowed. ANP is the last continuous dry tropical forest of scale in this ecoregion with its unique species mix. The plain of Marovoay to the north of the park is one of Madagascar's major rice granaries, with more than 38,000 ha of cultivation area.

The park is under direct pressures from fires which are set up outside park boundaries to improve pastures and create new agricultural land. Illegal logging for charcoal production poses an additional threat, as do foraging and poaching.

APPROACH OF THE ASSESSMENT

The assessment sought to evaluate the current pressure of agricultural practices on the park and the associated economic risks and consequential losses. It then examined how ANP's natural capital contributes to the region's development and what opportunities could be tapped in the future. The better understanding of the pressures as well as the parks contributions and potentials for development shall inform strategies defining development options and incentives in the region around Ankarafantsika National Park.

CASE STUDY
MADAGASCAR

SOME KEY FINDINGS

Concerning the important agricultural area of Marovoay north of the park the assessment quantified the effects of soil erosion to rice production. The rice paddies in this region are fed by rivers passing through the park. The Marovoay plain is threatened by siltation: Sedimentation of the watering system slowly degrades the rice paddies until they are unprofitable or require large restoration efforts.

Looking at the 10 municipalities around the Ankarafantsika National Park, the analysis showed that agricultural production in two municipalities is insufficient with regards to the population's needs from nutrition as well as a livelihood perspective today. In order to compensate for this insufficient supply, farmers extend agricultural activities and encroach into the national park and degrade of forest cover inside the park and in the buffer zone. In a business-as-usual scenario for 2030, this loss of natural capital will continue, resulting in a lack of soil fertility and water provision.

This large but remnant protected dry forest area influences the hydrology of the surrounding landscape. The assessment's projection showed that forest protection and sustainable agricultural practices could reduce erosion and avoid siltation of more than 500 ha of rice paddies by 2030. Also, the park's water provisioning function is of key importance to agricultural use in surrounding landscapes, where the population is exposed to food insecurity. This evidence is not yet well reflected in debates on regional development.

The natural capital assessment highlighted development potentials that are largely untapped today. One being nature-related tourism especially on the national level tourism due to the park's location on the main road connecting the capital of Madagascar Antananarivo with the Northern Coast. In 2019 nature-related tourism in ANP benefited 1,815 households directly as guides or in touristic facilities or indirectly as jobs are in conservation related-activities within the national park management and operations as well as the fire brigades. The value is mostly monetary and therefore constitutes cash income. In 2019 this value amounted to US$ 265,000. While the Covid-19 pandemic depreciates these benefits for years to come, investments in the park's infrastructure will allow for even higher incomes when travel recovers. Sensitively developed it could become an alternative source of income for the local population via the development of touristic service activities on the one hand and the supply of agricultural products to the hotel enterprises.

Source: Authors' analysis

Ankarafantsika National Park is famous for sandy eroded rock areas as well as for valuable dry tropical forests

Further benefits from conservation areas of high importance for food security include stocks of bushmeat and wild foods, and temporary access to grazing lands and water. These benefits require locally adapted harvest rules and management regimes to ensure that they do not lead to biodiversity and natural capital loss.

In the Congo Basin, about 4.5 million tons of **bushmeat** are hunted each year (Nasi et al. 2011). If unregulated, bushmeat hunting jeopardizes biodiversity. There are also significant risks of the spread of zoonotic diseases. At the same time, local populations rely on nutrients and proteins provided by bushmeat, and many forest areas are considered to provide sufficient protein for local inhabitants in a sustainable way (Nasi and Fa 2015). Conservation areas host reproduction sites and gene pool reservoirs. This can prevent species extinctions while simultaneously providing bushmeat, important for human health (Fa et al. 2015). Through the establishment of hunting regimes and regulations in **conservation areas, the latter can serve efforts to reconcile bushmeat hunting with biodiversity.** Conservation area managers also play an important role in monitoring use and stocks in order to prevent overconsumption in the long term. Given the pressures of population growth, market demand and purchasing power in the cities, alternative cash income generation needs to be pursued for game hunting to be sustainable. (Bushmeat as a vector for zoonotic diseases is addressed → in 4.9)

In West Africa, tens of millions of pastoralists engage in **transhumance** (seasonal movement of livestock) along long-established corridors (UNOWAS 2018). In a situation where mobile pastoralism is prompting conflicts with sedentary communities (due to growing herds, land degradation, and the extension of cropland blocking routes), **the buffer zones of conservation areas are taking on critical importance as a temporary supply of space, fodder and water.** This is the case for many (sub-)Sahel conservation areas, such as the Comoé National Park in Cote d'Ivoire. When well managed, the ecological impact of transhumance corridors near/within conservation areas is limited, while the social benefit they provide for pastoralists may be crucial for their survival. Some conservation areas are directly geared towards managing pastoralism as a means to maintain healthy rangelands, such as Biliqo-Bulesa Conservancy in Northern Kenya (Equilibrium Research 2020).

The various benefits conservation areas provide for agricultural productivity as well as availability of land lead to an increase of agricultural activity near and within conservation areas. Satellite data indicates that more than one quarter of Africa's total cropland area – i.e. 1 million out of 3.8 million km² – is located either inside conservation areas or within their 10 km buffer zones.

These benefits require locally adapted harvest rules and management regimes to ensure that they do not lead to biodiversity and natural capital loss.

CASE STUDY

LOMAMI NATIONAL PARK, DEMOCRATIC REPUBLIC OF THE CONGO

Developing the profile of the relatively new park as a source of local livelihoods and other benefits
Status: National park

STATUS: National park

SIZE: Core protection zone of 887,400 ha and a buffer zone of 2,101,700 ha

ECOSYSTEMS: Tropical rainforest

KEY ECOSYSTEM SERVICES: Provision of food and forest products and including traditional medicines,
carbon storage

NEARBY POPULATION AND INFRASTRUCTURE: Villages and rural communities along rudimentary road network with limited accessibility

LAND-USE: Only certain traditional land-uses allowed, sustainable bushmeat hunting and fishing allowed in buffer zone

CHALLENGES: Prospective overuse of natural resources by local population and lack awareness for conservation and funding

The Lomami National Park is situated at the eastern edge of the Congo Basin in Democratic Republic of the Congo (DRC). Lomami National Park was created in July 2016 by decree N°16/024 after several consultations with local communities to delineate the boundaries of the Park. These communities, which traditionally use a wide variety of forest products, accepted the use restrictions in the hope of gaining development opportunities. The Park covers 887,400 ha and extends more than 150 km from North to South along the Lomami River. The Lomami National Park is one of the only parks in DRC to have an officially declared buffer zone. Lomami is located in a region that is still partially troubled by militias and the effects of the conflict in the eastern part of DRC. Administratively, the Park is under the auspices of the national protected area agency (ICCN).

APPROACH OF THE ASSESSMENT

The assessment looked at Lomami National Park´s ecosystem services and natural capital stocks in order to gather information useful for enhancing the Park's visibility and gaining political backing. It highlighted the Park's wider benefits to society and its contributions toward regional development. More specifi-

CASE STUDY
DR CONGO

Lomami National Park is a relatively remote tropical rainforest. The local communities rely in many ways on its natural resources.

cally, it looked at societal demands upon and the socio-economic importance of the Park's ecosystem services as well as their contribution to national and regional strategies and policy objectives. It also proposed a number of specific management recommendations. The study focused on the territory of Kailo, specifically the two districts (secteurs) of Balanga and Balangele.

SOME KEY FINDINGS

The assessment confirmed the strong traditional links of local communities with the forest and its resources. People benefit from the Park's reservoir function, because it safeguards species that can be legally hunted and collected in the Park's buffer zone. The local communities rely in many ways on the Park's natural resources and forest products for their own consumption as well as for commerce. Bushmeat and fish are the prime sources of protein for the local population and are therefore a crucial part of their diet. In addition, bushmeat is the region's main commercial product, and the single most important source of cash income for about 3700 households (70% of people in the two districts surveyed). The total revenue from bushmeat in the two districts per year was estimated to amount to US$ 4 million.

The assessment revealed that natural resources, specifically game and fish, have been declining in recent years – indicating overconsumption. However, yields are higher closer to the Park's borders which highlights its role as a reservoir.

From a development perspective two natural capital stocks and ecosystem services appeared to be promising for the Lomami region: 1) the potential for smaller scale hydropower installations and 2) community forestry development based on a Congolese legal framework and linked to the national level REDD+ scheme and the global carbon market. Both are mentioned explicitly in national level development plans. Hydropower potential as well as community forest development could be pursued to make better use of the Park's natural capital and raise awareness about the services it provides.

Source: Authors' analysis

4.2.3.
PROSPECTS FOR 2030: CONSERVATION AREAS AND AGRI-FOOD SYSTEMS

Current projections foresee a severe aggravation of food insecurity: sub-Saharan Africa will see an increasing proportion of its population suffer from undernourishment, rising from 22% (2019) to 29% (2030) (FAO 2020). Current efforts to reduce undernourishment will be outpaced by a combination of rapid population growth and unstable food production. Additional short-term impacts are expected in relation to the Covid-19 pandemic (FAO 2020b).

In many African countries, the pathways for future agricultural systems are still entirely open. Some proposals seek to maintain ecologically intact landscapes while sustainably enhancing agricultural productivity within agri-food systems (Potts et al. 2016). Others focus on modernizing farming technologies, applying sophisticated agrochemicals and developing new breeds. Economic interests in globalizing agricultural value chains are unlikely to prove compatible with transitions toward equitable farming and food sovereignty (TEEB Agri-Food 2018). It is clear that conservation areas will not be able to compensate for any future large-scale losses of natural assets in Africa's agricultural landscapes themselves. For example, in Northern Africa losses in vegetable production value are likely to exceed 35% in the coming decade compared to 2004 production values, due to pollinator decline (Bauer & Wing 2016). To prevent such losses, on-farm conservation incentives and regulations will be needed in addition to protecting pollinator habitats.

In the **BAU scenario** agricultural land use inside conservation areas will increase further (→see Chapter 2). Where cropland replaces forests – as in the case of many conservation areas in West Africa – this can bring regional climates to tipping points, with critical impacts for, among other things, rain-fed extensive agriculture. In turn, the **ecological conservation scenario** for conservation areas requires compromises: significant efforts are needed to balance the interests of farmers and conservationists, notably in countries such as Nigeria, where 30% of protected land area is currently cropland (see technical annex). On the one hand, this spatial overlap requires determined political integration, where conservation area managers will need to prioritize the search for sustainable land-use regimes within the boundaries of their area. On the other hand, bolder strategies for developing sustainable agri-food systems beyond their boundaries are needed in addition, so as to reduce further encroachment pressures.

4.3.
African fisheries benefit from marine conservation areas

Fisheries in African marine waters are under threat and the continent is losing fish and biodiversity, thereby jeopardizing a sector that is important for food security and the economy. Marine conservation areas help to safeguard the continent's blue assets.

4.3.1.
SMALL-SCALE FISHERIES PROVIDE FOOD SECURITY AND JOBS FOR AFRICANS BUT ARE UNDER THREAT

Fisheries employ over 35 million people in Africa. Local fishing industries contributed US$24 billion – 1.3% – to the African economy in 2011 (Belhabib

et al. 2019, World Bank 2019). Almost one third of employees in the fisheries sector are women who work mostly in fish processing (de Graaf & Garibaldi 2014). The sector is growing fast, with numbers of fishers in Africa having increased by 130 % between 1995 and 2016 (FAO 2018). They supply local markets, contribute to regional economies and enhance food security. Fish provides over 20 % of protein to people in 28 African countries and forms a crucial part of a nutritious diet (FAO 2018).

Most fish species of commercial value are being fished at or even above their biological limits (FAO 2018). Foreign industrial fishing fleets are very active, especially in western, southern and south-eastern Africa. Local small-scale fisheries are unable to compete with large industrial vessels over dwindling fish stocks, threatening livelihoods and food security. At the same time, foreign industrial fisheries leave very little local revenue behind as they land and process fish caught in African waters in their home ports, e.g. in Europe or Asia. In addition, they pay very little for fishing rights. The license fees of Chinese fishing fleets in West African waters amount to only 4 % of the value of the landed catch; EU fleets pay 8 % (Belhabib et al. 2015). Massive losses due to illegal, unreported and undocumented (IUU) fisheries are aggravating the situation, especially in West Africa where marine law enforcement is inadequate.

African fisheries also lose large volumes of fish along the value chain: More than 25 % of fish landed in Africa never reaches the consumer: it spoils due to poor handling and transportation, is contaminated by bacteria or fungi or eaten by insect pests (World Fish Center 2009, FAO 2011). Together with dwindling fish stocks and ongoing illegal fishing, this harms prospects for the African fisheries sector and food security in the future (FAO 2018).

4.3.2. MARINE CONSERVATION AREAS SAFEGUARD IMPORTANT NURSERY AND FEEDING GROUNDS

African marine conservation areas (MCAs) cover 4.3 % of the EEZ and 22 % of inshore marine areas, and are an important asset for fisheries, employment and food security (UNEP-WCMC 2019, IPBES 2018). Ecosystems in marine conservation areas such as mangroves, coral reefs and estuaries have a higher resilience capacity than unprotected ones.

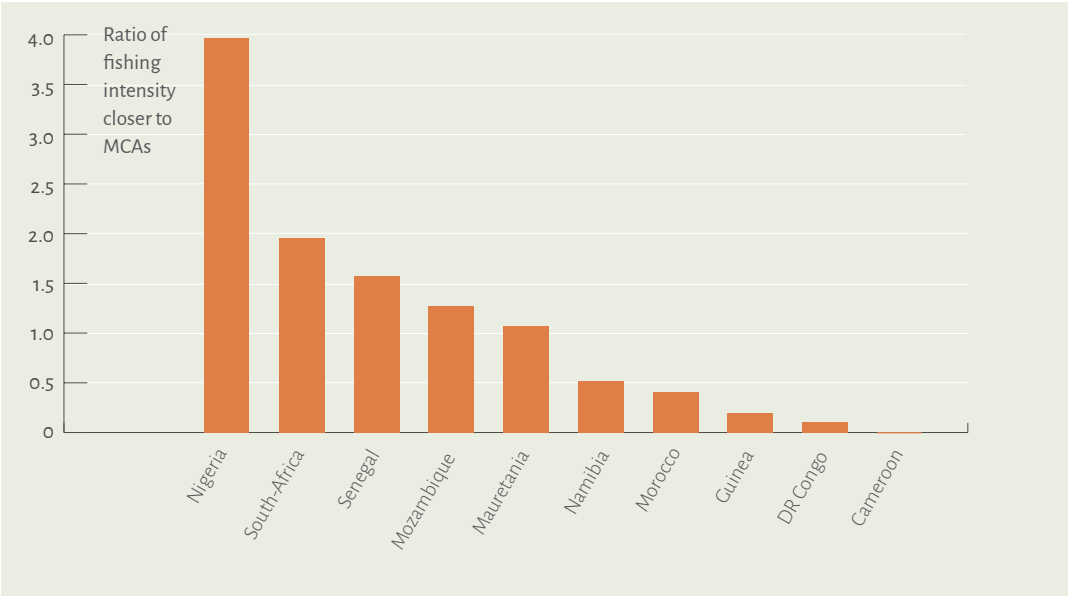


FIGURE 16
INDUSTRIAL FISHERIES PREFER TO FISH CLOSER TO MCAS

Ratio of fishing intensity of industrial fishing vessels closer to marine conservation areas (MCAs) (< 50 km versus further away (50 – 100 km) in the 10 most important African Fishing Nations. Ratios > 1 indicate a preference for fishing close to MCAs.

Source: Authors' analysis using data from → Global Fishing Watch, 2019, and UNEP-WCMC WDPA)

CASE STUDY

DIAWLING NATIONAL PARK, MAURITANIA

Using evidence from fisheries and other park benefits to position a RAMSAR site within a regional development context

STATUS: National park

SIZE: 15,500 ha

ECOSYSTEMS: Wetlands, and coastal and marine ecosystems

KEY ECOSYSTEM SERVICES: Sustainable grazing resources, habitat provision for inland and marine fisheries, water retention, diverse fibres and materials, horticulture, protection against desertification

NEARBY POPULATION AND INFRASTRUCTURE: 6,000 inhabitants live in remote villages in and around the park

LAND-USE: Sustainable fisheries and some agricultural land-uses are allowed

CHALLENGES: Resource exploitation, infrastructure development and rapid regional population increase

Diawling National Park conserves the Mauritanian part of the Senegal delta, covering 155 km² of (seasonal) wetlands, dunes and drylands. The RAMSAR site staff manage a complex hydrological regime in order to cope with the consequences of upstream dykes and dams along the Senegal river which have substantially changed the region's ecosystems over the past few decades. About 6,000 inhabitants (2013) live in small villages inside the park and its buffer zone. Their livelihoods are based mainly on fishing, livestock, horticulture and handicrafts from wild plant collection. In the nearby small town of N'Diago, a multipurpose port has recently been constructed, which will be used by the navy as well as for offshore gas exploration activities and industrial fisheries. This is expected to lead to significant population increases in this remote region. Economic activities and environmental impacts in the park's periphery are likely to increase.

APPROACH OF THE ASSESSMENT

In view of this situation, the park authorities expect risks to arise in relation to the delicate balance of ecological restoration and current largely sustainable natural resource use inside the park. Rather than arguing against the port and its probable side effects on regional ecosystems, the scoping process guided the study toward pursuing a positive, development-oriented narrative: What natural benefits does the

CASE STUDY
MAURITANIA

Diawling National Park covers 155 km² of wetlands, dunes and drylands

national park contribute to the region today? What are the likely prospects for 2030 in light of demographic growth and economic activity linked to the new port?

SOME KEY FINDINGS

- Fisheries:
  - Growing local demand and improved connectivity between the port/town of N'Diago and the capital Nouakchott are likely to increase local market prices and income. This in turn is likely to spur marine fishing efforts and attract non-local fishing boats. The benefits of increased income from fishing will only be sustainable if effective governance structures for managing the fisheries are developed.
  - The same applies to local inland fisheries inside the park and its buffer which currently produce about 150t/year.
- Horticulture (250+ households) and livestock (~100 households) inside the park will grow in importance: In 2030, the rotating production area (linked to the park's seasonal flood regime) will not need to have significantly expanded in size. But the larger regional demand for fresh produce will triple producer income and contribute to food security for 13,000+ inhabitants. The same applies to dairy production, which is prioritized in the national food security strategy.

So far, the number and size of threats to the park have appeared only to grow. The new evidence prompts different questions, such as: How can imminent regional development pressures be rendered sustainable? The natural capital assessment is thus able to position the park as a natural asset base in regional development and fisheries debates – in addition to, and in support of, its biodiversity objectives.

Source: Authors' analysis

They provide high quality ecosystem services, safeguarding coastal settlements against the negative effects of climate change, as well as overexploitation and other human impacts (IPBES 2018). Marine conservation areas yield higher fish biomass than comparable areas without protection. The spill-over effects benefit fisheries adjacent to MCAs, both through migration of adult fish and by transporting fish eggs, larvae and young fish to the surrounding areas:

- In Morocco, the Al-Hoceima National Park cooperates with local fishing communities in managing a 20 km no-take zone and in combating illegal bottom trawling and dynamite fishing. In the eight years following the establishment of this cooperation in 2008, fish resources in the national park's 190 km² marine conservation area have recovered by 20–30%. This has resulted in alleviating poverty by 30% for 1200 artisanal fishers (UNDP 2016). In addition, the production of sustainable fishing gear has opened additional local income streams (Equilibrium Research 2020).

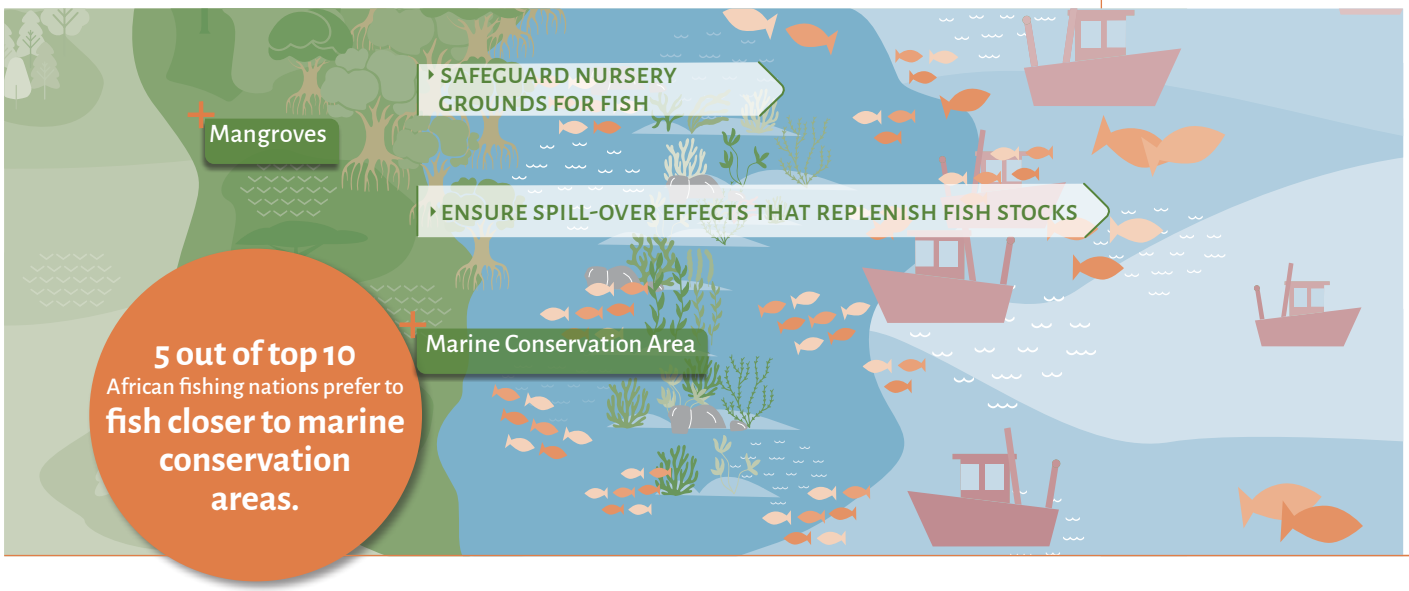
- In Kenya an increase in species richness, abundance and biomass was recorded after the declaration of protection measures. Eventually, fish stocks completely recovered in less than 10 years (McClanahan et al. 2007).

- Around South Africa's Goukamma MCA, the catch per unit of effort in the small-scale fisheries of Roman seabream doubled within 10 years of protection (Kerwath et al. 2013).

The improved ecosystem protection provided by MCAs enhances fish stocks in their vicinity. This finding from many cases is also reflected in industrial fishing patterns across Africa: **Industrial fisheries in 5 of the 10 most important fishing nations in Africa** (Nigeria, Mauritania, South Africa, Senegal and Mozambique, which account for 46% of total African landings), **prefer to fish within a 50 km range around MCAs, probably attracted by their favourable conditions**.

Despite many positive cases (Oliver et al. 2015, UNDP 2016), local populations have also suffered disadvantages from the establishment of MCAs when, for example, their traditional use rights have been revoked and their livelihoods put at risk (Sowman and Sunde 2018, Sunde and Isaacs, 2008). It is therefore critical to consider local livelihood needs and to include coastal communities in a meaningful way in the establishment and management of MCAs.

FIGURE 17
BENEFITS OF MARINE CONSERVATION AREAS FOR FISHERY.



4.3.3
PROSPECTS FOR 2030: CONSERVATION AREAS AND FISHERIES

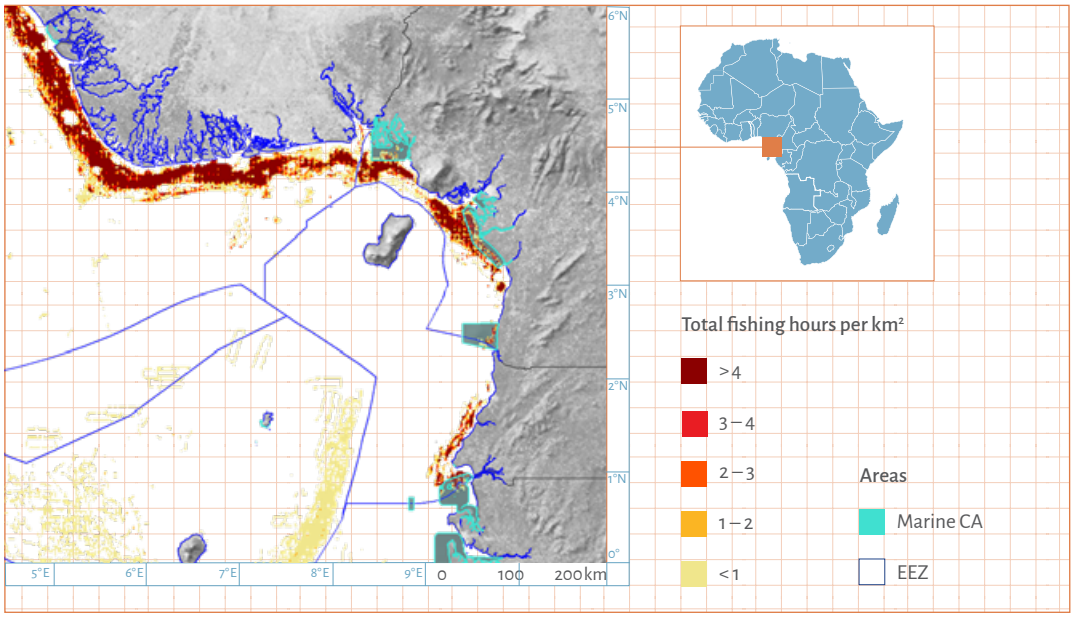
Demand for fish is forecast to increase by 30% from 2010 to 2030 as the African population grows and its economies and standard of living develop (World Bank 2013). Considering the rising global demand for fish, pressure on African fish stocks and MCAs will increase. Therefore, it is important to highlight the role of MCAs in fish supply and to improve their performance, specifically by enhancing human capacities, increasing financial resources, implementing better surveillance and monitoring, ensuring additional political support, and enforcement.

Some countries need to scale up efforts for establishing MCAs. For example, Nigerian fisheries risk overexploiting domestic fish stocks, in part due to the absence of Nigerian MCAs. At the same time, they benefit from ecological spill-overs from foreign MCAs, underlining the need for wider cost sharing of co-investments in conservation, for example under regional agreements.

Protecting critical breeding and nursery habitats for fish and shellfish will become more important for commercial fisheries. In Africa, this has not yet led to widespread co-investments in the protection of fish stocks by either national or foreign fisheries. The Banc d'Arguin National Park in Mauritania is a notable exception, receiving significant foreign funds linked to EU fisheries concessions (Binet et al. 2013).

The expansion and effective implementation of marine conservation areas in Africa is likely to depend on the interests of other fishing nations seeking stable fish stocks and access to them. As foreign fisheries continue to absorb large profits from this natural capital, the political issue of equitable benefit sharing remains unresolved and intertwined with conservation.

The status and potential of African inland fisheries was not examined as part of this study, despite the contributions these sectors make to food security and development and their impacts and dependency on natural assets and conservation areas. More natural capital analyses of these sectors, including aquaculture, would be helpful to identify and describe the threats and opportunities for food security, employment and development.



MAP 4

INDUSTRIAL FISHING IN THE GULF OF GUINEA

In the Gulf of Guinea there is intensive industrial fishing activity but very few marine conservation areas.

Source:
Data from Global Fishing Watch, 2019, and UNEP-WCMC WDPA

4.4. Conservation areas benefit sustainable hydropower operations in Africa

Africa has huge unmet energy needs. It also has the highest untapped hydropower potential globally. Conservation areas are cost-efficient solutions for safeguarding hydro infrastructure.

4.4.1 AFRICAN HYDROPOWER CAPACITY IS GROWING RAPIDLY — BUT FACES CHALLENGES

Hydropower capacity is growing rapidly, with many projects under construction, such as the Grand Ethiopian Renaissance Dam (expected capacity 6,350 MW), the Lauca hydropower project in Angola (2,070 MW) and countless smaller hydropower projects (IHA 2019, Korkovelos et al. 2018). Even now, 19 African countries rely on hydropower for more than 50 % of their total electricity production. For countries such as Malawi, Central African Republic and Zambia this share even exceeds 80 % (→ see technical annex).

Reservoir siltation is the greatest operational threat to hydropower sustainability. High sediment loads in water inflows reduces the water storage capacity of dams by 30 – 50 % (Wolancho 2012, Hathaway 2008). They have an adverse impact on turbines and give rise to high costs for sedimentation removal (Adeogun et al. 2018). Sedimentation has already brought the economic life of many dams to an early end (Kidane and Alemu 2015, Zenebe 2009) and is casting doubt on the prospects of ongoing projects (Adugna et al. 2013). Globally, rates of storage loss caused by sedimentation exceed rates of new dam storage construction (Annandale 2013). While sedimentation is considered in the dams' design and the calculation of their life span, many predictions fail to account for land-use changes: Actual sediment loads often exceed the rates used in planning phases (Moran et al. 2018). In addition, reservoir siltation is expected to become further exacerbated due to climate change (Annandale et al. 2016).

Africa has huge unmet energy needs. It also has the highest untapped hydropower potential globally. Conservation areas are cost-efficient solutions for safeguarding hydro infrastructure.

EXAMPLE: SECONDARY COSTS OF POORLY FUNCTIONING HYDROPOWER IN GHANA

Inadequate water levels in Ghana's three hydropower plants, poor maintenance of equipment and transmission losses have led to frequent power cuts. The government has responded by purchasing a fleet of emergency power barges, using fossil fuels. Ghana also rents two floating power plants to produce 450 MW of electricity for the nation's electricity grid. The 10-year rental contract will cost Ghana US$1.2 billion, with critics claiming that the government has secured an unfavourable deal. It is clear that emergency barges generate power at exceptionally high cost. What starts as an emergency response invariably becomes a permanent facility for delivering high-cost base-load power (Africa Progress Panel 2015).

There is also a stark social dimension to Africa's underperforming public utilities and its secondary effects (see box box on previous page): Poor African citizens pay 40 – 90 times more for energy than average consumers in Europe (Africa Progress Panel 2015). The ongoing need for electrification is clear. In view of the climate crisis the additional electricity required should come from renewable sources at socially reasonable costs (EIA 2019). Further development of hydropower offers a solution.

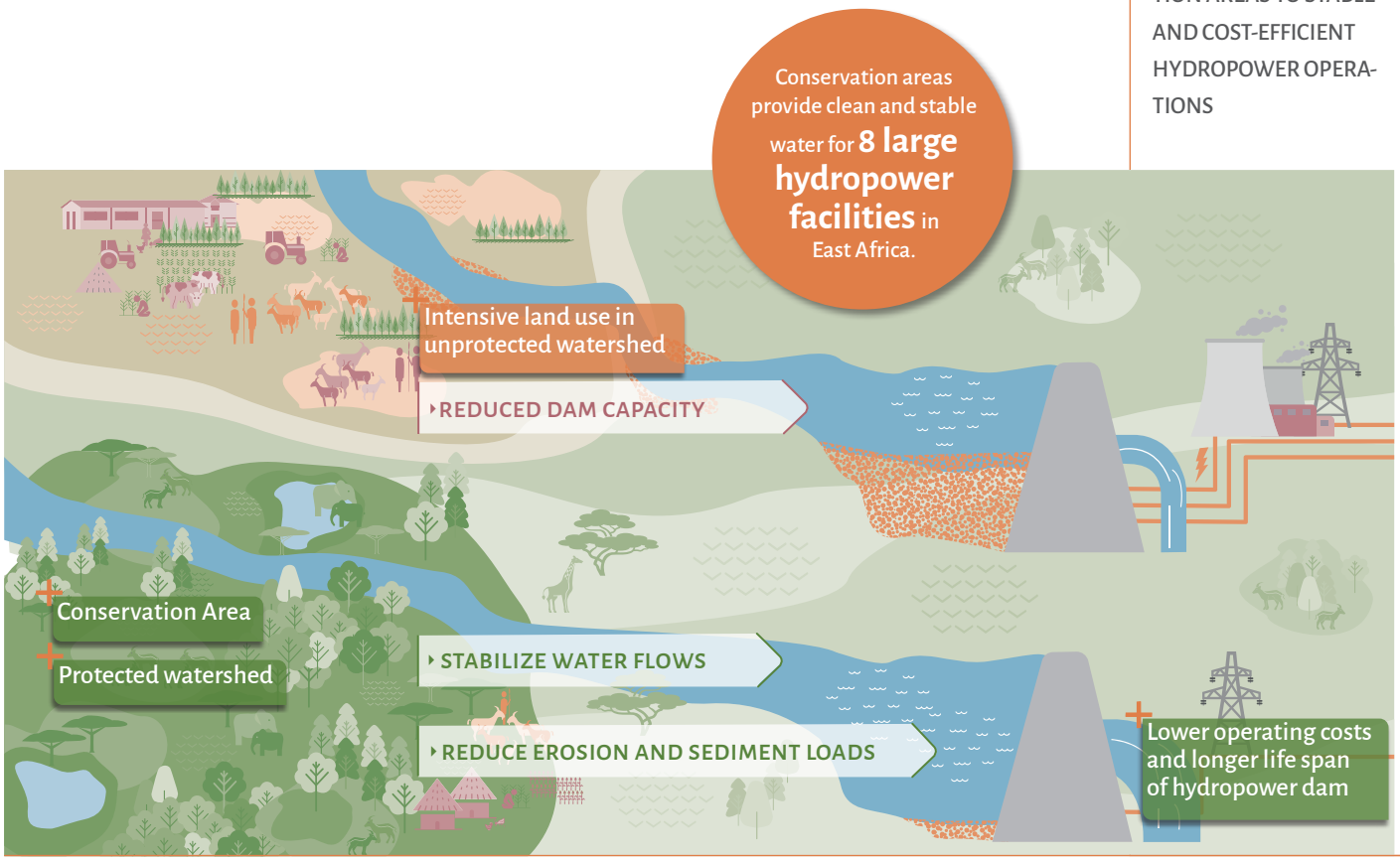
At the same time, setting up new hydropower dams changes entire landscapes in Africa. It affects local livelihoods, requires the displacement of communities, and spurs wider ecosystem degradation (Siciliano & Urban 2017, Okuku et al. 2016). Therefore, the sustainable long-term operation of existing dams is of critical importance as well as the development of smaller, local scale hydropower plants which minimize social and environmental impacts (EIA 2019).

4.4.2 CONSERVATION AREAS SUSTAIN THE LONG-TERM EFFECTIVENESS OF HYDROPOWER

Human disturbance of upstream vegetation cover can increase soil erosion rates by a factor of 10 as compared to intact natural vegetation (Annandale et al. 2016). This leads to high sediment loads in streams.

Conservation areas limit human land use and thereby maintain relatively intact vegetation cover. This is key for keeping hydrological systems intact and for preventing soil erosion and high sediment loads in streams. The precise contribution of conservation areas to water storage in dam reservoirs and resulting hydropower capacities is site-dependent and requires detailed analyses. However, for countries with significant hydropower capacity, sufficient watershed protection is critical to overall energy security.

FIGURE 18
BENEFITS OF CONSERVATION AREAS TO STABLE AND COST-EFFICIENT HYDROPOWER OPERATIONS

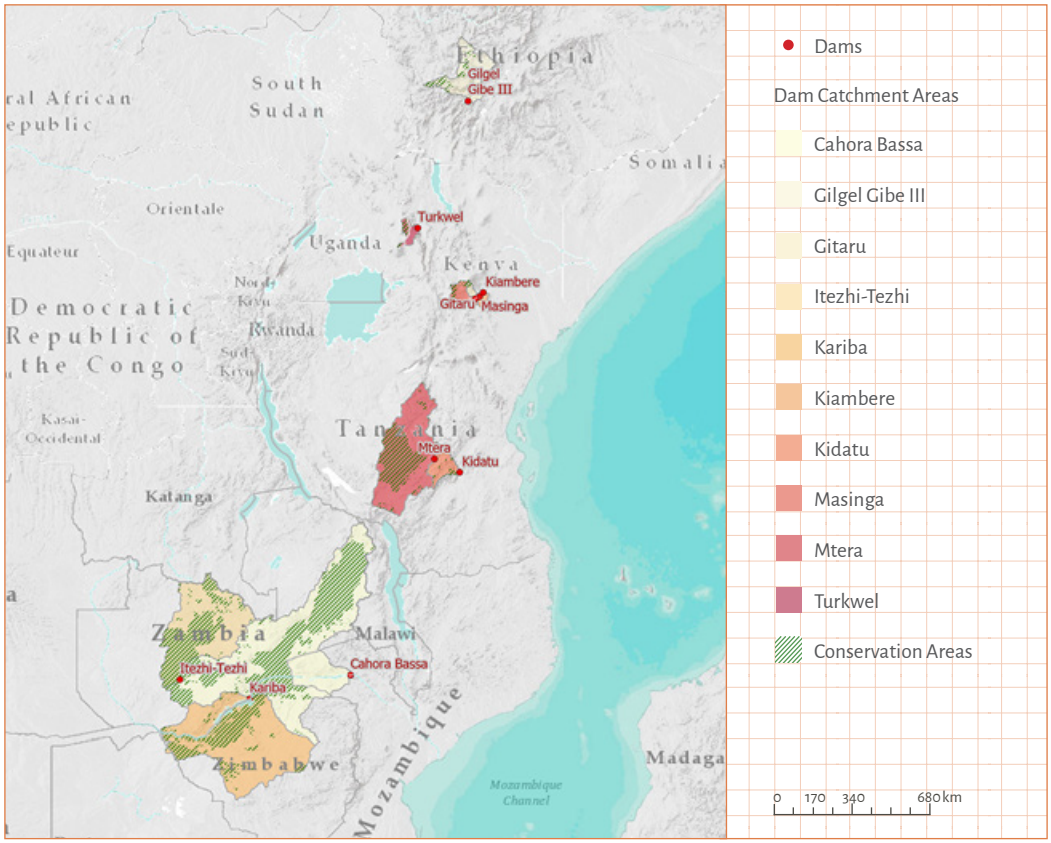


In East Africa, conservation areas contribute to comparatively clean and stable water supplies for the operation of at least eight large hydropower facilities (with an overall capacity of 6 GW) in five countries: Ethiopia, Kenya, Tanzania, Zambia and Mozambique have a joint hydropower capacity of 10 GW. Africa's total installed capacity reached 39 GW in 2019 (IHA 2020). Map 5 indicates the location and size of conservation areas in the watersheds that feed the hydropower dams in East Africa.

As shown in the table on the right, two of these hydro-power dams – Gibe III (Ethiopia) and Cahora Bassa (Mozambique) – are of critical importance for national energy security, ensuring 45 % and 73 % respectively of total national electricity production. However, Cahora Bassa's watershed is largely covered by conservation areas, while Gibe III's watershed is only minimally protected.

This can have serious implications: Watershed protection has been found to reduce the sediment related costs of hydropower infrastructure by 70 – 85 % in Nigeria (Adeogun et al. 2018). **In fact, return on investment in forest conservation for improved hydropower production can be 5:1** (Arias et al. 2011). Such estimates cannot be generalized, yet they illustrate the possible magnitude of costs to the hydropower sector of upstream ecosystem degradation.

➲ In 2003, Ntaruka dam (Rwanda) had to close down its operations due to low water levels, caused partly by poor watershed management. Resulting energy shortages sparked an economic crisis that hit the whole country. **The response, namely, protecting and restoring the Rugezi marshes, an upstream wetland, was effective in improving water supplies and stabilizing hydropower operations** (Hove et al. 2010).



MAP 5

PROTECTION STATUS FOR CATCHMENT AREAS OF THE BIGGEST DAMS IN EAST AFRICA

Conservation areas in watersheds that feed major hydropower dams in East Africa.

Source: UNEP-WCMC WDPA, USGS SRTM, FAO AQUASTAT CRS: WGS 1984

COUNTRY	HYDROPOWER DAM	HYDROELECTRIC CAPACITY (MW)	PROPORTION OF WATERSHED PROTECTED	PROPORTION OF TOTAL NATIONAL ELECTRICITY PRODUCED BY THE DAM(S)
ETHIOPIA	Gibe III	1870	15%	45%
KENYA	Gitaru	225	22%	16%
	Turkwel	106	34%	
	Masinga	40	24%	
MOZAMBIQUE	Cahora Bassa	2075	44%	73%
TANZANIA	Mtera	80	39%	19%
	Kidatu	204	12%	
ZAMBIA	Ithezi Tezhi	120	49%	4%

FIGURE 19
MAJOR HYDROPOWER DAMS IN EAST AFRICA

Conservation area coverage of their watersheds, and their contribution to total national electricity production

Source:
Authors' calculations based on diverse sources. → See technical annex

➲ In Kenya investments in sustainable land-use practices could increase power generation and avoid shutdowns and spillages along Tana River, which feeds the Masinga, Kiambere and Gitaru dams, among others, and provides 70% of Kenya's hydropower. When increased crop yields and reduced costs for water treatment are included, a US$10 million investment would deliver an overall return of US$21.5 million over 30 years (TNC 2015).

4.4.3. PROSPECTS FOR 2030: CONSERVATION AREAS AND HYDROPOWER

Hydropower is set to play an even larger role in meeting Africa's growing energy needs in climate-friendly ways. In the **BAU scenario**, sediment loads in rivers will accumulate and exacerbate the effects of siltation in hydropower reservoirs. In consequence, more dams will have to either reduce electricity production, invest in expensive end-of-pipe measures (such as reservoir dredging) or cease operation ahead of time. The economic effects for the 19 countries that currently rely on hydropower for more than half of their electricity production may well be dramatic. In the **EC scenario**, the effects of intensifying land use and of climate change on regional hydrology will be partly buffered by well-managed conservation areas. The latter can be complemented by sediment management plans, including strategic conservation measures, which can deliver better outcomes – both for the energy sector and for upstream watersheds.

Keeping hydropower installations fully functional and securing stable and sufficient influx of water so that they can operate properly are core elements of socially inclusive, climate-friendly development. One way to finance this is to redirect Africa's US$30+ billions of annual fossil fuel subsidies (Whitley & van den Burg 2015, Coady et al. 2015) – which tend to favour a largely unsustainable status quo (Alleyne et al. 2013) – towards investing in low-energy household solutions, in green energy sources, and in watershed protection for hydropower dams.

4.5 Conservation areas make Africa's cities more resilient and more liveable

African cities are growing very fast. Protected natural assets help to secure vitally important environmental conditions for them. Urban or peri-urban conservation areas make cities more liveable by providing a healthier environment, moderate climatic conditions, and some protection against extreme weather events.

4.5.1 UNPLANNED URBANIZATION DEGRADES THE NATURAL SYSTEMS CITIES DEPEND UPON

In Africa, urban population will triple from 550 million today to an expected 1.5 billion in 2030 (UN 2019). Urbanized land cover will grow in the coming decades (Seto et al. 2012). This is a major challenge for African societies. Rapidly growing urban populations need not only jobs, transport, education and housing but also clean air and water as well as a secure supply of food and protection against extreme weather events such as floods.

Up to 80% of urbanized areas in cities such as Dar es Salaam are unplanned or informal (Karutz et al. 2019). Informal settlements are marked by pollution, overuse and loss of critical natural habitats or 'green infrastructures'. This affects quality of life, increases public utility costs, and poses significant public health risks due to insufficient sanitation and limited access to safe water (dos Santos et al. 2017). By 2030, urban sprawl will also cause the loss of about 6 million ha of croplands, with hotspots in Egypt, Nigeria and Uganda (d'Amour et al. 2017). In addition, urban densification, with losses in urban greenspace, is also associated with increases in crime, community conflict and mental disorders (Hunter et al. 2019, Soga & Gaston 2016). Poor neighbourhoods are the ones most affected.

4.5.2 URBAN AND PERI-URBAN CONSERVATION AREAS PROVIDE VITAL GREEN INFRASTRUCTURE FOR FAST GROWING CITIES

Urban green spaces provide important benefits to African cities, such as drinking water supply, local cooling, purification of polluted air, flood protection (see section on natural hazards), and opportunities for recreation (White et al. 2017, Turpie et al. 2017). Many urban green spaces are not conserved land, but all conservation areas in cities contribute to generating these benefits.

A total of 1240 African cities (with a minimum of 50,000 inhabitants) benefit from various contributions of conservation areas to urban living. These cities have at least one conservation area within a 10 km radius. More than 340 million people live within this radius in these cities across Africa. Here we focus on safe drinking water and cooling benefits.

Urban water: People living in informal urban settlements have limited access to piped water (United Nations 2018; UNICEF & WHO 2019). For them, the proximity of natural water sources is critical. Informal wells and boreholes to shallow urban aquifers are therefore key to local urban water supply. Yet microbial contamination of these sources is widespread in sub-Saharan Africa (Lapworth et al. 2017).

Urban horticulture also relies heavily on open access surface water, often marked by overuse, pollution and catchment degradation. A global review of over 300 large cities estimates that water treatment costs associated with watershed degradation amount to some US$5.4 billion per year (McDonald et al. 2016). Conservation areas are key instruments for maintaining stable and good quality water supply, as illustrated by the Banco National Park in Abidjan and by protected water catchments of the Ruvu river in Dar es Salaam (Karutz et al. 2019).

Urban water quality is also closely connected to sanitation and waste water treatment. In some cities, such as Kampala (see box), conservation areas play a key role in supporting water purification through biological processes in intact wetlands.

A total of 1,240 African cities (with a minimum of 50,000 inhabitants) benefit from various contributions of conservation areas to urban living. These cities have at least one conservation area within a 10 km radius. More than 340 million people live within this radius in these cities across Africa.

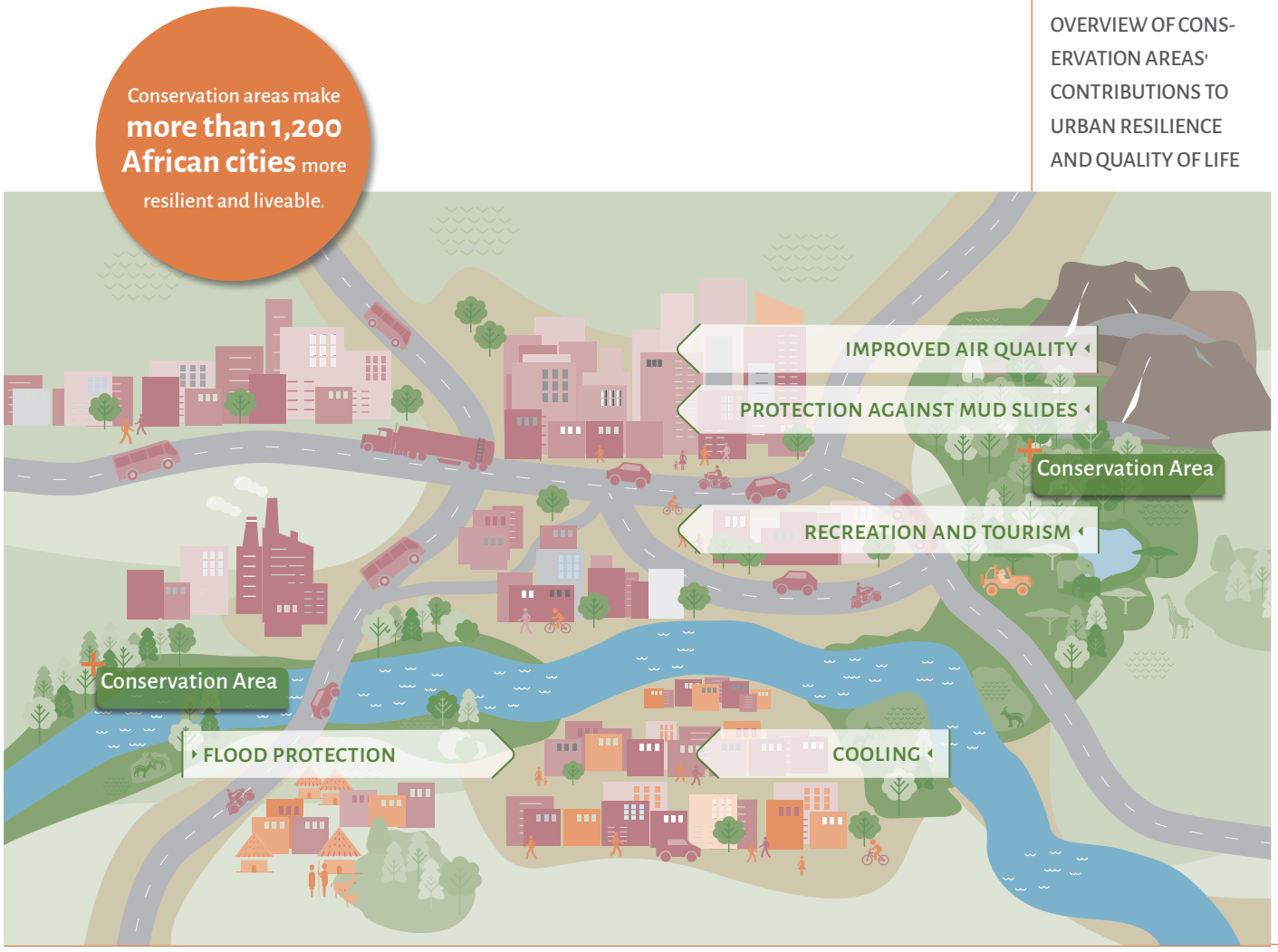


FIGURE 20
OVERVIEW OF CONSERVATION AREAS' CONTRIBUTIONS TO URBAN RESILIENCE AND QUALITY OF LIFE

CASE STUDY

BANCO NATIONAL PARK, COTE D'IVOIRE

Urban national park prevents water pollution and shut down of adjacent wells

STATUS: National park

SIZE: 3438 ha

ECOSYSTEMS: Tropical forest

KEY ECOSYSTEM SERVICES: Water provision, water retention, air pollution control, recreation and opportunities for nature tourism

NEARBY POPULATION AND INFRASTRUCTURE: Surrounded by Abidjan's urban neighborhoods; infrastructure includes multiple walking trails and environmental education and training facilities

LAND-USE: Recreation and environmental education

CHALLENGES: Pollution, unsustainable hunting and illegal use of forest areas as gardens

Banco National Park is a 3600 ha park within the city limits of Abidjan. Established in 1926 as a research site for tropical forestry and declared a national park since 1953, it has a long history. Despite the rapid growth of the Ivorian capital in the last few decades especially, it remains a natural place of refuge.

APPROACH OF THE ASSESSMENT

The natural capital assessment sought evidence and numerical arguments to highlight the role of the park in the life of the city and to advocate for its conservation within city planning processes. Various ecosystem services were examined on the basis of extant data collected at different agencies, government bodies, state and non-state institutions.

SOME KEY FINDINGS

In addition to a level of biodiversity observed nowhere else in the city, the results showed that the park plays an important role in the provision of water to the city: the freshwater wells located on the park's periphery account for 64% of the total water pumped from Abidjan's groundwater reservoir. Without the water purification provided by the park, water treatment costs and therefore water prices would be higher. In fact, some wells situated in other areas of Abidjan which do not benefit from these services had to be shut down due to pollution.

CASE STUDY
COTE D'IVOIRE

The park also provides a huge 'sustainable urban drainage system' with a largely unrecognized water retention function. Its arboreal vegetation and natural soils mitigate run-off during heavy rains. Abidjan is regularly affected by rain-related flood events which threaten human lives and the city's infrastructure. While the retention function can be seen in physical data, not enough numbers are available to quantify exactly the savings Abidjan accrues from damages prevented by the park's green infrastructure.

The assessment also revealed high option values linked to the educational and recreational values provided by such a large natural area within the city limits. Located in the city of Abidjan, home to 5 million people, the park currently receives only 10,000 visitors per year. It therefore offers an immense untapped potential for leisure, outdoor sports, environmental education and research activities. This includes employment opportunities in nature-related tourism and jobs associated with recreational activities.

Banco National Parc is a remnant tropical forest surrounded by highways and urban neighborhoods.

Source: Authors' analysis

Urban heat: Climate scenarios suggest that by 2050 the number of cities at risk of extremely hot weather will increase dramatically (UCCRN 2018). Buildings and sealed surfaces store heat and limit circulation, which results in urban 'heat islands': In the city centre of Addis Ababa, the temperature is up to 15°C higher than in the surrounding rural areas (Teferi and Abraha 2017).

This has various impacts on people, their societies and economies: Increasing temperatures will lead to reductions in labour productivity of up to 5% in sub-Saharan regions by 2050 (UNDP 2016). In turn, the cooling systems required to mitigate future heat stress in Africa will require additional investments of about US$ 50 billion up to 2035 (Parkes et al. 2019). Very hot days will cause substantial health risks – especially among poor populations whose homes lack thermal insulation or air conditioning and who have no access to health care. In addition, densely inhabited urban settlements are often affected by air pollution levels which far exceed WHO recommended thresholds.

Urban conservation areas and urban greenspace provide both local cooling and local air purification (Feyisa et al. 2014). **A single tree can provide the cooling capacity of up to ten standard air conditioners through transpiration alone** (Karutz et al. 2019). As greenspace tends to be degraded and lost in urban densification processes, urban conservation areas play an increasingly critical role as local climate regulators.

Despite their importance for urban resilience and quality of life, (peri-)urban conservation areas are particularly exposed to degradation threats. More than half of the above mentioned 1240 cities with CAs nearby show strong indications of ecosystem degradation within their (peri-)urban conservation areas. This means that **almost 200 million urban inhabitants are at risk of losing ecosystem benefits**

EXAMPLE: AS A CONSERVATION AREA, KAMPALA'S WETLAND COULD HAVE MAINTAINED ITS NATURAL WASTE WATER TREATMENT CAPACITY

Nakivubo illustrates the importance of protecting wetlands as green infrastructure for cities. The Nakivubo wetland is one of several large wetland systems around and within the Greater City of Kampala, Uganda. Through microbiological processes, the wetland effectively reduces the level of nutrients of urban wastewater from the city before it reaches Lake Victoria (Mugisha et al. 2007). Its capacity to reduce water pollution is of great importance for a safe local water supply (Emerton 2008). Even 20 years ago, this benefit was estimated to outweigh the costs of establishing and managing the wetland as a conservation area (Emerton et al. 1999). However, this did not happen.

Today, human encroachment and pollution have reduced the wetland's ecologically functional part to less than a quarter of its original size. The Inner Murchison Bay at Lake Victoria now faces higher contamination from pathogens and algal blooms. As a consequence, health risks have increased and fisheries in the bay have virtually collapsed. Restoring the wetland would also restore its water purification capacity (Turpie et al. 2017).

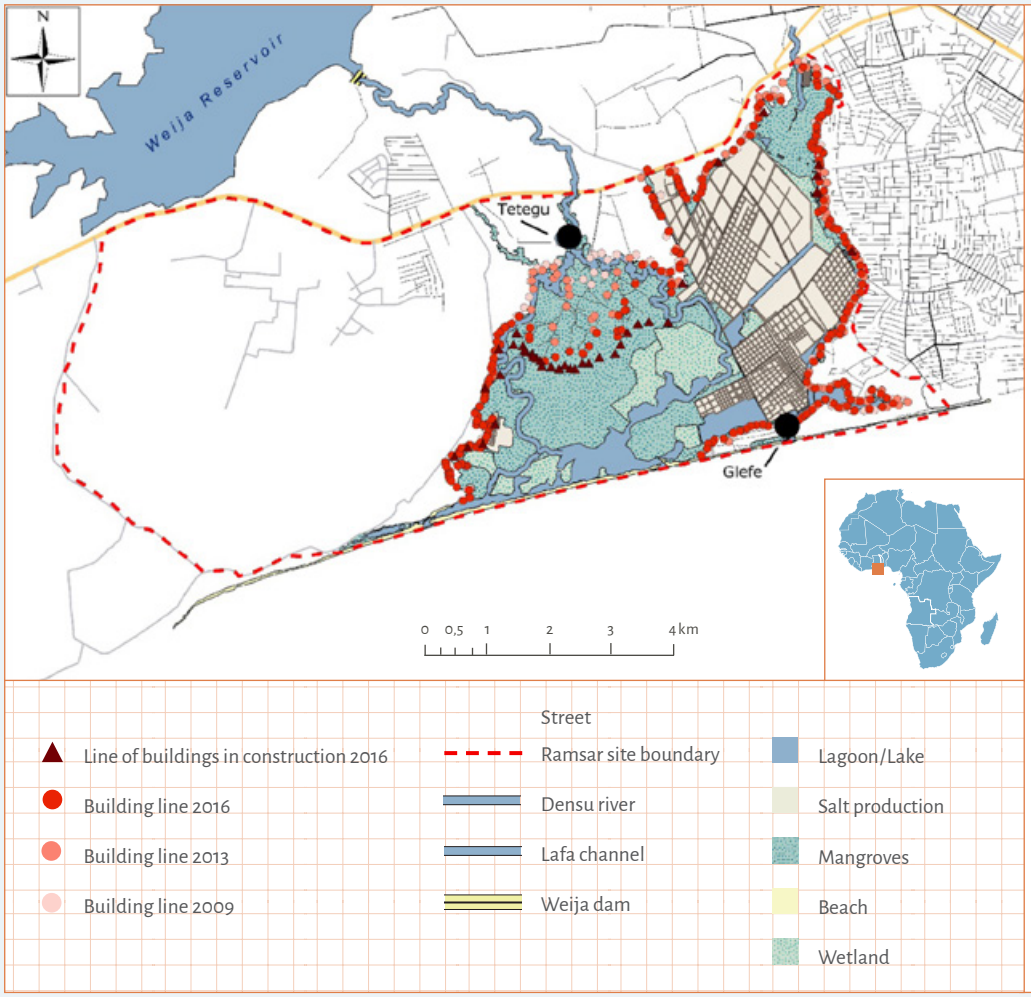
However, such restoration is now likely to require significantly higher investments than its establishment and protection as a conservation area would have cost over the past decade.

which these conservation areas provide – or have lost them already. The following examples illustrate the severe consequences this has on urban life.

EXAMPLE: ACCRA'S PROTECTED DENSU DELTA CANNOT REGULATE FLOODS ANYMORE

The Densu Delta in Accra, Ghana's capital, was declared a Ramsar site in 1998. Since then, more than half of the area has been lost and partly converted into one of the fastest growing areas of the metropolitan region, for lack of housing alternatives (Ekumah et al. 2020).

The dwellings constructed inside the protected delta are highly exposed to annual flooding, both from the sea and from the river. When water levels are high, the upstream intra-urban reservoir must release water into the delta, thereby creating additional downstream risks (Frick-Trzebitzky et al. 2017).



MAP 6

ACCRA'S PROTECTED DENSU DELTA CANNOT REGULATE FLOODS ANYMORE

Encroachment of the Densu Delta (RAMSAR site) inhibits its flood regulation capacity, while exposing new dwellers to high risk

Source: Frick-Trzebitzky et al. 2017

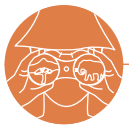
4.5.3
PROSPECTS FOR 2030: CONSERVATION AREAS AND URBAN RESILIENCE

Peri-urban conservation areas require significantly more efforts to protect them against intrusion and degradation than areas in less densely populated regions. In many settings, the social and economic (opportunity) costs of keeping urban lands 'off limits' are very high. Near cities, the BAU scenario is therefore much more likely than the EC scenario. The implications are rapidly rising costs for public service provision (such as pumping water from deeper wells or across longer distances). At the same time, the loss of natural assets from urban conservation areas directly impacts a much larger group of beneficiaries (as in the cases of local cooling, recreation or flood protection, for example)

.

One key strategy for improving these prospects is to engage more actively with non-conservation sectors that also manage public/private greenspace within cities. If land managers from water companies, infrastructure departments, universities or the military were to coordinate their management interventions for their respective urban green areas, both biodiversity targets and ecosystem services provision would likely be enhanced. Ultimately, urban planning will have to adapt to the immense speed of city growth so as to secure green infrastructure across territorial mandates.

4.6.
Conservation areas are essential for African tourism



Tourism is one of the cornerstones of many African economies - with conservation areas being highly profitable yet undervalued tourism assets.

4.6.1
TOURISM IN CONSERVATION AREAS CREATES JOBS AND GENERATES SIGNIFICANT GOVERNMENT REVENUES

The travel and tourism industry represents 8.5% of African GDP (WTTC 2019). Growth in international visitors to Africa, at 5% per year between 2003 and 2018, has been robust and above the global average prior to the Covid-19 pandemic (UNWTO 2018). One of Africa's competitive edges in the tourism market is nature tourism, with conservation areas being the principal drawcard for nature tourists. Africa's iconic wildlife is classically summarized under the heading of the only place to see the Big Five in their natural surroundings. Wildlife tourism accounts for 88% of total annual revenues for trips to Africa (UNWTO 2015).

Conservation areas in Africa attracted 70 million foreign and domestic visitors in 2015 (Balmford 2015). Their tourism spending generated revenue in excess of US$ 50 billion (Balmford 2015) – roughly equalling the GDP of Côte d'Ivoire – and supported 8 to 10 million jobs in conservation area management, tourism and supporting sectors. In Tanzania, Kenya, Uganda, Zambia, the Seychelles, Rwanda and Sao Tome and Principe, nature tourism based on conservation areas contributes more than 15% of foreign exchange revenues (based on the World Bank database on tourism as a percentage of exports and on UNWTO 2015). Tourism is unevenly spread across the African continent and also across conservation areas within individual countries. While some areas are fulfilling their potential, others lack market

access, wider travel and hospitality infrastructure, good public management, and private investment and know-how to develop tourism services.

Africa's marine conservation areas complement its terrestrial parks and are the cornerstones of the growing diving tourism sector in Africa. Most diving hotspots in the East African Marine Eco-region are around the reefs located within conservation areas (Dimopoulos 2018).

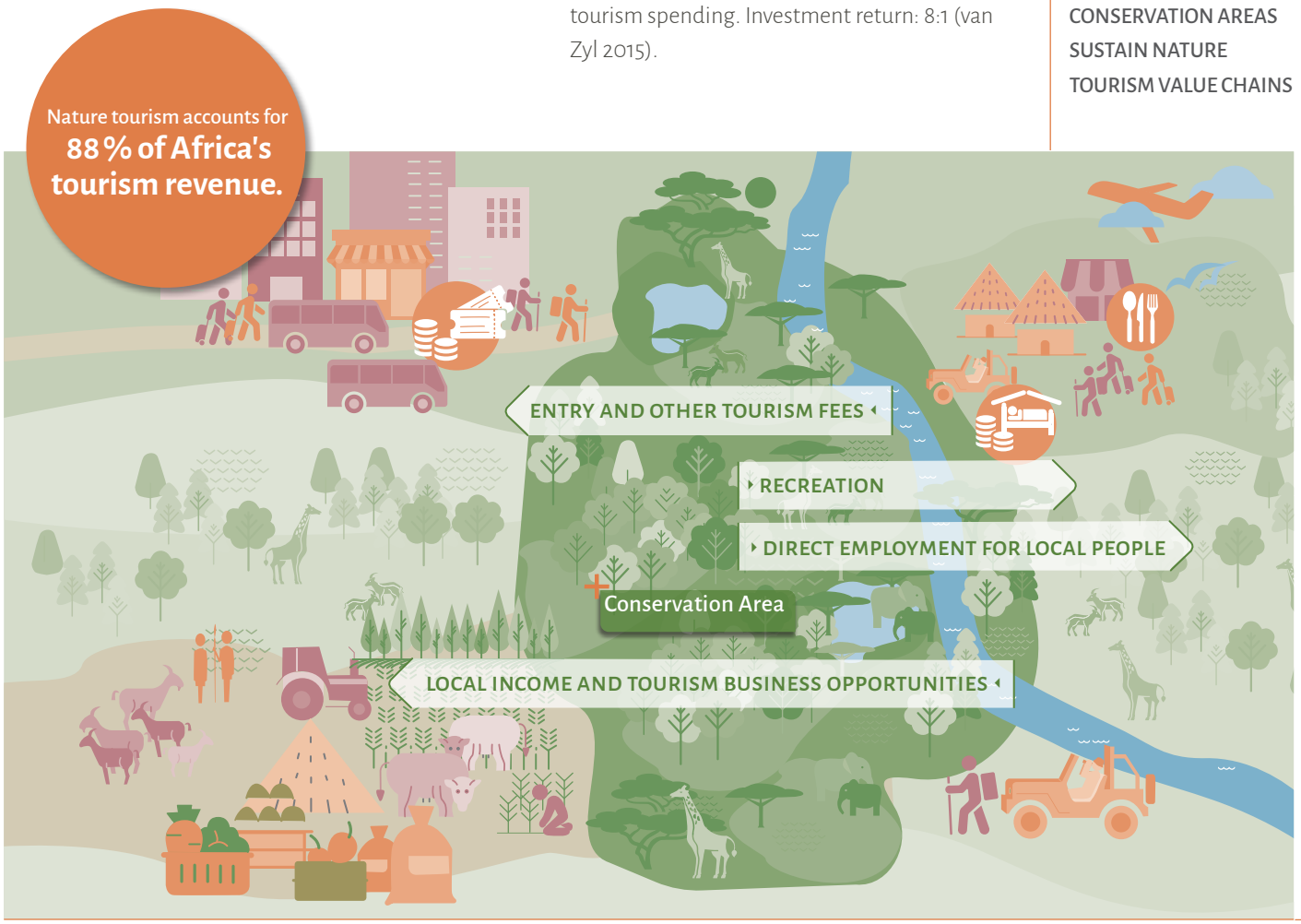
While no one can foresee the development of the tourism sector after the Covid-19 pandemic, natural assets will continue to be very important for tourism in the future. Developing tourism in a way that adds value to communities and their cultures and nature could be part of the post-coronavirus economic recovery.

4.6.2 TOURISM BENEFITS FROM CONSERVATION AREAS CAN BE ENHANCED AND DIVERSIFIED

The economic benefit:cost ratios associated with investments in upgrading and managing conservation areas to benefit tourism in Africa are highly significant.

- In 2010, the economic benefits of the Namibian protected areas system were estimated to be in the order of US$270 million, nine times their US$30 million of management costs. Investment return: 9:1 (Turpie et al. 2010).
- In Ethiopia, each Birr invested in the management of the protected area system in 2015 is associated with roughly eight Birr of increased tourism spending. Investment return: 8:1 (van Zyl 2015).

FIGURE 21
CONSERVATION AREAS SUSTAIN NATURE TOURISM VALUE CHAINS



- In Zambia, 2005 fiscal revenues generated from international tourists visiting national parks were between US$ 5 million and US$ 8 million and exceeded the US$ 1 million in funds allocated to the Zambia Wildlife Authority by a factor of between 5–8:1 (UNWTO 2015).

Benefit sharing is an increasingly important part of successful conservation area management and is often implemented through Community-based Natural Resource Management (CBNRM) programmes (see box below).

EXAMPLE: TOURISM BENEFITS AND COMMUNITY-BASED CONSERVATION IN NAMIBIA

The Namibian community-based natural resource management (CBNRM) programme has been particularly successful, with 83 Communal Conservancies and 23 Community Forests having been established by 2017, covering 20% of the country (MET/NASCO 2018). These conservancies keep the income they generate and can partner with private sector tourism operators. 38 conservancies were directly involved with tourism income generation activities, 54 joint-venture tourism agreements with private sector operators, 56 conservation hunting concessions, 17 small and medium enterprises, 1704 indigenous plant product harvesters and 445 craft producers.

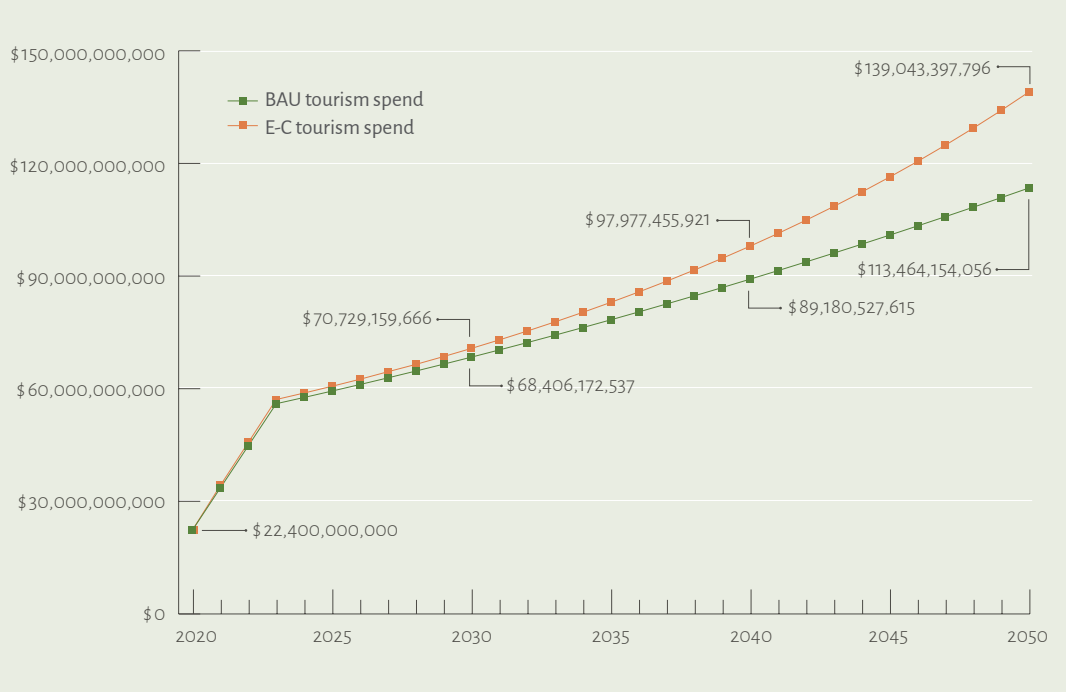
More than 200,000 members of local communities live within and benefit from Namibia's conservancies in one way or another. These benefits were estimated at US$10 million in 2017, including income to conservancies (primarily from partnerships with private sector operators), income to residents from enterprises (primarily through employment of approximately 5350 community members and the sale of crafts and natural products), and as in-kind benefits (primarily the distribution of game meat).

4.6.3 PROSPECTS FOR 2030: CONSERVATION AREAS AND NATURE TOURISM

The tourism industry in Africa has the potential for accelerated growth in the future as greater normality returns in a post-coronavirus world. The coronavirus pandemic and associated economic crisis has had a devastating impact on the global tourism industry. It is assumed here that international tourist numbers to conservation areas in Africa would gradually recover to pre-pandemic levels by the beginning of 2023. In 2023 and beyond, for the **BAU scenario** it is expected that continued land degradation would result in visitor growth falling from 3% to 2.25% over the next 30 years. For the **EC scenario** it was assumed that ecological and tourism management and investment improvements would improve growth in visitor numbers from 3% per year to 3.75% per year over the next 30 years.

The implications of these seemingly slight differences between scenarios are profound when compounded over time. **By 2030, the EC scenario would result in approximately US$ 2.3 billion in additional tourism spending per year and more than 370,000 additional jobs.** For 2050 the EC scenario would result in almost 4.1 million more jobs and additional tourism spending in the order of US$ 26 billion, as shown in the following figure page 77.

These economic benefits can only be realized under several conditions, including improved tourism infrastructure and facilities and services, more flight connections and increased marketing efforts. The maintenance and enhancement of key tourism assets will be crucial for reaping the benefits of growth. Given Africa's competitive edge in nature tourism, which is reliant on conservation areas, further development of this sector goes hand in hand with the prioritization of conservation efforts. Concerted efforts to strengthen conservation areas and stabilize or improve their ecological state will also increase their tourism value. Tourism development should also take into consideration issues of equity and fair distribution of tourism income. In order for wildlife tourism to be relevant to development, local stakeholders' participation in these business opportunities should be raised.



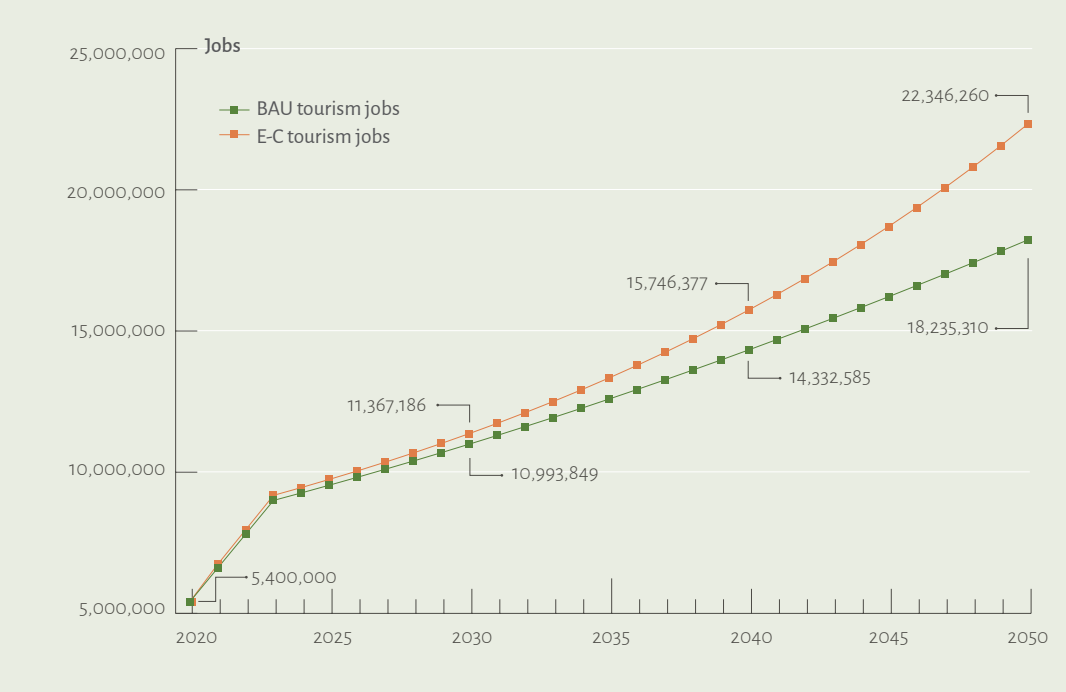


FIGURE 22

INCREASED TOURISM BENEFITS UNDER THE ECO-LOGICAL CONSOLIDATION SCENARIO RELATIVE TO THE BAU SCENARIO:

Annual expenditures and total tourism-related jobs

Source:
Authors' calculation

4.7. Conservation areas reduce Africa's vulnerability to natural hazards and climate risks

Natural hazards frequently affect African societies. About one third of the world's droughts occur in Africa (IMF 2020). Compared to the rest of the world, sub-Saharan Africa has witnessed significant increases in natural disasters over the past three decades (IMF 2020). Droughts and floods – two serious threats to African societies and economies – are set to worsen under continued climate change (IPCC 2014). As part of ecosystem-based approaches to reducing disaster risks, conservation areas are an important asset because they serve as natural protective barriers or buffers.

4.7.1 CONSERVATION AREAS SLOW DOWN PROCESSES OF DESERTIFICATION AND LAND DEGRADATION IN DRYLAND AREAS

Desertification and land degradation affect 45 % of total land area in Africa, causing soil erosion, nutrient depletion, water insecurity and the disruption of biological cycles (ELD & UNEP 2015, Cherlet et al. 2018). This significantly increases risks of famine, conflict and migration (UNCCD 2009a, FAO 2017) on a continent that is home to 250 million people who go hungry every day (FAO and ECA 2018) (see section 4.2.).

Conservation areas **increase the socio-economic and ecological resilience of wider landscapes.** The drought-prone Sahel has a population of around

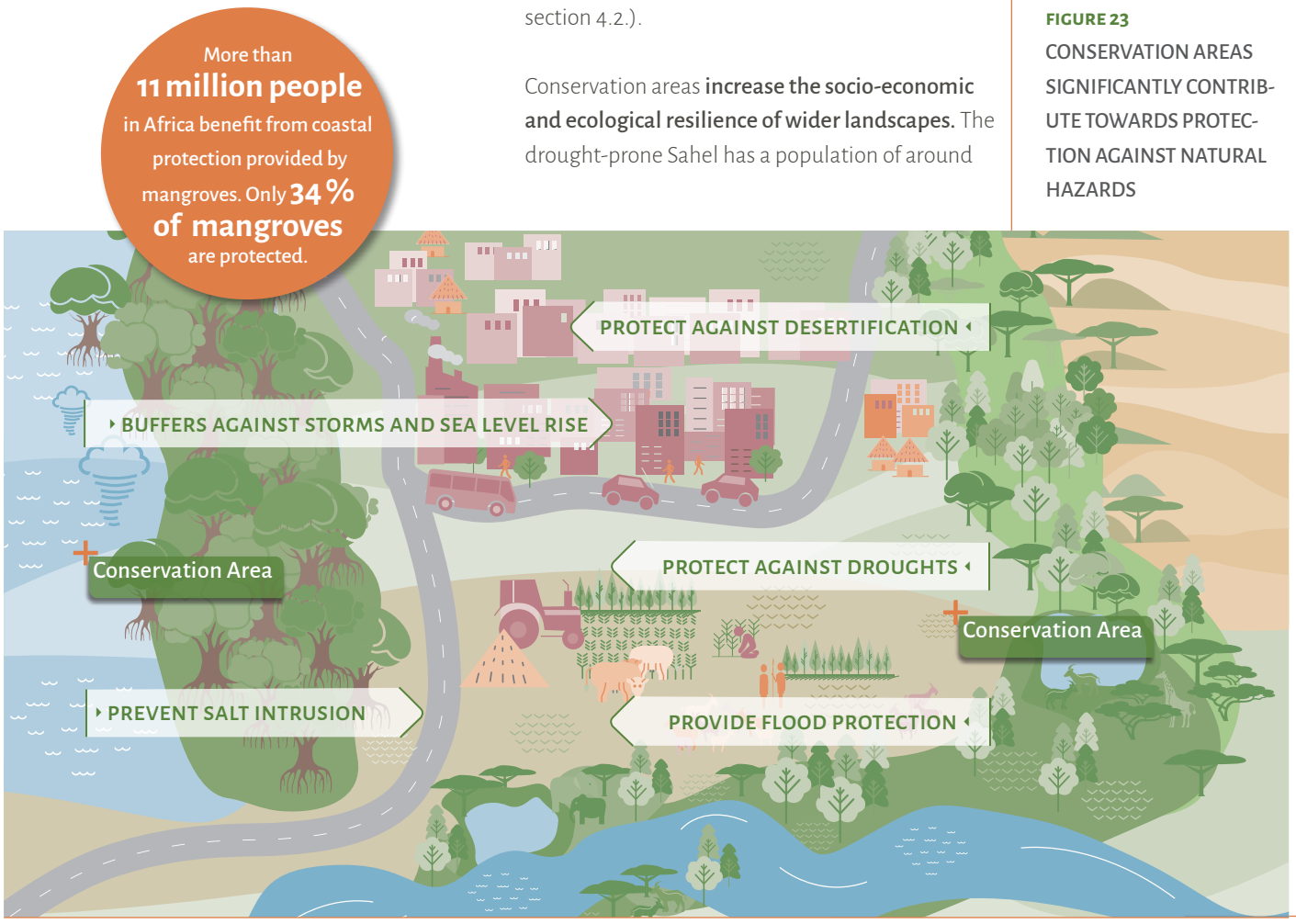


FIGURE 23
CONSERVATION AREAS SIGNIFICANTLY CONTRIBUTE TOWARDS PROTECTION AGAINST NATURAL HAZARDS

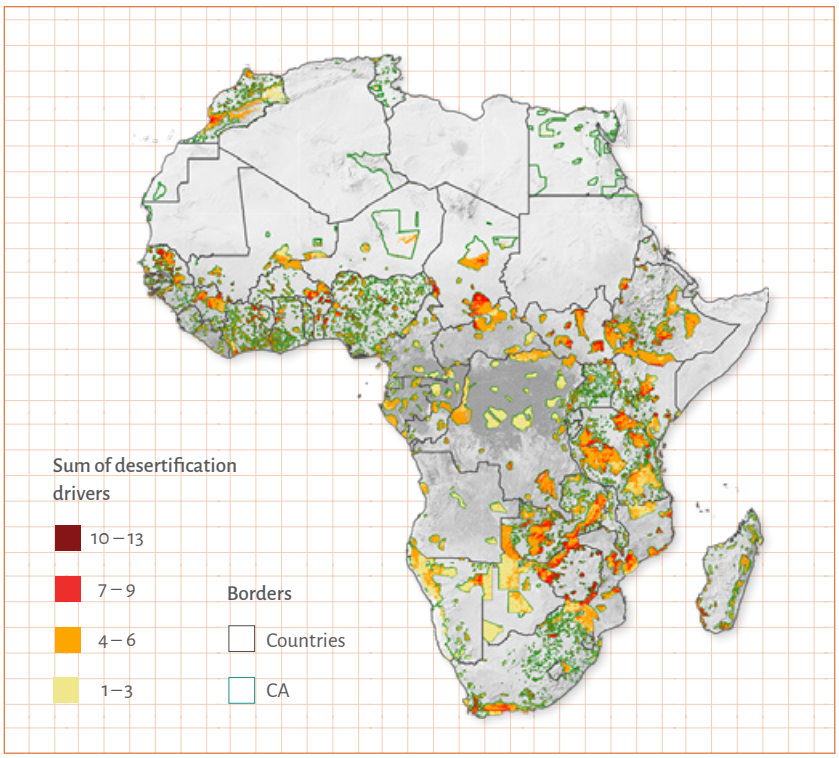
58 million people (Davis 2017). Conservation areas in drylands slow down desertification and land degradation by protecting the natural vegetation of landscapes. This is particularly relevant under current climate change scenarios, which predict more severe and frequent climatic events (IPCC 2018).

➲ For example, in Djibouti the Day Forest National Park has been proven to avoid the further loss of forests and the encroachment of deserts (Dudley et al. 2014, Lopoukhine et al. 2012). Likewise, the biosphere reserves in southwest Morocco have slowed down the continuous decrease of dry woodlands (>44% losses since 1970), mitigating the resulting risks of desertification (de Warroux & Lambin 2012).

Conservation areas have demonstrably provided concrete benefits to their surrounding regions, as they provide buffering against desertification. Their benefits include protecting watersheds (Harrison et al. 2016), stabilizing dunes and **reducing soil erosion** (with native vegetation) (Cherlet 2018). They also reduce soil degradation by **maintaining nutrients cycles** and fertility (Orgiazzi et al. 2016). In turn, they provide shelter and **act as a safety net** for humans, livestock and wildlife in cases of droughts.

Despite their proven positive effects regarding desertification, conservation areas are also at risk: **In more than half of Africa's countries conservation areas are under high potential pressure from desertification and land degradation.** Drivers include biophysical and socioeconomic variables[13] (data sources: JRC 2018, and UNEP-WCMC WDPA 2020). When these variables coincide, they jeopardize the proper ecological functioning and natural capital of conservation areas.

13 Biophysical variables: climate-vegetation trends, reduced productivity of land, aridity, tree loss, fires, water stress. Socioeconomic variables: livestock density, population change, population density, low nitrogen balance, high nitrogen balance, income level, irrigation, built-up area change.



MAP 7

DISTRIBUTION OF GLOBAL CHANGE ISSUES ACROSS AFRICA

Presence of ecological and land use related drivers of desertification in Africa's conservation areas

Source:
Based on data from the World Atlas of Desertification by JRC (2018), Natural Earth, GADM, WAD & WDPA

4.7.2 CONSERVATION AREAS PROTECT AGAINST FLOODS, SEA LEVEL RISE, STORMS AND COASTAL EROSION

Coastal regions in Africa are developing faster than inland areas. In 2000, about 54 million people lived in 'low elevation coastal zones' (LECZ, <10 m above mean sea level), and this number is expected to increase fourfold by 2060 (Neumann et al. 2015). Coastal regions are particularly exposed to natural hazards. In 2050, up to 75 million people living in these LECZ in Africa will face increased coastal risks (Chaplin Kramer et al. 2019).

Climate change and coastal development jointly aggravate such coastal risks: Sea level rise is predicted to reach 0.43–0.84 m by 2100 (IPCC Ocean and Cryosphere 2019). Extreme weather events are forecast to become more frequent, increasing flooding from storm surges and high waves. These will result in salt intrusion, leading to loss of arable land and spoiled freshwater sources. In turn, coastal infrastructure and other changes in land use increase the risks of coastal erosion over time (IPCC Ocean and Cryosphere 2019).

Africa´s green infrastructure – such as mangrove belts – provides effective coastal protection practically for free, while the costs of grey infrastructure such as dykes, dams and floodgates are often prohibitively high (Nayaran et al. 2016). A total of 38,000 km² of mangroves, 17,216 km² of coral reefs (WRI 2019) and 29,045 km² of saltmarshes protect Africa's coastal ecosystems and its communities and cities (Eliff & Silva 2017, Barbier 2016, Möller et al. 2014; data: UNEP-WCMC WDPA 2020).

These natural barriers can adapt to sea level rise to a certain extent: they are able to self-repair and also provide a variety of important ecosystem services (IPCC AR4 2007) such as tourism and fisheries. However, to provide these ecosystem services, they need to be better protected from coastal development (Nayaran et al. 2016).

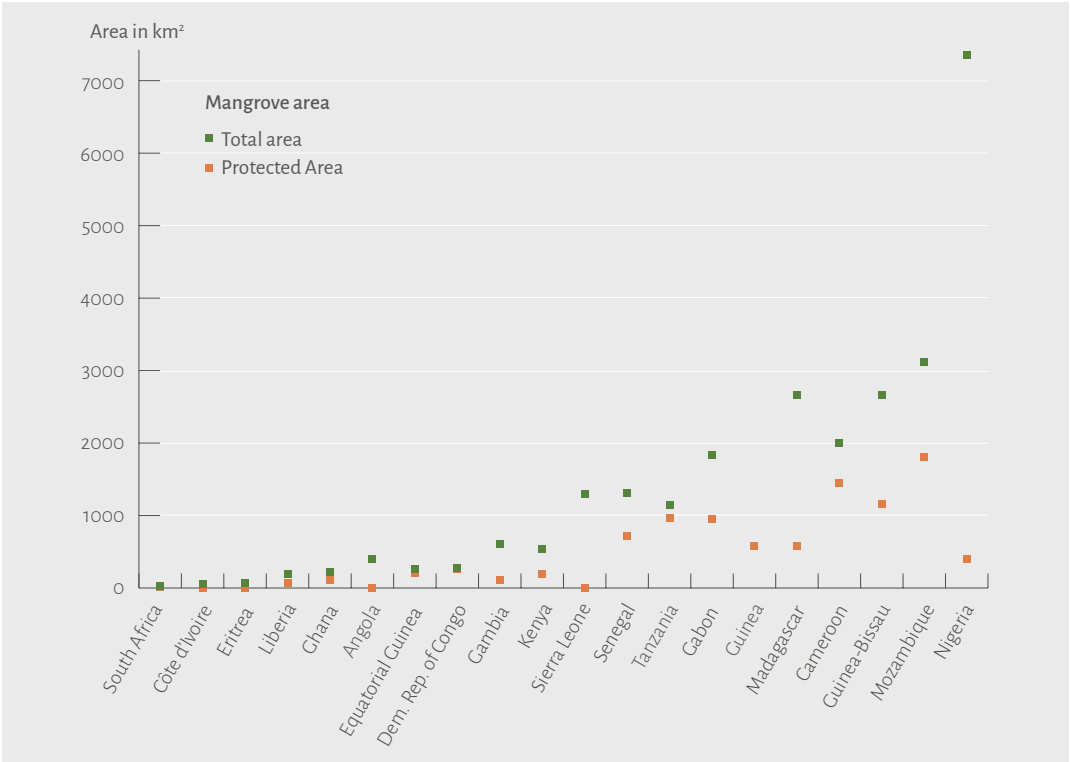


FIGURE 24
TOTAL (PROTECTED) MANGROVE AREA: TOP 20 COUNTRIES IN AFRICA

Distribution of mangroves across Africa, both inside and outside conservation areas

Source:
Authors' analysis.

More than 11 million people living in flood risk areas benefit potentially from the coastal protection provided by conserved and non-conserved mangroves today. However, another 6 million people have lost such protection due to mangrove deforestation since 1996. This number is expected to almost double by 2030 due to population growth. In addition, mangrove deforestation is expected to continue. Only **34% of mangrove assets in Africa are currently protected,** and key areas with high population density and growth rates are lagging even further behind. For example, in Nigeria less than 6% of mangroves are protected while Sierra Leone has no mangrove protection at all. Mangroves protect Africa's fast-growing coastal population while simultaneously being cheap and cost-efficient measures to safeguard human lives and livelihoods from coastal flooding events.

EXAMPLE: EXTREME FLOOD EVENTS IN MOZAMBIQUE CALL FOR STRATEGIC ESTABLISHMENT OF CONSERVATION AREAS

In Mozambique, floods and cyclones have increased in magnitude and frequency during the last decade. The latest case occurred in March 2019: Cyclone Idai affected more than 2.8 million people in Mozambique, Malawi and Zimbabwe, causing the death of 598 people in Mozambique alone (UNDRR, 2019). The economic damage in the three countries was in the order of US$ 2 billion (SwissRe 2019).

Conservation areas attenuate the effects and impacts of flood events by reducing water flow speed. They cannot entirely buffer extreme events like cyclone Idai, which brought up to 50 cm of rain per m^2 during just one week (NASA 2019). However, they can reduce the impacts of smaller flood events. Where poor wetland management and overgrazing in upper watersheds increase flood risk downstream, strategically placed conservation areas could be managed to create enhanced flood retention capacity. They can thus play an important role in Mozambique's disaster risk reduction efforts.

4.7.3 PROSPECTS FOR 2030: CONSERVATION AREAS AND VULNERABILITY TO NATURAL HAZARDS

Global estimates of average annual losses due to the rise of natural hazards such as droughts, floods and hurricanes are estimated to increase from US$260 billion in 2015 to US$414 billion by 2030 (IPCC 2018). Climatic projections for Africa estimate an increase in frequency and severity of extreme weather events for 2030, with a rise in mean annual temperatures and a decrease in precipitation, especially in northern as well as southwestern Africa.

In a **BAU scenario** with continued degradation of conservation areas, the effects of climate change and extreme weather events will heighten risks to the stability of social and ecological systems in drylands and in low elevation coastal zones. The presence or absence of a conservation area will not then make much of a difference. In contrast to this, in an **EC scenario** the halt of degradation trends inside conservation areas would contribute to more resilient landscapes which – in principle – are better adapted to mitigate natural disasters. For many natural hazards (such as desertification and coastal floods), however, the *intactness of larger landscapes*, dune belts or mangrove belts will make the critical difference. Intact conservation area 'islands' will only have limited buffering effects locally.

Mangroves protect Africa's fast-growing coastal population while simultaneously being cheap and cost-efficient measures to safeguard human lives and livelihoods from coastal flooding events.

4.8.
Conservation areas help Africa to combat global warming

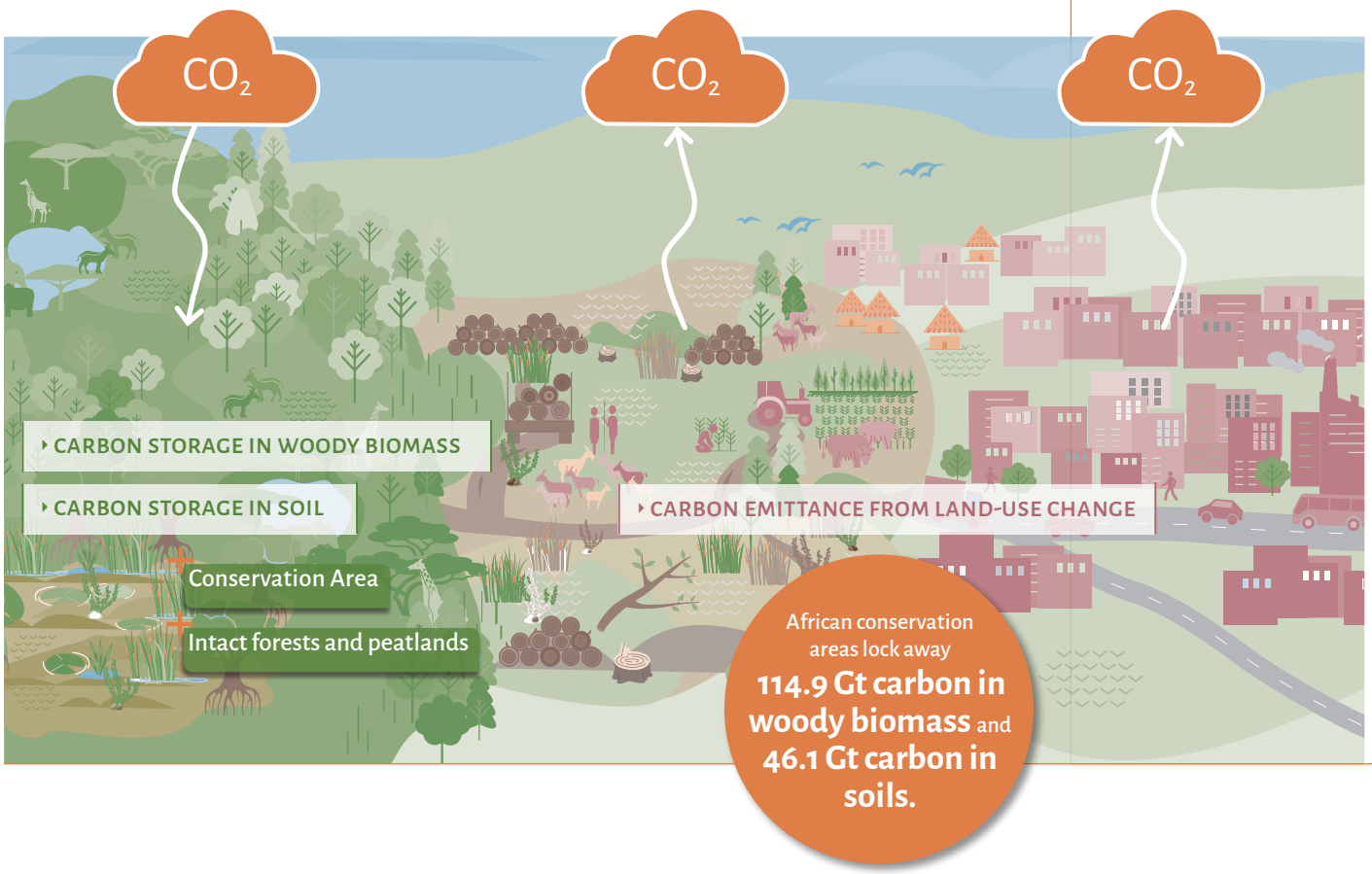
Conservation areas are a critical asset and a part of nature-based solutions to address climate change, which is impacting Africa more than any other continent.

4.8.1
A SIGNIFICANT PROPORTION OF AFRICAN GREENHOUSE GAS (GHG) EMISSIONS COMES FROM LAND-USE CHANGE, HABITAT LOSS AND DEGRADATION

Africa is the continent that contributes the least to global warming. Its emissions have, however, been growing in excess of the global average (Our World in Data based on the Global Carbon Project 2020) which is to be expected given development pressures and demographics. Global GHG emissions specifically from land use change and forestry (LUCF) reached 3.2 Gt CO_2e in 2016. Roughly half of these emissions came from sub-Saharan Africa (approximately 1.7 Gt CO_2e or 53%) (IPCC 2019). Land use change and associated habitat loss, often driven by agriculture and urban expansion, and ecological degradation including deforestation are thus among the principal drivers of emissions in Africa.

In terms of regional differences, West Africa stands out as the area where emissions from land use change have increased most significantly. Between 1980 and 2010 they increased by 75% from 279 Mt CO_2e to 487 Mt CO_2e/yr while emissions in other parts of the continent increased by only around 20% (updated from Houghton and Nassikas 2017, Hansis et al. 2015).

FIGURE 25
CONSERVATION AREAS ARE A CLIMATE SOLUTION IN STORING AND SEQUESTERING CARBON



4.8.2 WELL-MANAGED CONSERVATION AREAS AVOID GHG EMISSIONS, PRESERVE CARBON STOCKS AND STIMULATE SEQUESTRATION

Ecosystems remove CO_2 from the atmosphere and store it in wood, other biomass and soils. Carbon sequestration, as this process is called, contributes toward mitigating climate change.

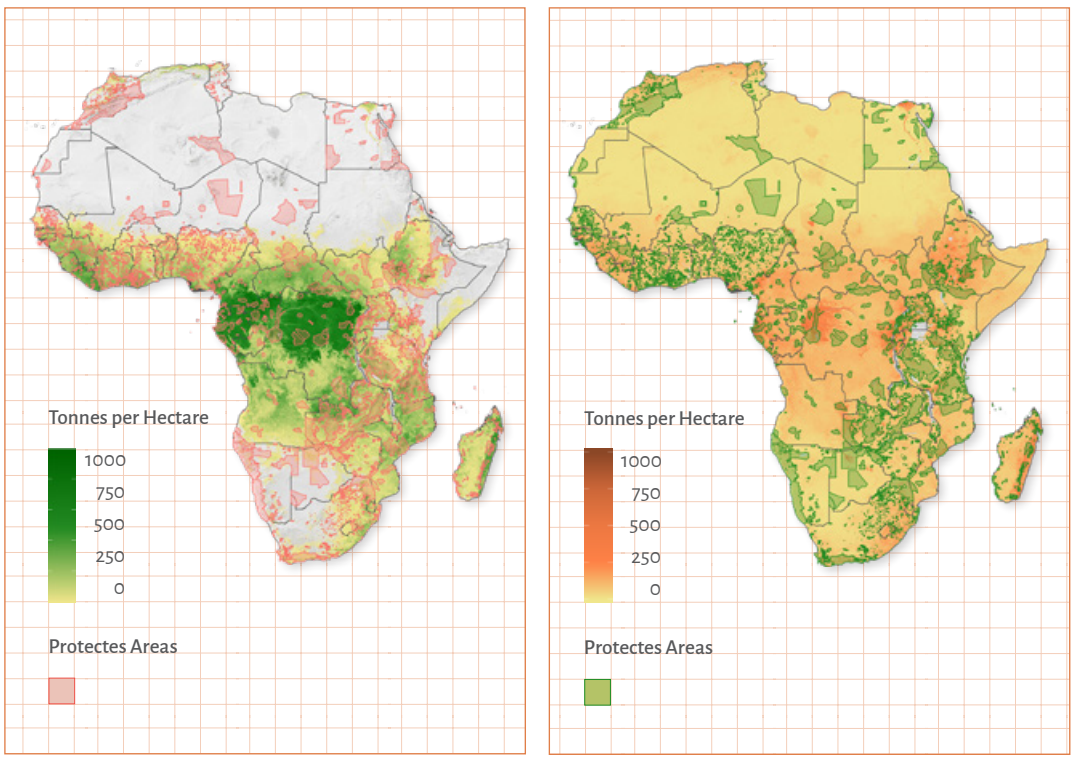
Conservation areas offer relatively higher levels of carbon storage to the extent that they contain intact natural ecosystems. For example, intact tropical forests in Central Africa can store 200 tons of carbon per hectare or more (Sullivan et al. 2017) whereas severely degraded forests may store as little as 10% to 20% of this amount. Further, tropical forests sequester 0.2–0.9 t C ha/yr if left undisturbed (Lewis et al. 2009). African forest conservation areas can thus make significant contributions to emission reduction efforts through carbon sequestration and storage.

The maps show woody biomass and soil carbon stock intensity per hectare, overlain with conservation areas. The relative importance of tropical forest areas in Central and West Africa is clear from this representation.

Based on the data in the below map, total carbon stocks in the live woody biomass contained in African conservation areas were estimated to be in the order of 14.9 Gt C in 2000.[14] To put this in perspective, 0.8–0.9 Gt C or about 8% of annual global anthropogenic emissions are released into the atmosphere as a result of global deforestation (ISU 2015).

The DRC, Tanzania, Zambia, Gabon, Cameroon, Republic of Congo, Mozambique and the Central

14 Continent-wide datasets that were comparable could only be obtained for the year 2000. For new forest carbon field data from the Congo Basin see Ploton et al. (2020).



MAP 8

LEFT: CARBON STOCKS OF WOODY VEGETATION IN 2000 *RIGHT:* SOIL CARBON STOCKS FOR DEPTHS OF 0 – 100 CM

Woody biomass and soil carbon stocks density in African conservation areas

Source: Based on the aboveground life woody biomass density by the Woods hole Research Center and the SoilGrids data set by the International Soil Reference and Information center (ISRIC). Data: Natural Earth, GADM, WADPA

African Republic make the most significant contributions to these protected carbon stocks. **By comparison, the stock in African conservation areas is roughly equivalent to the combined country-wide stock of woody biomass carbon in Cameroon, Kenya, Nigeria, Zambia, Tanzania and South Africa.**

Total soil carbon stocks to a depth of 100 cm in African conservation areas were in the order of 46.1 Gt C in 2017. DRC, Tanzania, Ethiopia, Zambia, South Africa, Mozambique and the Central African Republic made the most significant contributions to this total stock. To some degree they include parts of tropical peatlands which have an extremely high carbon content. The soil carbon stock in African conservation areas is roughly comparable to the combined country-wide soil carbon stock of Senegal, Uganda, Mozambique, Madagascar, Morocco and Ethiopia.

Although carbon storage is mainly linked to inland ecosystems, marine conservation areas also contribute significantly, especially by protecting mangrove and seagrass rich in blue carbon. The average total carbon stock of mangroves in West-Central Africa is 800 tons of carbon per hectare (86 % of which was soil carbon) which exceeds estimates for tropical forests (Kauffman and Bhomia 2017). Global reviews also indicate that healthy seagrass meadows produce calcium carbonate and can store up to 140 tons of carbon per hectare (based on Howard et al. 2017, Mazarrasa et al. 2015, Pendleton et al. 2012). Although not well researched, the role of African marine conservation areas in contributing to blue carbon sequestration is likely to be significant.

4.8.3 PROSPECTS FOR 2030: CONSERVATION AREAS AND COMBATING GLOBAL WARMING

The critical contribution of conservation areas to carbon sequestration and storage is under continued threat from degradation and deforestation. Within African conservation areas, losses of forest ecosystems between 2000 and 2018 totalled 83,500 km² or 5.8 % of all forests inside conservation areas. Average deforestation rates are lower within conservation areas. Even so, deforestation within African conservation areas resulted in average emissions of 39.5 Mt C per year between 2000 and 2018. The annual value of damages from these emissions was between US$ 5.5 billion and US$8 billion.[15]

Under the **BAU scenario**, it is assumed that future emissions volumes would continue to follow past trends. The value of annual damages from emissions, however, would accelerate as damages per ton are predicted to increase (World Bank 2017 based on Carbon Pricing Leadership Coalition 2017). Annual damages would increase from US$ 8.7 billion in 2020 to US$10.9 billion in 2030. Under the **EC scenario**, above ground emissions would stay at 2020 levels. The cumulative total of saved carbon damages from deforestation inside conservation areas would amount to US$107 billion by 2030 (assuming a 0 % discount rate – or US$ 95 billion at a 2 % discount rate). For comparative purposes, predicted total climate adaptation costs for sub-Saharan Africa range between US$ 30 – 50 billion annually over the coming decade (IMF 2020).

Uganda was the first African country, in June 2020, to submit advanced reporting on avoided deforestation. This paves the way for results-based payments for emissions reductions under the global REDD+ mechanism, one of the financial instruments available to governments to increase investments in forest conservation areas (FAO 2020c).

15 Based on global carbon emissions damage costs guidance. This does not include potential soil carbon losses.

The extent to which the result-based payments on offer prove effective in reducing pressure on conservation areas by ensuring better forest protection outside their boundaries will need to be motored. Examples from South America show that results-based payments have often been too low compared to the opportunity costs of forest conversion (Wong et al. 2016).

The critical contribution of conservation areas to carbon sequestration and storage is under continued threat from degradation and deforestation.

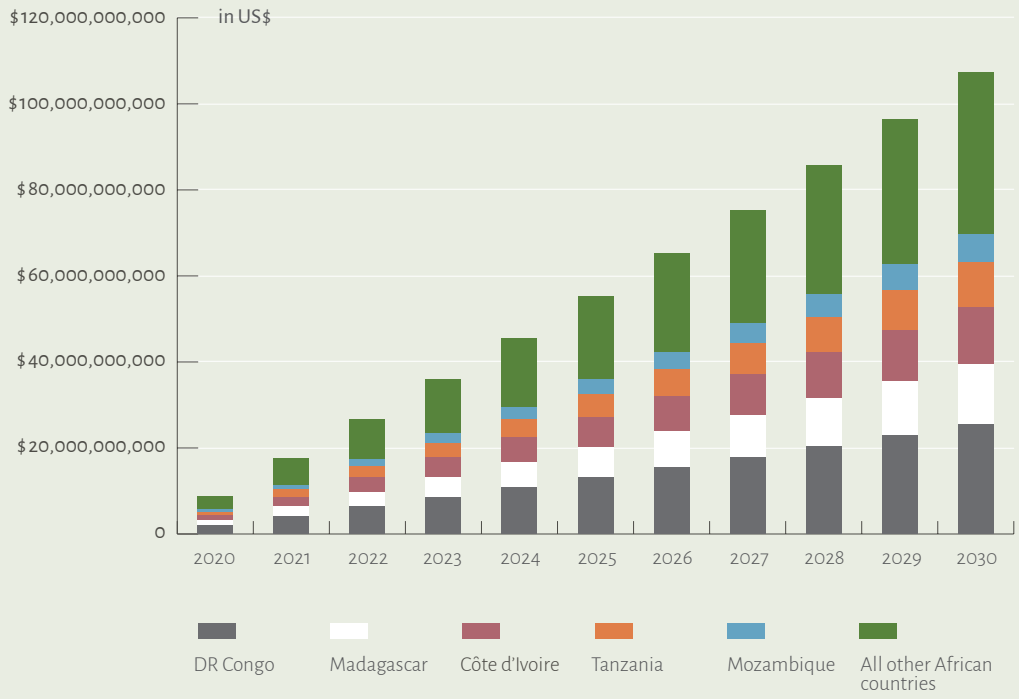


FIGURE 26
THE CUMULATIVE TOTAL VALUE OF FUTURE POTENTIAL DAMAGES FROM CARBON EMISSIONS DUE TO CONTINUED DEFORESTATION IN CONSERVATION AREAS UNDER THE BAU SCENARIO

Based on an assumed 0% discount rate.

Source:
Authors' calculations

4.9.
Conservation areas contribute to healthy societies

Conservation areas provide important benefits to healthy environments and healthy societies. They provide these benefits in diverse ways: As a cross-cutting issue, several health aspects have been addressed in previous sections, such as nutritional food in → section 4.2. (agri-food systems), or air purification, cooling and clean water in → section 4.5. (resilient cities). In this section, the focus is on medicinal plants and emerging infectious disease control.

Africa's rich medicinal heritage is rooted in natural habitats. Conservation areas can serve as reservoirs of plant species for local use, and for finding plant components that can be developed as new drugs. In addition, they reduce environmental and anthropogenic health risks, providing ecosystem-based disease control while helping prevent respiratory disorders, supplying safe drinking water, and co tributing to mental health (Hockings et al. 2020).

4.9.1.
CONSERVATION AREAS ARE A MAJOR SOURCE OF NATURAL REMEDIES FOR MEDICATION

Africa accounts for 3% of the world's health workers, accounts for less than 1% of the world's healthcare expenditure, yet bears 25% of the global disease burden (Mash et al. 2017). Unsurprisingly given this global health gap, Africans rely heavily on traditional medicine. African countries have a strong tradition in the use of medicinal plants: **Country estimates range between 20 – 99% of national populations who use traditional medicine as a source of primary health care, involving tens of thousands of traditional medical practitioners** (WHO 2019). This range indicates the absence of large scale quantitative studies in African ethnobotany. Nonetheless, there is site-level evidence across the continent of the importance of conservation areas for ethnobota ny and the supply of medicinal plants, e.g. in Mada-

FIGURE 27
CONSERVATION AREAS PROVIDE DIVERSE HEALTH BENEFITS

gascar (Rakotonandrasana 2013), in Cameroon (Betti et al. 2011), or in Nigeria (Amusa and Jimoh 2010).

Ethno-medicine requires botanical and medical knowledge. In many parts of Africa it also informs the way people interact with their surrounding ecosystems. Shrines, rituals and harvesting rules not only constitute core elements of local cultures but also contribute to the conservation of biotic communities (Anyinam 1999).

In the light of ecosystem conversion and degradation of landscapes, conservation areas play an increasingly important role in maintaining the number and diversity of medicinal plants: they act as repositories of genetic material and – ideally – protect endangered species from overexploitation (Mahomoodally 2018). Conservation areas can thereby contribute to a relatively higher availability of medicinal plants, both within and outside their boundaries.

If harvested sustainably, medicinal plants from conservation areas can also constitute an important source of local income.

- In Namibia, the root of Devil's claw (Harpagophytum spp.) is commercialized internationally for its anti-inflammatory and pain-relieving properties, with total national export earnings exceeding US$ 1 million annually. Devil's claw continues to be harvested predominantly from the wild by indigenous peoples, for example in the Bwabata National Park. In 2005, the park residents established a legal entity to manage income from tourism, trophy hunting and the Devil's claw trade and to co-manage the park with Namibia's Ministry of Environment and Tourism (Thiem and Muduva 2015). With international partners, the entity achieved organic certification of its Devil's claw, with local collectors receiving the majority of the sales revenues (Equilibrium Research 2020).

EXAMPLE: MEDICINAL PLANTS IN CHEBERA CHURCHURA NATIONAL PARK, ETHIOPIA

Ethiopia is believed to be home to between 6500 and 7000 plant species including medicinal plants, 12 – 19% of which are endemic (Admasu & Yohannes, 2019). There is a robust stock of indigenous knowledge about the use of medicinal plants and their ethno-botany (Birhanu et al. 2015). Reliance on traditional medicine is high, with about 80% of the population using it and even more in rural areas. In addition, 90% of the livestock population is treated with medicinal plants (Mekonen, 2019).

Mander (2006) estimated the total value of medicinal plants in Ethiopia to be approximately US$ 35 million per year, and Sutcliffe (2009) translated this into an average value of US$ 3.52/ha/yr within protected areas.

Chebera Churchura National Park, located in the southwestern part of Ethiopia, is home to about 120 plant species used to treat human and livestock illnesses. The total annual value of medicinal plant harvesting for the park was estimated to be US$ 490,000 based on an average value per hectare generated via benefits transfer (GIZ 2021).

Source: Authors' analysis

At a larger scale, the role of African conservation areas in food security (section 4.2.) also implies significant health benefits. Thus, childhood stunting, linked to malnutrition, is lower in areas close to conservation areas in the Congo Basin because of their continued provision of bushmeat (Fa et al. 2015). At the same time, bushmeat consumption can increase the risk of zoonotic disease.

4.9.2. CONSERVATION AREAS CONTRIBUTE TOWARD CONTROLLING HEALTH RISKS AND THE SPREAD OF DISEASES

Between 631,000 and 827,000 viruses are thought to be potentially able to affect humans via zoonotic transmission (IPBES 2020). The Covid-19 pandemic illustrates the impacts of zoonotic diseases in a globalized world. The World Bank (2020) estimates that the economic consequences could push up to 43 million people into extreme poverty in Africa, erasing at least five years of progress in fighting poverty. Human-induced land conversion is considered to drive the emergence of such infectious diseases. Even though empirical data does not allow for precise predictions, the transmission of pathogens between (wild) animals and humans is increasing (Faust et al. 2018). It is highly plausible that combined factors such as increased forest use, fragmentation of wild habitats, more (long-distance) travel, traditional game consumption and rapid urban growth are a push factor for the risk of zoonotic epidemics. Most viruses of the type known to infect people remain unidentified (IPBES 2018).

Conserved wild habitats harbour viral reservoirs – when ecosystems degrade and human population densities increase, contacts between humans and wild species occur more frequently. Thus, malaria – one of the deadliest diseases in Africa – is exacerbated by deforestation. **Conservation areas slow down deforestation, therefore also lowering the incidence and spread of malaria and of zoonotic diseases such as Ebola** (Bauhoff & Busch 2020; Olivero et al., 2020; MacDonald & Mordecai 2019). However, there is also evidence that conservation areas can increase the risk of malaria (Valle & Clark 2013).

Since the first Ebola virus was discovered in 1976, such viruses have re-emerged sporadically from an unknown reservoir and caused more than 20 human outbreaks across Africa. The 2014 Ebola epidemic in West Africa gave rise to economic losses impacts in the order of US$ 53 billion (IPBES 2020).

The encroachment of people into potential Ebola hotspots for agricultural production (as in West and Central Africa) enhances human exposure to various potential vector species, including fruit bats (Alexander et al. 2015). Together with the traditional consumption of game meat, this has led to an increase of Ebola infections, enabling the virus to cross the animal-human boundary. The reduction of forest cover also changes the natural circulation of viruses, as well as the behaviour, composition, abundance and viral exposure of reservoir species, thus increasing the possibility of spreading the virus (Maganga et al. 2014, Olivero et al. 2017). There is clear evidence for links between Ebola-infected apes

It is highly plausible that combined factors such as increased forest use, fragmentation of wild habitats, more (long-distance) travel, traditional game consumption and rapid urban growth are a push factor for the risk of zoonotic epidemics.

and human Ebola disease outbreaks. The hunting and eating of wild great apes are therefore a major risk factor. Bats, monkeys and other wildlife can also infect humans. The true reservoir(s) and precise natural circulation routes of Ebola viruses remain to be identified (Leendertz et al. 2017).

Beyond acting as natural safeguards against disease,conservation areas can be partners in One Health approaches. They could contribute to the surveillance of zoonotic pathogens (Terraube and Fernández-Llamazares 2020) and to early reporting of disease outbreaks. Needed actions include monitoring wildlife health, reaching out to bushmeat hunters and livestock farmers to track disease transmission, and supporting veterinary capacity for wildlife and zoonotic diseases (IPBES 2020; FAO, CIRAD, CIFOR and WCS 2020).

Conservation areas can also play a role in reducing airborne diseases: In arid and semi-arid parts of Africa, sand and dust storms have a significant impact on human health, ranging from infections, chronic cardiovascular and acute respiratory diseases to lung cancer. Green belts around settlements are effective against sand and dust storms in that they reduce dust deposition by 40% to 76% (Al-Dousari et al. 2016, Annexes). In 2015, almost 200,000 people died of meningitis in Africa (WHO 2019) – a bacterial disease that has been reliably linked to airborne dust and sandstorms (Jusot et al. 2017, WHO 2019). Conservation areas stabilize soils, thereby reducing wind soil erosion; they also significantly reduce sand deposition rates, which contribute to dust storms (WCPA 2015, Marselle et al. 2019).

Conservation areas also reduce the spread of diseases by maintaining quality habitats for **vulture populations.** Vultures control the number of mammalian scavengers around carcasses, resulting in lower levels of contact with potentially infected individuals. However, the population of vultures in Africa has declined on average by 62 – 80% over three generations (Ogada et al. 2016). An assessment of the impact of this decline on Africa has not yet been conducted, but in India human health costs related to a decline in vulture populations have been estimated at US$1.5 billion annually (Markandya et al. 2008).

4.9.3. PROSPECTS FOR 2030: CONSERVATION AREAS AND PUBLIC HEALTH

Population growth, combined with high dependence on traditional medicine, will likely increase demand (and the need) for medicinal plants. At the same time, land conversion and degradation within and around conservation areas could weaken the supply and diversity of medicinal plants (i.e. genetic pool, diversity of species).

In a **BAU scenario**, these trends will likely exacerbate overharvesting and local extinction trends (Okigbo et al. 2008). Losing medicinal plants and traditional knowledge regarding their applications in health care jeopardizes African communities' capacity for self-medication and reduces their potential to identify new medicines (Aswani et al. 2018). Deforestation and land conversion could also foster an increase of contagious diseases due to the higher interaction between humans and the vector of the disease. The incidence of diseases related to dust and sandstorms would also be likely to increase. In an **EC scenario**, these risks are likely to be lower, given the substantial proportion of endemic habitats and of intact vegetation and forest cover inside conservation areas. Thus, IPBES also calls for better protection of conservation areas as a means to reduce future pandemic risks (IPBES 2020).

The various health benefits of conservation area efforts are not yet systematically appraised – under any scenario public health could strongly benefit from systematic integration of health in conservation management (Terraube and Fernández-Llamazares 2017).

5. SYNTHESIS: THE CALL FOR AN EXPANDED VISION FOR PROTECTED AREAS

The utmost importance of safeguarding Africa's biodiversity and natural capital has been recognized in many African policy strategies, such as the Agenda 2063.[16] However, the reality lags behind the ambition, and the wider prospects for the coming decade are challenging. This report examines the state of natural capital stocks and benefit flows from conservation areas, analyses their current socio-economic importance, and enquires about their future role in satisfying rapidly growing societal needs for nature's benefits.

5.1. Summary of results

The findings of the report can be synthesized as follows:

As refuges for biodiversity and intact nature, more than 7000 conservation areas in Africa serve as 'ecological back-bone' for healthy landscapes. They influence living conditions and development prospects far beyond their boundaries. Despite significant gaps in data and knowledge, the tremendous socio-economic importance of conservation areas for a broad range of policy areas and economic sectors is more than evident. Directly or indirectly, conservation areas affect many, if not most, aspects of human well-being for a large proportion of Africa's growing population.

About 30% of Africa's total population – more than 370 million people – live within 10 km of a conservation area today. They are likely affected in different ways by conservation areas, benefiting from the water, food, natural hazard protection and other ecosystem services they provide, but also bearing the societal costs of human-wildlife conflicts and restricted land use. Thus, the ecological status of conservation areas, as well as their management regimes and governance structures, should become a matter of broad societal interest.

Ecosystem degradation, deforestation and encroachment are affecting the integrity of conservation areas in substantial ways. The drivers of this development are local, national and also global. Increasing demand for natural resources coincides with various other factors, including governance challenges and climate change, and will likely take an unprecedented toll on conservation areas within the coming decade. Thus, efforts to ensure their ecological status is enhanced and consolidated should be stepped up; additionally, conservation approaches and structures will need to be reviewed and reformed in view of worsening operating conditions. The way conservation is currently conceptualized and organized is unlikely to be equal to the challenges ahead.

Food and water security for a rapidly growing population are among the top policy priorities in Africa. National policies and strategies for fisheries, agriculture and water management struggle to meet the immediate needs without compromising future conditions for continued supplies. These tensions cannot be resolved without a stronger focus on conservation areas: 28.5% of all African croplands are located within conservation areas and their 10 km buffers; the absence or weak enforcement of marine conservation areas affects fish stocks; and 40 out of the 50 largest reservoirs in Africa receive their water

16 The African Union adopted its Agenda 2063 in 2013. The continent's strategic framework aims to deliver on its goal for inclusive and sustainable development.

partly from conservation areas (as do thousands of small reservoirs). Thus, conservation areas should be appreciated as core assets for food and water security.

Significant parts of African economies rely on hydropower for stable energy supply – and all hydropower facilities depend on ecologically intact watersheds (for secure water supplies and sediment control) for their efficient operation. Thus, national energy security requires watershed protection – and strategically located conservation areas are one suitable instrument to assume that task.

Africa's urban population is expected to triple by 2030. Cities directly depend on intact natural systems for safe housing and healthy living. However, rapid unplanned growth exerts powerful pressures on urban greenspace and nearby conservation areas. More than 600 African cities have strongly degrading conservation areas nearby. Today's plans and decisions about such 'green infrastructures' – or their neglect – will be decisive for city life in a very few years.

International nature tourism is a key economic sector and foreign exchange earner in several countries across Africa. Wildlife tourism accounts for 88% of total annual revenues from trips to Africa. It depends directly on conservation areas. In 2015 they attracted visitor spending in excess of US$ 50 billion. Many countries have significant potential to improve and diversify their nature tourism sectors – despite the sectors' crisis linked to the Covid-19 pandemic. Yet future tourism prospects will necessarily depend on ecologically intact conservation areas.

Conservation areas are a key pillar of climate mitigation and adaptation efforts. They lock away more than 60 Gt of carbon in soils and woody biomass. Desertification and land degradation affect 45% of Africa's total land area today, and at least 54 million people face significant coastal risks. As part of nature-based solutions, conservation areas are an – as yet widely neglected – asset capable of addressing these risks and acting as natural buffers and green belts. Thus, national and regional climate and disaster prevention efforts would strongly benefit from considering, engaging with, and making use of conservation areas.

Human health depends on intact landscapes. With a growing population, the importance of Africa's conservation areas in reducing many threats to human health will grow. This can occur through their provision of protection against diseases linked to dust and sandstorms, safe and unpolluted water, natural pest control done by vultures and scavengers, a bounteous supply of medicinal plants, and reduced risks of zoonotic disease transmission through unfragmented forests. The unfolding Covid-19 pandemic reminds us that the health of ecosystems, humans and animals alike is interconnected; importantly, health has a powerful influence on economic and social stability. Thus, conservation management should be opened up to include preventive health planning and policy, as promoted, for example, by the One Health approach.

While beyond the scope of a natural capital perspective, the educational, cultural and spiritual importance of healthy natural environments for social well-being is pre-eminent and widely acknowledged (IPBES 2018, IPBES 2019). Thus, conservation areas also merit attention for their stewardship of landscapes which sustain knowledges, cultures and identities.

In sum, the natural capital of both protected and unprotected land- and seascapes will further erode – unless suitable actions are taken – while the already high demand for these assets will further grow. In the coming decade, the loss of natural assets, in part from conservation areas, will likely become a major social and economic concern across Africa.

Despite this, across many sectors and policy areas synergistic interests and entry points exist for engaging with conservation areas and cooperating in

their management, financing and further political integration at landscape scale. Investing in natural capital would benefit rural economies especially in Africa, securing the future supply of sustainable food, water and other resources. A natural capital perspective has been proven to work in practice. The six case studies show problem-driven and context-specific applications of this perspective, whose positive impacts extend far beyond conservation area boundaries.

The enhanced focus on maintaining the natural asset base is not only a prerequisite for tackling many development challenges and for achieving the Sustainable Development Goals. It is also a prime strategic opportunity for pursuing collaboration and integration across sectors and government programmes. Conservation areas not only protect natural assets; their governance structures also have much to contribute – in terms of socio-ecological expertise – to such integration efforts.

In the coming decade, the loss of natural assets, in part from conservation areas, will likely become a major social and economic concern across Africa.

5.2. Implications for current conservation approaches

The above findings call into question whether today's conservation area efforts are adequate for tackling the combined challenges of biodiversity loss, climate change and growing societal needs. According to the Global Biodiversity Outlook, loss, degradation and fragmentation of habitats remain high especially in the most biodiversity-rich tropical regions (GBO-5 2020). **Can current conservation approaches respond adequately to the magnitude and intensity of human impacts, and to the speed and scale of environmental and societal change?**

The Covid-19 pandemic has worsened the situation also for conservation areas. This has prompted calls for a 'radical reset' towards boosting African conservation efforts and Western philanthropy (Nuwer 2020). Yet, it may not be enough to promote better management, wider acceptance and additional funding for conservation. The resurgence of approaches that adopt a defensive and restrictive stance, while emphasizing a business case narrative, puts at risk the ethical advances conservation has made (Büscher et al. 2012, Butt, 2016, Fletcher et al. 2020). Where enforcement becomes militarized, they also undermine the efforts aimed at building good conservation governance (Duffy et al. 2019). Yet, such good governance – and the absence of armed conflict which it nurtures – has been found a key factor for conservation success (Daskin and Pringle 2018).

An inclusive natural capital perspective is by itself insufficient to transform conservation. Yet, it recognizes the need for a broad societal debate with regard to the social costs of environmental degradation, and the future role for conservation areas. And it offers a possibly useful language to actively engage across sectors and boundaries, which has

been urgently called for (IUCN-ESARO 2020). Because protected and unprotected lands (and seas) have to meet the diverse needs of entire societies, conservation areas should not be considered as an end in themselves.

In this way, heated biodiversity debates may fall into place: There are diverse values of biodiversity, and competing motivations, emphases, and ethical underpinnings for nature conservation (Kopnina et al. 2018). Yet, entrenched visions on competing concepts for conservation waste time and resources (Gavin et al. 2018). Neither 'people-centred', nor 'science-led', nor 'capitalist' conservation convictions adequately capture and resolve prevalent tensions (Sandbrook et al. 2019). There is a need for diverse solutions. And there is the need for placing conservation within a much larger search for a sound development trajectory at national or landscape scale.

The evidence in this report underlines that public goods of critical importance to society need to be wisely used and adequately protected. Conservation areas are a key tool to protect the biophysical basis which is fundamental to guaranteeing water, energy and food security as well as future development options for Africa.

The broadening out of conservation towards responding to societal needs should not be misunderstood as an abandonment of its long-term stewardship role for nature. This delicate balance will require…

- open(minded-)ness to question current convictions. Conservation approaches need to evolve and expand in view of the growing demands of societies. Conservation areas harbour natural assets which are critical to development: conservation cannot be considered separately from development processes.

- intensive debates across sector boundaries about strategies for meeting societal needs. This includes renegotiation of the goals, methods and means of conservation within society. What is needed is a more inclusive and better-informed debate on natural assets in the context of societal needs and ambitions: What should be protected, where and in what way?

- the willingness of governments, donors and practitioners to allow, fund and pursue multiple conservation pathways. Different combinations of conservation area goals, governance structures and management approaches will have to be explored and established in combination with non-area-based approaches to increase the chances of striking the right balance between biodiversity protection and the maintenance and wise use of natural assets.

Society-centred conservation should recognize that mindsets and values are at the root of both the problems and the solutions. **This entails a medium-term and multi-layered evolution of biodiversity conservation from an environmental issue to a sustainable development issue.** Ultimately, it is about maintaining the long-term capacity of the planet to sustain human populations.

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5.3. A broadened conservation vision

Such a bold change process will need many thinkers and practitioners to engage with it. General ideas will also need to be translated into site-specific strategies for the highly divergent conditions that exist across Africa. For further discussion we dare to challenge some of the convictions shaped by prevailing conservation debates (Gassner et al. 2021). **There are many ways to argue this; we choose to do so by envisioning how an inclusive natural capital perspective could change conservation approaches and priorities.**

In this vision, conservation will be responsive to societal demands upon natural capital. Conservation areas will accommodate a broad set of goals, extending beyond biodiversity. Conservationists see themselves as 'stewards of public benefits from nature' and engage in co-shaping sustainable development. They have a strong voice in development debates based on evidence and arguments that point to the multiple societal benefits and interdependencies with natural capital and to environmental injustices. This could entail changes in different areas.

1. Conservation managers/planners will claim a co-pilot seat in development planning. This includes regional and sectoral planning where conservation will point to the trade-offs and implications of different development alternatives regarding natural capital. It will inform negotiations among interest groups about how competing needs can be met.
2. Management of conservation areas will systematically include – in addition to biodiversity conservation – additional goals to ensure the supply of natural capital benefits in line with development planning.
3. Conservation areas will be conceived as integral parts of multifunctional landscapes because natural capital benefits extend far beyond them. Conservation management will expand its scope to contribute additionally to maintaining natural capital assets outside conservation areas, given the many socio-ecological links across boundaries.
4. Conservation managers will approach the beneficiaries of protected natural assets from diverse private and public sectors and invite them to participate and co-invest in their maintenance.
5. Conservation managers will make use of evidence from the natural capital perspective to identify wasteful uses of natural resources and use this information to build alliances and contribute to develop incentives for more efficient use.
6. Conservation managers will know how to navigate political will, advocate for society taking good care of natural capital and be prepared to encounter vested interests.

These are major changes that cannot be put into practice without further ado. Within the purview of this expanded ambition, those engaged in conservation and development would not only need to deal with the enormous existing challenges but would also make additional efforts to promote new, broader mindsets, approaches and processes at the interfaces between development, human well-being and conservation. Furthermore, we all must seek ways and means to shape the desired changes – and win supporters to help implement them.

The future of Africa's natural protected assets is at a crossroads. As the current and future prosperity and resilience of African societies depend largely on its vast natural capital, healthy multi-functional landscapes including well-managed conservation areas should be widely acknowledged and safeguarded as a foundation for African development.

6. Recommendations: Responding to changing societal demands

In Chapter 5 we outlined a broadened vision for conservation areas that addresses both biodiversity objectives and societal demand for natural capital. Such an expanded conservation vision is a necessary response to Africa's sustainability challenges during the coming decade. The following recommendations are designed to prepare the ground for this transition.

1.
Make nature's values a crucial factor in politics. Highlight the importance of natural assets for societal prosperity and human well-being.

Rationale: An inclusive natural capital perspective reveals how nature provides multiple benefits upon which people and economies depend. Healthy landscapes and conservation areas are not an obstacle to development but rather contain key assets that support it. Rapid economic growth based on the rapid pollution and depletion of natural capital is not the way out of any of Africa's sustainability challenges. This perspective is critical for achieving the 2030 Agenda and the Agenda 2063.

More detailed and disaggregated natural capital and ecosystem services assessments can show where these assets are being forfeited, and what the impacts are of such losses. In taking a close look at beneficiaries, polluters and stewards of natural capital, they can also identify the opportunities and mechanisms which help maintain the bio-physical basis for resilient and prosperous societies in Africa.

2.
Connect conservation areas with societal and economic development priorities and establish their role as nature-based solutions.

Rationale: This report has shown how nine economic sectors and societal areas are crucially dependent on protected natural assets. Conservation actors should use this evidence to reach out to other sectors. Conservation areas are nature-based solutions that contribute to achieving societal and economic development priorities. They may not be largely recognised in this regard. Therefore, an inclusive natural capital perspective is well suited to better engage with other sectors - with their languages, concepts and policy objectives.

For example, African countries strongly rely on hydropower for their total electricity production. Conservation areas can play a key role in water supplies and sediment control, both of which are prerequisites for stable and cost-efficient hydropower operations. Such causal connections need to be communicated and used not only at the level of single conservation areas but should become integral to development and sector planning per se. The same applies to policies and programmes regarding water security, agriculture, disaster risk reduction, urban resilience, and many more.

This is also critical information for ambitions that seek to expand conservation area land. Many countries in Africa and around the world are currently

pledging to protect at least 30% of their land and seas by 2030 (30x30 goal). Natural capital should be one of the criteria to guide the operationalization of this goal in that it identifies areas that are critical for maintaining natural capital flows and the provision of public goods. In Africa, gaps in the protection of critical natural capital areas exist for example for hydropower relevant watersheds, coastal protection relevant mangroves, fisheries relevant nursery grounds, and others.

3.
Enhance the fair governance of conservation areas by using evidence regarding natural capital in ne gotiations around the use and management of natural assets. This can generate new combinations of conservation area aims, governance structures and management regimes.

Rationale: More plural conservation pathways are better equipped to accommodate and respond to society's multiple demands on a landscape than restrictive protection-based approaches. Recognizing the rights and livelihood needs of all people is at the heart of society-oriented nature conservation, which embraces human rights and social justice as foundational principles. Conservation area management is expected to achieve a delicate balance between pursuing biodiversity objectives and responding to societal needs and development ambitions. The example of bushmeat hunting pinpoints inherent tensions: bushmeat hunting jeopardizes biodiversity as demand outgrows sustainable harvest levels. At the same time, rural and urban populations rely on the nutrients provided by bushmeat. Bushmeat is also key to zoonotic disease transmission, requiring additional regulation and monitoring by the health sector.

In this regard, disaggregated natural capital analyses can show the various natural benefit flows and their beneficiaries, stewards and degraders. They reveal that more issues, sectors and actors have stakes than are typically included in conservation area governance. This calls for more flexible conservation area objectives, and more space for crafting solutions regarding how and by whom these objectives are to be pursued.

4.
Link conservation finance more closely with climate, agriculture, infrastructure and post-pandemic recovery finance.

Rationale: Underfunding and lack of sustainable finance are serious risks when it comes to protecting natural assets. At the same time, programmes and regulations that do not penalize – and sometimes even incentivize – unsustainable land use (e.g. in agriculture) drive the loss of natural capital and increase the costs of conservation. Africa's conservation areas need to be understood as a strategic long-term investment in the future of the continent.

A cost-benefit analysis for Ethiopian national parks shows that increased funding can be clearly justified, as it would contribute to key sectors in the economy and to climate change adaptation and mitigation and associated water, food and energy security. The benefit-cost esti- mate for Chebera Churchura National Park is up to 51:1!

One major challenge is to convince governments that pro-active investments in the maintenance of healthy landscapes and conservation areas are vastly more cost-effective than damage repair funds (e.g. after flood events). Other opportunities include infrastructure investments in 'greenbelts' against urban pollution or desertification, and coastal belts (e.g. mangroves/dunes) instead of costly dykes.

To attract such funding from other sectors, conservation actors should team up with those entitled to and familiar with the respective sectoral funding. The same holds true for post-pandemic recovery spending: Conservation areas can play a role in health programmes (e.g. monitoring of zoonoses) and job creation programmes (e.g. in ecosystem restoration for enhanced water security). To tap this potential, conservation actors need to learn how to better argue their case within other sectors' rationales.

5.
Shape debates on sustainable development solutions not just within but also beyond conservation areas. Dramatically changing ecological conditions demand active involvement in policy and planning choices.

Rationale: For turning towards development pathways that enable societal well-being and resilience, a democratic re-shaping of society-nature relations is needed, both within and beyond conservation areas. The natural capital perspective pinpoints a fundamental challenge: Societies' demand for nature's benefits is rising sharply – yet degrading landscapes will fail to meet them. This trajectory will become increasingly material and will require transformative changes. Nature conservation and (rural) development strategies have to reconcile multiple societal needs in a rapidly changing world.

This will not succeed without bold steps away from past mistakes, for example in agricultural policies. Where agricultural systems cause a loss of natural capital, pollute and deplete soils and water bodies, and give rise to climatic changes, they must be transformed. The report highlights the fact that more than ¼ of Africa's croplands are located either inside conservation areas or within a 10 km buffer area.

This calls for a broadened vision for conservation in which conservationists take the co-pilot seat in development planning. Their knowledge regarding ecosystem change, its impacts on people, and the social processes and management options for dealing with it, is key. They should engage in development processes that go well beyond conservation areas: e.g. promoting regional development policies and planning which go hand in hand with area-based conservation and other measures for healthy and multi-functional landscapes.

Societies' demand for nature's benefits is rising sharply – yet degrading landscapes will fail to meet them. This trajectory will become increasingly material and will require transformative changes. Nature conservation and (rural) development strategies have to reconcile multiple societal needs in a rapidly changing world.

7. THE WAY FORWARD: CONCLUSION AND OUTLOOK

The Report on Africa's Protected Natural Assets comes at a pivotal moment. In 2021, countries need to adopt a new Global Biodiversity Framework at COP15 of the Convention on Biological Diversity in China, where the world community will need to agree on ambitious targets that herald a decade of transformative action in the face of the ongoing nature and biodiversity crisis. At the COP 26 of the UN Framework Convention on Climate Change in Glasgow, UK, later in 2021, countries are also expected to significantly raise their climate ambitions with nature-based solutions playing an increasingly recognized role. This report makes the case why politics, economies and societies at large should elevate nature conservation to the top of their agendas. It demonstrates the multiple economic and societal benefits that conservation areas in Africa provide and the dependency of development goals and economic sectors on the natural capital they protect. It therewith seeks to contribute to building momentum and ambition in Africa and around the globe for an ambitious Global Biodiversity Framework and unprecedented action.

This report does so in the face of a rise in pledges to protect 30 % of land- and seascapes by 2030 (30 x 30 goal), including a growing number of African countries. Ambitious conservation area targets such as the 30 x 30 goal, however, will likely accelerate competition for land in Africa and increase tensions between environmental protection and the quest for livelihoods. On the other hand, negative impacts from the diminishing provision of ecosystem services from conservation areas will become increasingly tangible hitting communities and thereby jeopardizing those development and livelihood ambitions.

It is in the light of these challenges, that the Africa's Protected Natural Assets Report calls for a reset of our relationship with nature and provides a clear pathway forward for existing and new conservation areas in Africa. Instead of withdrawing to a defensive stance that shields land 'set aside'for conservation this is the opportunity for nature conservation's mission, objectives and approaches to be responsive to societal needs and development ambitions. A natural capital perspective helps to guide this way.

The Covid-19 pandemic has proven once more the potentially catastrophic consequences of a development path that incentivizes nature destruction and disregards the values of biodiversity. By taking on a natural capital perspective that uncovers the public goods and ecosystem services provided by conservation areas, this report connects conservation with society and the economy. This opens the floor to viewing conservation from a different angle and contributes to leaving behind its conception of being a luxury and an obstacle to development. This is the message behind which the report seeks to rally decision-makers from policy, economy and civil-society: Protecting Africa's natural assets is a crucial investment for the continent's sustainable future!

However, also the limitations of this pathway and the report's recommendations in solving the nature and biodiversity crisis need to become apparent. While being a cornerstone for nature conservation, conservation areas alone and conservation decision-makers alone cannot bend the curve of nature destruction and biodiversity loss. A wider societal and economic change will be necessary. Agri-food systems and urban areas will be principal fields for this transformation in Africa. A recoding of financial and economic systems to become nature-positive will also be a key task ahead. It is aspired that the CBD COP15 in 2021 and the new Global Biodiversity Framework will be the platform to accelerate and leverage the necessary ambitions and action to protect the world's most precious asset: our natural capital.

Annex 1
Technical Annex:

Overview:

1 – Conservation areas: Distribution and extension
2 – Human population near conservation areas
3 – NDVI trend and extrapolation
4 – Forest loss inside and outside conservation areas
5 – Conservation areas and cropland (and West Africa: Land Cover Change)
6 – Conservation areas and ‚water towers' in Africa
7 – Conservation areas and pollination dependent crop production
8 – Conservation areas and fisheries
9 – Hydropower and the protection status of dam catchment areas
10 – Conservation areas near cities
11 – Coastal risks and mangroves
12 – Carbon stocks: Soils
13 – Carbon stocks: Trees

1 – CONSERVATION AREAS

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
Exclusive Economic Zones (World EEZ Version 11)	Flanders Marine Institute (2019). Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at: http://www.marineregions.org/. https://doi.org/10.14284/386	2019	–	Global distribution of exclusive economic zones (EEZ)

Methodology:
For all terrestrial analysis, the PA data set was masked to the outline of Africa using the GADM data set. In contrast, Marine PAs were masked to the EEZ data. No further filtering to the PAs based on the status field (Designated/Proposed/Not Reported/Established) was conducted. As described by UNEP-WCMC (2017), removing proposed or established PAs may lead to an exclusion of sites that are contributing conservation on the ground and might lag in status change for several years due to the legal system of a country or the lag of reporting changes to the database. Further processing included dissolving the vector data in order to bypass the issue of overlapping polygons. Only PAs with an area > 0.01km² were included throughout all analysis.

Limitations:
Known limitations next to the lag in status change and overlapping polygons are spatial inaccuracies of the data set due to the wide range of sources. Furthermore, a variety of different techniques and scales were applied to generate the database for protected areas that is publicly available.

Terrestrial Protected Area Coverage (according to WDPA – updated: November 2020)

Country	% of terrestrial area under conservation status	Total km² of terrestrial conservation area incl inland water bodies
Algeria	4.64%	107,865 km²
Angola	6.97%	87,507 km²
Benin	29.60%	34,369 km²
Botswana	29.14%	169,370 km²
Burkina Faso	14.89%	41,158 km²
Burundi	7.59%	2,066 km²
Cabo Verde	2.9%	120 km²
Cameroon	10.95%	51,397 km²
Central African Republic	18.06%	112,827 km²
Chad	20.97%	267,716 km²
Congo	42.35%	145,567 km²
Côte D'Ivoire	22.96%	74,419 km²
Democratic Republic of Congo	13.83%	324,290 km²
Djibouti	1.57%	344km²
Egypt	13.14%	129,390 km²
Equatorial Guinea	19.27%	5,228 km²
Eritrea	4.87%	5,936 km²
Eswatini, the Kingdom of	4.26%	738 km²
Ethiopia	17.62%	200,074 km²
Gabon	22.44%	59,708 km²
Gambia	4.11%	442 km²
Ghana	14.84%	35,675 km²
Guinea	35.83%	88,286 km²
Guinea-Bissau	26.32%	8,954 km²
Kenya	12.39%	72,693 km²
Lesotho	0.5%	153 km²
Liberia	4.05%	3,916 km²
Libya	0.21%	3,437 km²
Madagascar	7.49%	44,521 km²
Malawi	22.88%	27,190 km²

Mali	8.23%	103,445 km²
Mauritania	0.62%	6,508 km²
Mauritius	4.73%	97 km²
Mayotte	13.94%	55 km²
Morocco	4.27%	17,382 km²
Mozambique	28.88%	228,502 km²
Namibia	37.89%	313,534 km²
Niger	18.2%	216,586 km²
Nigeria	13.93%	127,359 km²
Réunion	63.13%	1,601 km²
Rwanda	9.11%	2,320 km²
Senegal	25.35%	50,179 km²
Seychelles	49.79%	242 km²
Sierra Leone	9.39%	6,825 km²
Somalia	0.00%	0 km²
South Africa	8.63%	105,720 km²
South Sudan	15.5%	98,214 km²
Sudan	2.28%	42,698 km²
Togo	27.98%	16,081 km²
Tunesia	7.91%	12,286 km²
Uganda	16.06%	39,054 km²
United Republic of Tanzania	38.24%	362,264 km²
Western Sahara	0.23%	616 km²
Zambia	41.26%	311,773 km²
Zimbabwe	27.21%	106,838 km²

Marine Protected Area Coverage (according to WDPA – updated: November 2020)

Country	% of marine exclusive economic zone under conservation status	Total km² of of marine and coastal conservation area
Algeria	0.07%	88 km²
Angola	0.00%	24 km²
Benin	0.00%	0 km²
Botswana	0.00%	0 km²
Burkina Faso	0.00%	0 km²
Burundi	0.00%	0 km²
Cabo Verde	0.00%	5 km²
Cameroon	10.89%	1,602 km²
Central African Republic	0.00%	0 km²
Chad	0.00%	0 km²
Congo	3.21%	1,280 km²
Côte D'Ivoire	0.07%	127 km²
Democratic Republic of Congo	0.24%	31 km²
Djibouti	0.17%	12 km²
Egypt	4.95%	11,716 km²
Equatorial Guinea	0.24%	730 km²
Eritrea	0.00%	0 km²
Eswatini, the Kingdom of	0.0%	0 km²
Ethiopia	0.00%	0 km²
Gabon	28.83%	55,721 km²
Gambia	0.07%	16 km²
Ghana	0.1%	219 km²
Guinea	0.53%	583 km²
Guinea-Bissau	8.99%	9,574 km²
Kenya	0.76%	857 km²
Lesotho	0.00%	0 km²
Liberia	0.1%	256 km²
Libya	0.64%	2,278 km²

Madagascar	0.91%	11,018 km²
Malawi	0.00%	0 km²
Mali	0.00%	0 km²
Mauritania	4.15%	6,488 km²
Mauritius	0.00%	50 km²
Mayotte	100%	112,521 km²
Morocco	0.69%	1,904 km²
Mozambique	1.7%	9,763 km²
Namibia	1.71%	9,646 km²
Niger	0.00%	0 km²
Nigeria	0.02%	31 km²
Réunion	0.01%	41 km²
Rwanda	0.00%	0 km²
Senegal	1.11%	1,766 km²
Seychelles	26.1%	350,003 km²
Sierra Leone	0.54%	863 km²
Somalia	0.0%	0 km²
South Africa	14.56%	224,640 km²
South Sudan	0.0%	0 km²
Sudan	15.96%	10,662 km²
Togo	0.2%	31 km²
Tunesia	1.04%	1,042 km²
Uganda	0.00%	0 km²
United Republic of Tanzania	3.02%	7,330 km²
Western Sahara	0.2%	513 km²
Zambia	0.00%	0 km²
Zimbabwe	0.00%	0 km²

2 – HUMAN POPULATION NEAR CONSERVATION AREAS

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
Global Human Settlement Layer (GHSL)	European Commission, Joint Research Centre (JRC); Columbia University, Center for International Earth Science Information Network - CIESIN (2015): GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre (JRC)	1975, 1990, 2000, 2015	250m (spatial)	Global estimate of human population density and distribution

Methodology:
Buffers with the sizes of 5, 10 and 20 km around PAs were computed and intersected with population density information from 2015 by JRC. The sum of pixel values for each buffer and each country based on the GADM data set were hereby calculated.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1.

3 – NDVI TREND COMPUTATION

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries

MCD43A4.006 MODIS Nadir BRDF-Adjusted Reflectance (NBAR)	European Commission, Joint Research Centre (JRC); Columbia University, Center for International Earth Science Information Network - CIESIN (2015): GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre (JRC)	2001 – 2018	500 m (spatial) Daily (temporal)	500 m BRDF-corrected reflectance data of the MODIS bands 1 – 7

Methodology:
Daily MODIS satellite imagery since January 1st, 2001 until December 31st, 2018 were used to calculate annual median values per pixel. A simple linear regression analysis on said annual median images was performed to extract the trend information on a per pixel basis. The analysis was conducted in Google Earth Engine (GEE). Trend numbers for each country based on the GADM data set inside and within different buffers around PAS were calculated.

Furthermore, the trend numbers per pixel inside PAs were extrapolated to 2020 and 2030 using said linear regression. The median NDVI value per pixel within the time span 2001-2003 was calculated. All pixels within the median image with a NDVI < 0.3 were ignored in order to only consider vegetated areas. A mask covering only areas with NDVI values that are above average in 2001-2003 was generated per country. Subsequently, the extrapolated NDVI images in 2020 and 2030 were clipped to said mask. Lastly, the area with NDVI values that lie below the average in 2001-2003 were computed for the 2020 and 2030 NDVI images.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1. Furthermore, the medium resolution of 500 m of the MODIS data set might limit comparability for very small PAs.

NDVI Trend in 2018 per country (compared to mean NDVI 2001 – 2003)

	Inside CAs		20 km buffer around CAs	
Country	**Area with Positive trend in % (2018)**	**Area with Negative Trend in % (2018)**	**Area with Positive trend in % (2018)**	**Area with Negative Trend in % (2018)**
Algeria	80,9	19,1	80,4	19,6
Angola	68,3	31,7	65,9	34,1
Benin	62,3	37,7	50,0	50,0
Botswana	65,3	34,7	69,3	30,7
Burkina Faso	56,7	43,3	44,0	56,0
Burundi	59,5	40,5	45,9	54,1
Cameroon	82,7	17,3	84,7	15,3
Cape Verde	78,5	21,5	89,5	10,5
Central African Republic	91,8	8,2	92,4	7,6
Comoros	64,6	35,4	64,4	35,6
Democratic Republic of the Congo	53,5	46,5	76,8	23,2
Djibouti	56,6	43,4	11,8	88,2
Egypt	84,8	15,2	62,6	37,4

Equatorial Guinea	13,0	87,0	83,9	16,2
Eritrea	64,8	35,2	41,2	58,8
Ethiopia	87,0	13,0	55,7	44,3
Gabon	59,3	40,7	85,4	14,6
Gambia	59,8	40,2	57,5	42,5
Ghana	88,1	11,9	54,7	45,3
Guinea	53,2	46,8	56,2	43,8
Guinea-Bissau	68,7	31,3	60,1	39,9
Côte d'Ivoire	43,0	57,0	59,5	40,5
Kenya	56,7	43,3	48,1	51,9
Lesotho	38,0	62,0	9,3	90,7
Liberia	11,2	88,8	87,6	12,4
Libya	91,5	8,5	63,7	36,3
Madagascar	58,3	41,7	31,8	68,2
Malawi	41,4	58,6	44,7	55,3
Mali	64,6	35,4	65,0	35,0
Mauritania	68,1	31,9	63,0	37,0
Mauritius	67,3	32,7	67,0	33,0
Morocco	93,6	6,4	85,5	14,5
Mozambique	91,4	8,6	55,1	44,9
Namibia	68,0	32,0	66,4	33,6
Niger	65,2	34,8	66,8	33,2
Nigeria	54,7	45,3	40,7	59,4
Republic of Congo	47,6	52,4	87,6	12,4
Reunion	89,6	10,4	69,7	30,3
Rwanda	85,0	15,0	39,4	60,6
Saint Helena	66,2	33,8	90,6	9,4
São Tomé and Príncipe	48,1	51,9	72,7	27,3
Senegal	70,9	29,1	58,8	41,2
Seychelles	68,2	31,8	65,0	35,0

Sierra Leone	73,3	26,7	51,0	49,0
Somalia	54,8	45,2	5,8	94,2
South Africa	0,0	100,0	36,1	64,0
South Sudan	44,2	55,8	89,9	10,1
Sudan	86,1	13,9	77,6	22,4
Swaziland	87,6	12,4	70,1	29,9
Tanzania	75,4	24,6	50,9	49,1
Togo	71,0	29,0	59,7	40,3
Chad	68,1	31,9	65,5	34,5
Tunisia	48,5	51,5	76,9	23,2
Uganda	77,9	22,1	47,3	52,7
Western Sahara	91,3	8,7	88,4	11,6
Zambia	75,8	24,2	66,5	33,5
Zimbabwe	57,8	42,2	59,8	40,2

4 — FOREST LOSS

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
GFC forest loss	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. 'High-Resolution Global Maps of 21st-Century Forest Cover Change.' Science 342 (15 November): 850–53. Data available online: http://earthenginepartners.appspot.com/science-2013-global-forest.	2000 – 2018	30 m (spatial)	Global forest loss between 2000 and 2018

Tree cover	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. 'High-Resolution Global Maps of 21st-Century Forest Cover Change.' Science 342 (15 November): 850 – 53. Data available online: http://earthenginepartners.appspot.com/science-2013-global-forest.	2000	30 m (spatial)	Tree cover in the year 2000, defined as canopy closure for all vegetation taller than 5 m in height.

Methodology:
The global forest loss and tree cover data was masked to the boundaries of the African continent. Tree cover loss data was furthermore clipped to only include loss information for forests with a canopy density >= 20 %, based on the tree cover data set. For each country, the total and relative forest loss information between the years 2000 and 2018 was extracted inside protected areas, inside a 5 km buffer around protected areas, outside of protected areas and lastly outside of protected areas with a 5 km buffer. The loss information was then extrapolated into the years 2020 and 2030, by adding the same annual loss rate as calculated between 2000 and 2018.
The final product shows the total and relative loss of forests with a canopy density >= 20% between 2000 and 2018, as well as the extrapolated total and relative loss between 2000 and 2020/2030.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1.

Forest Loss per country in 2018 compared to 2000

	Inside CAs			Outside CAs		
Country	**Forest area in km² in 2018**	**Area lost since 2000 in km²**	**Area lost since 2000 in %**	**Forest area in km² in 2018**	**Area lost in km² since 2000**	**Area lost in % since 2000**
All Africa	1.367.767	83.515	5,8	5.880.154	603.786	9,3
IPBES sub-regions						
North Africa	6.098	550	8,3	35.815	3.386	8,6
West Africa	142.048	22.802	13,8	570.445	136.560	19,3
East Africa and adjacent islands	363.604	24.263	6,3	835.042	97.410	10,4
Central Africa	536.510	15.671	2,8	3.038.584	228.617	7,0
Southern Africa	319.507	20.230	6,0	1.400.269	137.813	9,0
Countries						
Algeria	579	190	24,7	16.254	2.645	14,0
Angola	17.766	676	3,7	687.838	45.226	6,2
Benin	3.784	129	3,3	9.666	1.245	11,4
Botswana	1.069	2	0,1	296	2	0,5
Burkina Faso	9	1	8,1	17	3	14,2

Burundi	1.135	13	1,1	11.644	248	2,1
Cameroon	38.036	115	0,3	333.340	14.005	4,0
Cape Verde	7	0	0,0	82	0	0,5
Central African Republic	87.424	676	0,8	465.077	9.328	2,0
Comoros	558	24	4,1	13.330	2.671	16,7
Democratic Republic of the Congo	456	7	1,5	1.107	37	3,2
Djibouti	41.465	12.001	22,4	135.310	35.177	20,6
Egypt	300.313	13.195	4,2	1.743.273	188.278	9,7
Equatorial Guinea	0	0	NA	0	0	NA
Eritrea	273	0	0,1	6.744	10	0,2
Ethiopia	5.006	85	1,7	20.519	1.401	6,4
Gabon	0	0	NA	0	0	0,0
Gambia	55.072	1.609	2,8	141.557	2.898	2,0
Ghana	52.666	576	1,1	199.283	4.068	2,0
Guinea	16	0	0,0	478	29	5,7
Guinea-Bissau	17.516	2.128	10,8	62.182	14.479	18,9
Côte d'Ivoire	6.108	727	10,6	12.853	2.201	14,6
Kenya	25.027	2.305	8,4	105.156	22.532	17,6
Lesotho	13.933	1.232	8,1	36.427	3.292	8,3
Liberia	16	0	0,0	50	0	0,7
Libya	10.336	611	5,6	61.586	24.059	28,1
Madagascar	0	0	NA	93	3	3,0
Malawi	37.748	9.201	19,6	136.317	51.332	27,4
Mali	12.719	1.114	8,1	16.763	1.565	8,5
Mauritania	692	96	12,2	1.409	188	11,8
Mauritius	0	0	NA	0	0	100,0
Morocco	94	1	0,8	1.144	23	2,0
Mozambique	4.818	329	6,4	5.257	268	4,9
Namibia	99.398	6.860	6,5	360.866	44.681	11,0
Niger	98	3	2,9	73	6	7,6

Nigeria	0	0	NA	0	0	NA
Republic of Congo	30.215	3.994	11,7	124.545	14.045	10,1
Reunion	51.225	988	1,9	252.054	8.618	3,3
Rwanda	1.473	20	1,3	693	34	4,7
Saint Helena	1.671	10	0,6	8.260	391	4,5
São Tomé and Príncipe	0	0	NA	0	0	NA
Senegal	147	0	0,0	64	0	0,4
Seychelles	1.644	15	0,9	3.952	225	5,4
Sierra Leone	93	0	0,0	1	0	0,0
Somalia	3.343	743	18,2	42.468	21.502	33,6
South Africa	0	0	NA	2.387	50	2,0
South Sudan	23.961	4.636	16,2	68.103	18.149	21,0
Sudan	41.223	68	0,2	187.255	1.295	0,7
Swaziland	6	0	0,0	4.827	12	0,2
Tanzania	515	5	1,0	7.550	1.438	16,0
Togo	192.174	10.472	5,2	218.621	28.781	11,6
Chad	1.889	52	2,7	10.744	874	7,5
Tunisia	422	31	6,8	2.641	447	14,5
Uganda	19.669	1.644	7,7	101.273	9.278	8,4
Western Sahara	0	0	NA	0	0	NA
Zambia	155.837	6.327	3,9	230.347	23.739	9,3
Zimbabwe	8.128	607	6,9	28.383	3.007	9,6

Forest Loss in CAs: Extrapolation for 2020 and 2030 compared to 2000

Country	Forest loss in CAs in km² in 2020	Percentage of forest loss in CAs in 2020	Forest loss in CAs in km² in 2030	Percentage of forest loss in CAs in 2030
All Africa	92.794	6,4	139.191	9,6
IPBES sub-regions				
North Africa	611	9,2	916	13,8
West Africa	25.335	15,4	38.003	23,1
East Africa and adjacent islands	26.959	7,0	40.438	10,4

Central Africa	17.413	3,2	26.119	4,7
Southern Africa	22.477	6,6	33.716	9,9
Countries				
Algeria	211	27,4	317	41,2
Angola	751	4,1	1127	6,1
Benin	144	3,7	216	5,5
Botswana	2	0,2	3	0,2
Burkina Faso	1	9,0	1	13,5
Burundi	14	1,2	21	1,8
Cameroon	127	0,3	191	0,5
Cape Verde	0	0,0	0	0,0
Central African Republic	751	0,9	1127	1,3
Chad	27	4,6	40	6,9
Comoros	8	1,6	11	2,5
Côte d'Ivoire	13.335	24,9	20.002	37,4
Democratic Republic of the Congo	14.661	4,7	21.992	7,0
Djibouti	0	NA	0	NA
Egypt	0	0,1	0	0,1
Equatorial Guinea	94	1,9	141	2,8
Eritrea	0	NA	0	NA
Ethiopia	1.788	3,2	2.682	4,7
Gabon	640	1,2	959	1,8
Gambia	0	0,0	0	0,0
Ghana	2.364	12,0	3.546	18,1
Guinea	808	11,8	1.212	17,7
Guinea-Bissau	2.561	9,4	3.841	14,1
Kenya	1.369	9,0	2.053	13,5
Lesotho	0	0,0	0	0,0
Liberia	679	6,2	1.018	9,3
Libya	0	NA	0	NA
Madagascar	10.223	21,8	15.335	32,7

Malawi	1.238	8,9	1.857	13,4
Mali	106	13,5	159	20,3
Mauritania	0	NA	0	NA
Mauritius	1	0,9	1	1,3
Morocco	365	7,1	548	10,6
Mozambique	7.622	7,2	11.433	10,8
Namibia	3	3,2	5	4,9
Niger	0	NA	0	NA
Nigeria	4.438	13,0	6.656	19,5
Republic of Congo	1.098	2,1	1.647	3,2
Reunion	22	1,5	33	2,2
Rwanda	11	0,7	17	1,0
Saint Helena	0	NA	0	NA
São Tomé and Príncipe	0	0,0	0	0,0
Senegal	17	1,0	25	1,5
Seychelles	0	0,0	0	0,0
Sierra Leone	826	20,2	1.239	30,3
Somalia	0	NA	0	NA
South Africa	5.151	18,0	7.727	27,0
South Sudan	75	0,2	113	0,3
Sudan	0	0,0	0	0,0
Swaziland	6	1,2	9	1,7
Tanzania	11.635	5,7	17.453	8,6
Togo	58	3,0	87	4,5
Tunisia	34	7,5	51	11,3
Uganda	1.827	8,6	2.740	12,9
Western Sahara	0	NA	0	NA
Zambia	7.030	4,3	10.545	6,5
Zimbabwe	674	7,7	1.012	11,6

5 – CONSERVATION AREAS AND CROPLAND (AND WEST AFRICA: LAND COVER CHANGE)

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
West Africa: Land Use and Land Cover Dynamics	Tappan, G. G., Cushing, W.M., Cotillon, S.E., Mathis, M.L., Hutchinson, J.A., and Dalsted, K.J., 2016, West Africa Land Use Land Cover Time Series: U.S. Geological Survey data release, http://dx.doi.org/10.5066/F73N21JF	1975, 2000, 2013	2 km (spatial)	Land cover classification of west Africa for the years 1975, 2000 and 2013
Global Human Settlement Layer (GHSL)	European Commission, Joint Research Centre (JRC); Columbia University, Center for International Earth Science Information Network - CIESIN (2015): GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre (JRC)	1975, 1990, 2000, 2015	250 m (spatial)	Global estimate of human population density and distribution

Methodology:
Land cover classifications of West Africa for the years 2000 and 2013 were simplified to the following classes: 'Forest', 'Savanna', 'Wetland', 'Agriculture', 'Mangrove', 'Water bodies', 'Open area', 'Settlements', 'Degraded forest' and 'Shrubland'. Based on these simplified land cover classifications, a land cover change map visualizing the changes 'Urbanization' and 'Agricultural Expansion' was created. Buffers with the sizes of 5, 10 and 20 km around PAs, as well as a 1 km inner buffer from the edge to the inside of the PAs were computed and intersected with the change map. Also, a PA core area was defined by subtracting the 1 km inner buffer from the PAs. The percentage of urbanization, agricultural expansion and forest degradation within each buffer and each country were hereby calculated. Furthermore, the population living in areas classified as agriculture were computed for the different buffers around PAs based on GHSL data.[C16]

The final product includes land cover and land cover change maps for the years 2000 and 2013 in West Africa, as well as the percentage of urbanization and agricultural expansion within different PA buffers per country.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1. Furthermore, the low spatial resolution of the land cover information might limit the comparability for very small PAs.

West Africa: Agricultural expansion within and around CAs in West-African countries between 2000 and 2013

Cropland per country (2018)

Country	Total Cropland area per country in km²	Cropland area inside CAs + 10km buffer in km²	Cropland area inside CAs in km²	Percentage of cropland inside CAs of total CA land	Percentage of cropland area inside CAs + 10 km buffer of total national cropland	Percentage of cropland inside CAs of total national cropland
All Africa	3.826.444	1.092.149	324.835	7,7	28,5	8,5
IPBES sub-regions						
North Africa	728.356	49.591	15.083	2,9	6,8	2,1
West Africa	1.193.445	410.159	97.840	14,2	34,4	8,2
East Africa and adjacent islands	838.600	337.581	100.503	11,0	40,3	12,0
Central Africa	446.088	69.362	35.198	4,5	15,5	7,9
Southern Africa	619.955	225.456	76.211	5,7	36,4	12,3
Countries						
Algeria	75.121	2.239	510	0,5	3,0	0,7
Angola	59.759	5.396	2.371	2,9	9,0	4,0
Benin	31.264	11.958	2.031	7,5	38,2	6,5
Botswana	13.296	3.609	2.539	1,5	27,1	19,1
Burkina Faso	104.979	27.497	9.609	23,6	26,2	9,2
Burundi	6.958	2.366	41	3,0	34,0	0,6
Cameroon	42.107	8.150	3.816	6,9	19,4	9,1
Central African Republic	9.528	1.139	447	0,4	12,0	4,7
Chad	222.182	27.570	17.853	10,4	12,4	8,0
Comoros	47	32	7	1,5	67,5	15,6
Côte d'Ivoire	42.678	28.845	8.040	11,3	67,6	18,8
Democratic Republic of the Congo	135.405	21.767	8.713	2,7	16,1	6,4
Djibouti	190	8	1	0,1	4,2	0,3
Egypt	40.754	3.751	849	0,5	9,2	2,1
Equatorial Guinea	571	385	157	3,0	67,4	27,4
Eritrea	20.676	1.364	389	6,0	6,6	1,9
Ethiopia	294.132	80.541	35.869	15,5	27,4	12,2
Gabon	7.017	2.068	1.018	1,8	29,5	14,5
Gambia	4.120	1.611	41	9,7	39,1	1,0

Ghana	43.128	22.129	2.398	6,9	51,3	5,6
Guinea-Bissau	2.457	1.009	310	3,3	41,1	12,6
Guinea	9.379	4.905	2.527	4,6	52,3	26,9
Kenya	105.245	46.728	9.803	10,7	44,4	9,3
Lesotho	7.450	1.740	799	12,5	23,4	10,7
Liberia	4.010	811	182	1,7	20,2	4,6
Libya	13.378	8	0	0,0	0,1	0,0
Madagascar	47.364	13.920	3.588	5,6	29,4	7,6
Malawi	46.413	19.767	1.961	10,0	42,6	4,2
Mali	223.829	34.165	21.320	30,0	15,3	9,5
Mauritania	97.587	454	106	1,7	0,5	0,1
Morocco	58.781	33.135	11.865	6,0	56,4	20,2
Mozambique	115.243	27.442	15.481	9,9	23,8	13,4
Namibia	16.457	5.685	3.277	1,1	34,5	19,9
Niger	206.477	9.796	1.927	1,0	4,7	0,9
Nigeria	423.081	217.200	35.528	29,8	51,3	8,4
Republic of Congo	22.145	5.746	3.101	5,4	25,9	14,0
Rwanda	11.598	3.256	76	3,3	28,1	0,7
Saint Helena	216	96	19	17,6	44,5	8,7
São Tomé and Príncipe	175	170	52	9,7	97,4	29,5
Senegal	74.930	39.241	12.733	25,4	52,4	17,0
Seychelles	35	3	3	1,3	9,0	9,0
Sierra Leone	4.627	1.283	167	4,1	27,7	3,6
Somalia	23.219	27	0	0,0	0,1	0,0
South Africa	172.859	74.747	15.671	8,6	43,2	9,1
South Sudan	31.122	6.829	4.730	3,9	21,9	15,2
Sudan	414.864	2.283	1.412	5,3	0,6	0,3
Swaziland	3.597	1.324	16	2,2	36,8	0,5
Tanzania	215.809	114.118	41.580	11,6	52,9	19,3
Togo	18.486	9.707	1.026	16,9	52,5	5,5
Tunisia	26.399	7.534	197	1,6	28,5	0,7

Uganda	89.163	70.755	4.458	12,4	79,4	5,0
Western Sahara	1.472	188	143	0,9	12,8	9,7
Zambia	82.204	50.540	16.452	5,6	61,5	20,0
Zimbabwe	102.460	35.110	17.626	16,8	34,3	17,2

West Africa: Agricultural expansion within and around CAs in West-African countries between 2000 and 2013

	Percentage of agricultural expansion			Total area of agricultural expansion in km²		
Country	Inside CAs	Outer buffer 5 km	Outer buffer 10 km	Inside CAs	Outer buffer 5 km	Outer buffer 10 km
Benin	5,2	11,6	12,7	1.412	3.072	5.368
Burkina Faso	5,1	16,3	18,3	2.104	5.460	10.788
Côte d'Ivoire	2,9	3,7	4,4	2.036	5.216	9.504
Gambia	2,8	4,2	5,4	12	64	200
Ghana	3,3	3,9	5,0	1.152	3.764	6.428
Guinea	8,3	7,9	8,0	4.568	3.664	6.104
Guinea-Bissau	2,3	6,3	6,4	204	364	704
Liberia	1,1	2,4	3,0	116	364	748
Mali	1,8	3,5	3,8	1.324	1.804	2.948
Niger	0,4	0,9	1,8	204	564	1.292
Nigeria	8,6	9,8	9,7	10.220	26.532	44.508
Senegal	2,0	5,6	6,8	1.020	4.088	6.844
Sierra Leone	2,6	3,8	4,1	104	440	908

Agricultural land (2013) and population (2015) within a buffer of 5km, 10km, 20km around CAs in West Africa

Country	Agricultural land within 5 km buffer in km²	Population within 5 km buffer	Agricultural land within 10 km buffer in km²	Population within 10 km buffer	Agricultural land within 20 km buffer in km²	Population within 20 km buffer
Benin	5.325	738.369	12.190	1.857.226	26.134	5.245.532
Burkina Faso	11.192	3.031.947	23.408	5.780.094	49.096	9.721.467
Côte d'Ivoire	20.919	7.561.572	40.036	13.924.842	76.070	21.434.866
Gambia	459	861.584	1.180	1.170.322	2.379	1.662.811
Ghana	21.247	6.261.422	37.545	12.091.006	59.020	20.530.626
Guinea	5.177	2.852.607	13.375	5.342.617	23.607	7.838.871

Guinea-Bissau	862	129.719	1.850	258.302	3.452	576.418
Liberia	1.054	263.551	2.436	662.549	5.407	2.245.793
Mali	3.194	514.512	6.338	806.619	13.677	1.624.521
Niger	1.394	139.040	4.217	608.483	13.205	1.950.630
Nigeria	84.206	41.998.710	175.637	81.637.553	301.484	141.313.712
Senegal	9.265	2.204.728	17.783	4.803.161	28.425	7.723.344
Sierra Leone	1.197	1.561.804	2.812	2.274.154	5.998	3.829.307

6 – CONSERVATION AREAS AND 'WATER TOWERS' IN AFRICA

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Water Towers	UNEP (United Nations Environment Programme) (2010): Africa Water Atlas. Division of Early Warning and Assessment (DEWA). Nairobi, Kenya. URL: https://na.unep.net/atlas/africaWater/downloads/africa_water_atlas.pdf	2010	–	Water towers of Africa

Methodology:
The manually digitized water towers were used to subset the PA data set. After calculating the areas of all features, fractions of protected areas were calculated and visualized.

The final product shows the location of water towers defined by the UNEP overlayed by protected areas. Additionally, the fraction of each water tower area covered by protected areas is given.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1. Furthermore, the quality of the produced result is depended on the manual geo-referencing of the water tower information.

7 — CONSERVATION AREAS AND POLLINATION DEPENDENT CROP PRODUCTION

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
Potential pollination dependent nutrient production	Chaplin-Kramer, R.; Sharp, R.P.; Weil, C.; Bennett, E.M.; Pascual, U.; Arkema, K.K.; Brauman, K.A.; Bryant, B.P.; Guerry, A.D.; Haddad, N.M.; others. Global modeling of nature's contributions to people. Science 2019, 366, 255–258.	2019	300 m (spatial)	Potential pollination dependent annual nutrient production in KJ/100 g

Methodology:
Buffers with the sizes of 5, 10 and 20 km around PAs were computed and intersected with potential pollination dependent annual nutrient production. The sum of pixel values for each buffer and each country based on the GADM data set were hereby calculated.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1.

8 — CONSERVATION AREAS AND FISHERIES

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Fishing Effort	Global Fishing Watch (2020): Datasets and Code: fishing effort. Available online at: https://globalfishingwatch.org/datasets-and-code/fishing-effort/	2016–2018 (used data has not been officially published yet)	0.01° (spatial) Daily (temporal)	Daily fishing effort, gridded at 0.01 degrees
Exclusive Economic Zones (World EEZ Version 11)	Flanders Marine Institute (2019). Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at http://www.marineregions.org/ https://doi.org/10.14284/386	2019	–	Global distribution of exclusive economic zones (EEZ)

Methodology:
The fishing effort data was masked to the African EEZ. The total fishing time in hours was subsequently calculated in a raster grid with a cell size of 5 km for the years 2016, 2017, 2018 and 2016–2018. Buffers of 0–50km and 50–100km around marine PAs were computed and intersected with the fishing time information. The total fishing time within PAs, and within the two buffers around the PAs were calculated for each EEZ and each timespan. Said total fishing time per area was subsequently divided by the total area of the PAs and buffers respectively to receive the total fishing time per km² of a given area.

The final product contains the total fishing time per km² of a given area (PAs; 0-50 km buffer; 50-100 km buffer) and time span (2016, 2017, 2018, 2016–2018) per EEZ.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1.

9 — PROTECTION STATUS OF DAM CATCHMENT AREAS

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Dams	FAO-UN Land and Water Division (2011): AQUASTAT. Geo-referenced Database on Dams. Rome, Italy. URL: http://www.fao.org/aquastat/en/databases/dams	2011	–	Location of dams across Africa
Shuttle Radar Topography Mission (SRTM) elevation data	Flanders Marine Institute (2019). Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at http://srtm.csi.cgiar.org	2000	90 m (spatial)	Global digital elevation data

Methodology:
For both west and east Africa the top 10 most important dams were identified by filtering the dam data set by reservoir capacity. Based on the filled SRTM elevation model, a hydrological model of the African continent was then processed by calculating the flow direction and flow accumulation for each SRTM-pixel. The dam locations were corrected, when needed, by overlaying ESRI Living Atlas Imagery and snapped to the flow accumulation raster. Watersheds for each snapped pour point were subsequently processed.

The final product shows the location of the 10 biggest dams in east and west Africa based on their reservoir capacity as well as their dynamically processed catchment area overlaid by the protected areas. Additionally, proportions of protected areas in each dam catchment area were calculated.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1.

Countries with more than 50% electricity production from hydroelectric sources in 2015
(Data from World Bank, IEA Statistics, UNEP and AFREC)

Country	Electricity production from hydroelectric sources (approximate % of total)
Angola	53
Burundi	95
Central African Republic	90
Cameroon	75
Congo, Dem. Rep.	~ 99
Congo, Rep.	53
Ethiopia	92
Ghana	50
Equatorial Guinea	55
Liberia	51
Lesotho	99
Mozambique	86
Malawi	98
Namibia	~97
Sudan	64
Togo	69
Uganda	75
Zambia	96
Zimbabwe	51

10 — CONSERVATION AREAS NEAR CITIES (>50.000 INHABITANTS)

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries

MCD43A4.006 MODIS Nadir BRDF-Adjusted Reflectance (NBAR)	European Commission, Joint Research Centre (JRC); Columbia University, Center for International Earth Science Information Network - CIESIN (2015): GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre (JRC)	2001 – 2018	500 m (spatial) Daily (temporal)	500 m BRDF-corrected reflectance data of the MODIS bands 1–7
OpenStreetMap (OSM)	Map data copyrighted OpenStreetMap contributors and available from https://www.openstreetmap.org	2019	–	Global land cover information
Total Population	United Nations (2019): World Population Prospects 2019. Available online: https://population.un.org/wpp/Download/Standard/Population/	2019 (Numbers for 2018 used)	–	

Methodology:
In order to identify large cities (50.000 inhabitants or more), the total population numbers for each country in 2018 based on the data by the United Nations (2019) was used as a reference. OSM data was masked to each country and filtered to only include residential areas. For each residential area the population number was calculated based on the size of the polygon compared to the whole residential area of the country and its total population number. Since many cities are divided into separate OSM residential zones, polygons which are in proximity of <= 500 m to each other were combined to avoid multiple counts of the same city. All polygons with an estimated population of less than 50.000 were filtered out. In the next step, the percentage of degradation per PA was calculated by using the previously computed NDVI trend analysis. All PAs in which more than 50 % of the area has a negative NDVI trend were subsequently extracted. Buffer sizes of 5, 10 and 20 km around said degrading PAs were calculated and intersected with large cities.

The final product includes the number of large cities (>= 50.000 inhabitants) and their estimated population within the three buffer zones 5, 10 and 20 km around PAs, as well as only around PAs that are degrading to >= 50 % per country.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1. Furthermore, the quality of used OSM data varies across different countries and could therefore exclude some residential zones. Lastly, a homogenous distribution of the population across a country was assumed for the analysis. This is highly unlikely und thus, population numbers in cities might be underestimated.

11 – DRIVERS OF DESERTIFICATION

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries

Convergence of Evidence on global change issues	WAD3 JRC Team - Cherlet, M., Hutchinson, C., Reynolds, J., Hill, J., Sommer, S., von Maltitz, G. (Eds.), World Atlas of Desertification, Publication Office of the European Union, Luxembourg, 2018.	2019	1 km (spatial)	Distribution of biophysical and socio-economic key issues
Global Human Settlement Layer (GHSL)	European Commission, Joint Research Centre (JRC); Columbia University, Center for International Earth Science Information Network - CIESIN (2015): GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre (JRC)	1975, 1990, 2000, 2015	250 m (spatial)	Global estimate of human population density and distribution

Methodology:
The mean sum of all socio-economic and biophysical change issues was calculated inside PAs per country. Furthermore, the relative and absolute area of each biophysical key issue inside PAs and within a 10 km buffer around PAs was computed per country.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1.

12 — COASTAL RISKS AND MANGROVES

Dataset	Source	Date	Resolution(s)	Description
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
Global Human Settlement Layer (GHSL)	European Commission, Joint Research Centre (JRC); Columbia University, Center for International Earth Science Information Network - CIESIN (2015): GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre (JRC)	1975, 1990, 2000, 2015	250 m (spatial)	Global estimate of human population density and distribution
SRTM Digital Elevation Model	Jarvis A., Reuter, H.I., Nelson, A., Guevara, E. (2008): Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT). URL: http://srtm.csi.cgiar.org	2000	30 m (spatial)	Global digital elevation data

Methodology:
This analysis provides the population per country separated by coastal area and inland. The coastal area is defined by a negative 10 km buffer around the African continent borders based on the GADM data set. The population of the coastal area was further separated by only taking areas into account that have an absolute altitude of 10 m or less. This was done by overlaying the population raster layer with a resampled Digital Elevation Model (SRTM). Furthermore, this population analysis provides estimated population values for the year

2030. These values were calculated by using linear regression methods on the pixel scale of the GHSL data.

Limitations:

The provided population for the year 2030 is based on simple statistical methods. Due to the low temporal resolution (only information for 4 years since 1975 available) of the population dataset, the estimated values should be taken with care.

Mangrove distribution

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
Mangrove cover	Bunting P., Rosenqvist A., Lucas R., Rebelo L-M., Hilarides L., Thomas N., Hardy A., Itoh T., Shimada M. and Finlayson C.M. (2018). The Global Mangrove Watch – a New 2010 Global Baseline of Mangrove Extent. Remote Sensing 10(10): 1669. doi: 10.3390/rs1010669. Data available online at: https://data.unep-wcmc.org/datasets/45	1996, 2007, 2008, 2009, 2010, 2015, 2016	300 m (spatial)	Global coverage of mangroves for select years from 1996 to 2016
Coastal Population	Chaplin-Kramer, R.; Sharp, R.P.; Weil, C.; Bennett, E.M.; Pascual, U.; Arkema, K.K.; Brauman, K.A.; Bryant, B.P.; Guerry, A.D.; Haddad, N.M.; others. Global modeling of nature's contributions to people. Science 2019, 366, 255–258.	2015, 2050	1 km (spatial)	Coastal Population 1–2 km close to the coastline and less than 10 m above sea level for 2015 and the Shared Socioeconomic Pathways (SSP) scenarios SSP1 SSP3 and SSP5 in 2050

Methodology:

The relative protected area of mangroves per country was computed by intersecting the PA data set with the mangrove distribution in 2016. Furthermore, the difference in mangrove coverage between 1996 and 2016 was calculated, revealing the mangrove loss within that time span. A buffer of 2 km around existing mangroves in 2016 and lost mangroves since 1996 was computed and intersected with the coastal population data by Chaplin-Kramer et al. (2019). Subsequently, the sum of all population numbers was calculated for each country.

The final products of this analysis include the lost mangrove area between 1996 and 2016, as well as the percentage of protected mangroves stands in 2016 per country. Furthermore, the number of people living along the coastline and less than 10 m above sea level that are affected by the mangrove loss since 1996 and protected by present mangrove stands are visualized.
Mean and sum values for the three indices 'Maximum Potential Benefit', 'Natures Contribution' and 'Benefit Gap in Coastal Risk Reduction' as defined by Chaplin-Kramer et al. (2019) for the year 2015 and the three future scenarios SSP1, SSP3 and SSP5 were calculated inside and outside of protected area per country. The coastal risk reduction data was hereby intersected with the PA data set. Mean and sum values for the three indices were calculated.

Limitations:

The same limitations of the used data set for protected areas apply as described in section 1. In case of coastal population data, the relatively low resolution of 1 km and the limited area coverage of 1–2 km close to the coastline might impair the quality of the analysis.

Countries with mangroves and their population in flood risk areas

Country	Number of people (2015) living in flood risk areas that benefit from coastal protection through (conserved and non-conserved) mangroves
Angola	42.641
Benin	6.799
Cameroon	931.241
Comoros	28.572
Côte d'Ivoire	43.937
Democratic Republic of the Congo	4.970
Equatorial Guinea	14.835
Gabon	143.944
Gambia	237.420
Ghana	128.490
Guinea-Bissau	186.403
Guinea	366.579
Kenya	331.863
Liberia	168.712
Madagascar	227.714
Mauritania	3.777
Mauritius	50.268
Mozambique	432.727
Nigeria	1.490.833
São Tomé and Príncipe	1.035
Senegal	65.249
Seychelles	20.705
Sierra Leone	290.149
Somalia	1.038
South Africa	92.148
Tanzania	717.218

Countries and their (future) population that lost coastal protection from mangroves through deforestation (since 1996):

Country	Population exposed to coastal risk due to mangrove deforesta-tion (2015)	Amount of people in that vulnerable area in 2050 (SSP1)	Amount of people that vulnerable area in 2050 (SSP2)	Amount of people that vulnerable area in 2050 (SSP3)
Angola	36.669	70.351	90.586	70.550
Benin	5.710	10.954	13.147	11.092
Cameroon	930.322	1.177.154	1.470.114	1.171.039
Comoros	3.345	4.473	8.297	4.181
Côte d'Ivoire	35.069	43.396	69.147	39.764
Democratic Republic of the Congo	3.169	5.704	6.589	5.711
Equatorial Guinea	8.436	15.852	18.032	16.963
Gabon	127.361	180.912	207.123	179.484
Gambia	230.080	343.307	409.405	328.097
Ghana	137.557	218.463	256.327	215.084
Guinea-Bissau	175.334	259.753	274.315	253.236
Guinea	290.149	383.156	559.568	326.100
Kenya	439.188	690.038	867.086	670.304
Liberia	147.026	327.454	377.857	359.061
Madagascar	173.517	294.257	420.712	293.358
Mauritania	3.089	5.138	6.256	4.903
Mauritius	41.798	45.296	46.868	45.931
Mozambique	387.372	607.685	688.984	601.201
Nigeria	1.699.378	3.118.307	3.697.090	3.091.570
Senegal	63.341	91.787	160.246	86.244
Seychelles	6.628	7.272	8.341	8.340
Sierra Leone	269.449	405.370	454.145	413.927
Somalia	849	1.140	2.032	956

South Africa	62.487	79.730	74.624	82.781
Tanzania	612.999	1.161.217	1.349.312	1.129.401

13 – CARBON STOCKS: SOILS

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
Soil Carbon Density	ISRIC Soil Grids – 2017. Available at: https://www.isric.org/explore/soilgrids	2017	250 m (spatial)	Organic carbon density in the topsoil (0–30 cm depth and 0–100cm depth) in tons per Ha

Methodology:
Buffers with the sizes of 5, 10 and 20 km around PAs, as well as a 1 km inner buffer from the edge to the inside of the PAs were computed and intersected with the soil carbon density raster file. Also, a PA core area was defined by subtracting the 1 km inner buffer from the PAs. The sum of pixel values for each buffer and each country based on the GADM data set were hereby calculated.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1. Furthermore, the medium resolution of 250 m of the soil carbon density data set might limit comparability for very small PAs.

Soil carbon stocks in African countries and conservation areas

Country	Total soil carbon stock in 0–30cm depth in tons	Soil carbon stock in 0–30cm depth in CAs in tons	Total soil carbon stock in 0–100cm depth in tons	Soil carbon stock in 0–100cm depth in CAs in tons
Algeria	3.966.423.456	184.126.769	8.039.121.831	435.827.875
Angola	6.529.076.488	420.235.738	12.873.983.350	930.081.244
Benin	583.586.150	146.198.975	1.027.647.738	253.300.288
Botswana	1.150.395.281	370.941.481	2.506.808.338	802.199.638
Burkina Faso	1.284.976.531	187.190.500	2.137.898.675	313.728.794
Burundi	247.419.981	15.609.463	609.498.431	36.592.925
Cameroon	3.893.461.438	478.762.769	7.683.541.163	1.006.132.494
Cape Verde	32.081.944	1.473.919	82.214.394	4.014.200

Central African Republic	4.721.343.056	792.258.194	8.576.770.706	1.422.830.206
Chad	3.854.118.719	577.990.275	7.528.987.475	1.141.916.938
Comoros	25.142.325	9.292.494	59.507.250	22.730.206
Côte d'Ivoire	1.900.360.381	434.763.313	3.485.646.850	798.377.988
Democratic Republic of the Congo	17.886.962.613	2.778.726.219	35.268.334.781	5.604.978.869
Djibouti	68.773.225	1.188.769	194.138.075	3.313.369
Egypt	1.445.168.413	212.237.919	3.128.327.338	497.957.838
Equatorial Guinea	307.072.300	72.671.019	677.911.138	169.737.131
Eritrea	417.356.450	16.226.594	1.012.442.388	43.157.806
Ethiopia	8.302.328.531	1.847.804.538	17.699.007.306	3.953.559.500
Gabon	2.822.818.488	697.798.844	6.472.761.888	1.740.303.531
Gambia	74.384.625	4.528.000	162.973.094	12.027.106
Ghana	1.263.802.644	201.654.006	2.302.155.956	370.480.075
Guinea-Bissau	315.930.200	95.040.156	687.070.906	216.060.113
Guinea	1.999.828.388	403.386.013	3.825.870.906	757.651.594
Kenya	3.050.574.713	566.527.200	6.772.382.306	1.266.377.375
Lesotho	272.667.113	71.799.394	588.743.275	155.362.175
Liberia	746.293.744	91.795.744	1.533.520.588	194.916.200
Libya	2.192.962.863	707.500	4.030.770.056	1.516.338
Madagascar	4.505.559.331	687.972.544	9.871.934.969	1.524.125.050
Malawi	514.335.656	131.017.756	1.089.792.594	280.885.238
Mali	2.980.651.456	201.963.925	5.267.768.381	359.393.588
Mauritania	1.289.983.819	9.585.594	2.334.758.006	22.293.944
Mauritius	27.545.731	1.672.300	65.839.606	3.922.094
Morocco	1.611.061.838	616.850.838	3.661.938.063	1.418.205.231

Mozambique	4.166.295.963	877.177.300	8.770.670.569	1.892.463.750
Namibia	1.438.007.206	542.758.350	3.302.369.288	1.303.482.519
Niger	1.990.678.731	243.291.056	3.517.125.063	461.537.756
Nigeria	5.124.041.400	720.807.869	9.503.447.669	1.366.034.400
Republic of Congo	2.994.553.744	475.657.388	6.689.910.231	1.041.754.019
Reunion	61.082.338	44.862.463	156.661.613	115.164.188
Rwanda	276.356.931	32.841.831	665.191.900	76.774.819
Saint Helena	9.635.844	2.553.556	25.487.813	6.852.469
São Tomé and Príncipe	18.144.138	10.553.219	46.703.119	26.904.931
Senegal	911.926.856	227.348.219	1.693.596.519	427.879.625
Senegal	911.926.856	227.348.219	1.693.596.519	427.879.625
Seychelles	7.250.350	3.542.675	19.620.181	9.937.025
Sierra Leone	613.128.000	38.398.538	1.254.204.013	76.901.194
Somalia	2.160.614.731	154.956	4.974.738.606	420.225
South Africa	5.681.702.588	1.077.175.231	12.222.264.475	2.279.960.225
South Sudan	4.347.163.569	874.389.869	8.176.667.181	1.709.137.450
Sudan	4.488.601.769	78.174.675	9.036.986.788	166.200.956
Swaziland	130.147.006	5.819.788	264.560.306	11.694.000
Tanzania	4.822.519.138	1.957.674.506	10.549.761.888	4.316.610.188
Togo	292.751.488	34.077.613	528.850.350	61.890.269
Tunisia	514.750.831	38.598.638	1.163.647.888	98.711.500
Uganda	1.948.726.481	358.425.694	4.035.475.538	744.634.281
Western Sahara	281.546.263	15.372.288	546.753.356	30.807.569
Zambia	3.984.768.281	1.551.637.781	8.296.792.788	3.243.619.256
Zimbabwe	1.538.475.894	393.981.475	3.177.311.981	822.718.069

14 — CARBON STOCKS: TREES

Dataset	Source	Date	Resolution(s)	Description
Protected Areas (PAs)	UNEP-WCMC (2017). World Database on Protected Areas User Manual 1.5. UNEP-WCMC: Cambridge, UK. Available at: http://wcmc.io/WDPA_Manual Data available at: https://www.protectedplanet.net/	2020 (January)	–	Global database of protected areas
Global Administrative Areas (GADM)	Global Administrative Areas (2018). GADM database of Global Administrative Areas, version 3.6. URL: www.gadm.org.	2018	–	Global database of the administrative boundaries
Aboveground live woody biomass density	Woods Hole Research Center. Available at: http://data.globalforestwatch.org/datasets/8f93a6f94a414f9588ce4657a39c59ff_1	2000	30 m (spatial)	Aboveground live woody biomass density in tons per Ha
Tree cover	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. 'High-Resolution Global Maps of 21st-Century Forest Cover Change.' Science 342 (15 November): 850–53. Data available online: http://earthenginepartners.appspot.com/science-2013-global-forest.	2000	30 m (spatial)	Tree cover in the year 2000, defined as canopy closure for all vegetation taller than 5 m in height.

Methodology:
The above-ground live woody biomass density was multiplied by 0.5 to estimate the carbon density in tons per Ha. The data was further subsetted to only consider forest areas with a canopy density of >= 20 % based on the treecover data set in 2000 by Hansen et al. (2013). Buffers with the sizes of 5, 10 and 20 km around PAs, as well as a 1 km inner buffer from the edge to the inside of the PAs were computed and intersected with carbon density of live woody biomass. Also, a PA core area was defined by subtracting the 1 km inner buffer from the PAs. The sum of pixel values for each buffer and each country based on the GADM data set were hereby calculated.

Limitations:
The same limitations of the used data set for protected areas apply as described in section 1.

Carbon stocks of woody vegetation in African countries and conservation areas

Country	Total carbon stock in live woody biomass in tons	Total carbon stock live woody biomass in CAs in tons	Carbon stock in live woody biomass (only forests) in tons	Carbon stock live woody biomass (only forests) in CAs in tons
Algeria	109.488.089	4.577.601	134.907.914	4.989.363
Angola	4.192.543.910	75.113.348	4.701.505.358	122.478.961
Benin	90.880.177	25.899.931	320.351.531	69.602.208
Botswana	4.200.285	3.130.175	42.454.478	19.306.182

Burkina Faso	140.415	43.940	84.628.397	16.678.410
Burundi	63.761.044	8.758.449	91.353.433	8.930.097
Cameroon	4.540.221.483	576.071.834	4.659.731.453	597.901.904
Cape Verde	NA	NA	NA	NA
Central African Republic	4.348.125.960	716.169.367	4.464.703.727	763.312.666
Chad	91.185.662	2.876.405	390.519.786	80.837.576
Comoros	17.161.776	5.854.620	17.385.689	5.917.985
Côte d'Ivoire	1.457.893.521	395.847.990	1.713.186.240	442.961.309
Democratic Republic of the Congo	25.812.239.262	3.991.467.753	25.923.056.350	4.006.412.983
Djibouti	0	0	30.061	642
Egypt	32.824.474	1.112.327	53.230.401	1.799.370
Equatorial Guinea	425.058.807	78.591.035	425.181.196	78.643.163
Eritrea	224	0	983.388	10.884
Ethiopia	1.460.830.127	520.707.147	2.040.202.035	601.350.207
Gabon	3.910.858.904	776.452.817	3.923.000.601	780.172.726
Gambia	2.546.566	73.921	18.580.613	895.691
Ghana	677.290.687	163.019.697	895.756.826	197.793.985
Guinea-Bissau	135.753.854	40.541.075	164.790.660	45.233.743
Guinea	1.059.656.579	208.567.007	1.370.741.392	316.505.290
Kenya	366.445.092	134.646.956	518.725.866	154.016.830
Lesotho	270.246	81.917	15.382.201	3.575.973
Liberia	988.685.285	123.119.888	989.754.422	123.254.924
Libya	333.053	0	1.383.617	0
Madagascar	2.057.400.392	472.116.543	2.524.984.426	495.830.174
Malawi	205.585.498	90.799.325	349.769.397	103.537.418

Mali	16.606.644	5.473.431	303.993.008	32.425.543
Mauritania	516	0	249.826	8.084
Mauritius	11.121.458	1.187.338	12.841.002	1.201.125
Morocco	61.436.406	30.459.181	91.836.772	39.079.838
Mozambique	3.192.629.286	673.502.268	3.748.427.987	776.900.484
Namibia	654.571	383.791	30.794.050	10.891.269
Niger	0	0	1.192.424	572.033
Nigeria	1.203.922.255	265.993.051	2.077.611.591	396.091.106
Republic of Congo	3.950.211.702	654.005.656	4.003.263.610	663.189.224
Reunion	22.881.650	16.740.620	23.864.811	17.335.758
Rwanda	62.937.475	17.244.761	94.816.192	18.345.798
Saint Helena	0	0	0	0
São Tomé and Príncipe	1.903.250	1.348.392	2.151.656	1.509.943
Senegal	29.546.658	8.073.313	197.137.701	50.126.483
Seychelles	431.989	422.709	523.853	509.124
Sierra Leone	471.118.471	36.032.517	486.663.245	36.170.097
Somalia	6.944.834	0	43.520.646	0
South Africa	755.220.655	192.042.047	1.149.617.776	286.581.706
South Sudan	993.806.260	167.905.310	1.415.257.447	236.455.778
Sudan	23.304.319	34.705	131.621.636	4.704.328
Swaziland	51.915.189	2.081.905	66.575.903	2.595.488
Tanzania	2.775.852.111	1.321.898.619	3.328.925.200	1.542.189.218
Togo	79.852.022	13.107.276	162.691.237	22.613.220
Tunisia	20.372.507	2.987.669	25.029.010	3.330.637
Uganda	602.391.094	161.686.785	699.679.169	175.788.521
Western Sahara	0	0	6.110	1
Zambia	2.815.556.203	1.114.543.555	3.478.115.232	1.375.959.037
Zimbabwe	206.803.950	47.562.583	618.204.564	175.162.598

Annex 2
References and further suggested readings

Abd El-Ghani, M. M. (2016). Traditional medicinal plants of Nigeria: an overview. *Agriculture and Biology Journal of North America*, 7(5), 220–247.

Adeogun, A. G., Sule, B. F., & Salami, A. W. (2018). Cost effectiveness of sediment management strategies for mitigation of sedimentation at Jebba Hydropower reservoir, Nigeria. *Journal of King Saud University-Engineering Sciences*, 30(2), 141–149.

Africa Progress Panel (2015). Energy, Planet and Population. 2015 Progress Report on Africa, Africa Progress Panel, Geneva.

Ahmed, M., Al-Dousari, N., & Al-Dousari, A. (2016). The role of dominant perennial native plant species in controlling the mobile sand encroachment and fallen dust problem in Kuwait. *Arabian Journal of Geosciences,* 9(2), 134.

Alexander, K. A., Sanderson, C. E., Marathe, M., Lewis, B. L., Rivers, C. M., Shaman, J., ... & Eubank, S. (2015). What factors might have led to the emergence of Ebola in West Africa?. *PLoS Negl Trop Dis*, *9*(6), e0003652.

Allan, J. R., Possingham, H. P., Atkinson, S. C., Waldron, A., Di Marco, M., Adams, V. M., ... & Watson, J. E. (2019). Conservation attention necessary across at least 44% of Earth's terrestrial area to safeguard biodiversity. *bioRxiv*, 839977.

Alleyne, M. T. S. C., & Hussain, M. M. (2013). *Energy subsidy reform in Sub-Saharan Africa: Experiences and lessons.* International Monetary Fund.

Amusa, T. O., & Jimoh, S. O. (2010). Ethnobotany and conservation of plant resources of Kainji Lake National Park, Nigeria. *Ethnobotany Research and Applications*, 8, 181–194.

Annandale, G. (2014, September). Sustainable water supply, climate change and reservoir sedimentation management: Technical and economical viability. In *Proceedings of River Flow* (pp. 3–10).

Annandale, G. W., Morris, G. L., & Karki, P. (2016). *Extending the life of reservoirs: sustainable sediment management for dams and run-of-river hydropower.* The World Bank.

Anyinam, C., Kalipeni, E., & Zeleza, P. T. (1999). Ethnomedicine, sacred spaces, and ecosystem preservation and conservation in Africa. *Sacred Spaces and Public Quarrels: African Cultural and Economic Landscapes*, 127–46.

Arias, M. E., Cochrane, T. A., Lawrence, K. S., Killeen, T. J., & Farrell, T. A. (2011). Paying the forest for electricity: a modelling framework to market forest conservation as payment for ecosystem services benefiting hydropower generation. *Environmental Conservation*, 473–484.

Aswani, S., Lemahieu, A., & Sauer, W. H. (2018). Global trends of local ecological knowledge and future implications. *PLoS One*, *13*(4), e0195440.

Baade, J., Franz, S., & Reichel, A. (2012). Reservoir siltation and sediment yield in the Kruger National Park, South Africa: a first assessment. *Land Degradation & Development,* 23(6), 586–600.

Barbier, E. B. (2016). The protective service of mangrove ecosystems: A review of valuation methods. *Marine pollution bulletin*, 109(2), 676–681.

Balmford, A., Green, J. M., Anderson, M., Beresford, J., Huang, C., Naidoo, R., ... & Manica, A. (2015). Walk on the wild side: estimating the global magnitude of visits to protected areas. *PLoS Biol*, *13*(2), e1002074.

Belhabib, D., Sumaila, U. R., & Pauly, D. (2015). Feeding the poor: contribution of West African fisheries to employment and food security. Ocean & Coastal Management, 111, 72–81.

Bauer, D. M., & Wing, I. S. (2016). The macroeconomic cost of catastrophic pollinator declines. *Ecological Economics*, *126*, 1–13.

Bauhoff, S., & Busch, J. (2020). Does deforestation increase malaria prevalence? Evidence from satellite data and health surveys. *World Development*, *127*, 104734.

Berghöfer, A., Brown, C., Bruner, A., Emerton, L., Esen, E., Geneletti, D., ... & van Zyl, H. (2016). Increasing the policy impact of ecosystem service assessments and valuations.

Berghöfer, A., Berger, J., Koné, I., Tröger, U., & Caspary, H. U. (2018). Ecosystem services for conservation finance: applying the TEEB stepwise approach in Côte d'Ivoire. *Biodiversity and Conservation*, *27*(11), 2897–2917.

Belhabib, D., Sumaila, U. R., & Le Billon, P. (2019). The fisheries of Africa: Exploitation, policy, and maritime security trends. *Marine Policy*, *101*, 80–92.

Betti, J. L., & Yemefarsquo, S. M. (2011). An ethnobotanical study of medicinal plants used in the Kalamalou National Park, Cameroon. *Journal of Medicinal Plants Research*, *5*(8), 1447–1458.

Beyi, M. W. (2018). Traditional medicinal plants in Ethiopia. *International Journal of Biology Physics and Mathematics*, *1*(1), 80–87.

Binet, T., Failler, P., Chavance, P. N., & Mayif, M. A. (2013). First international payment for marine ecosystem services: The case of the Banc d'Arguin National Park, Mauritania. *Global environmental change*, *23*(6), 1434–1443.

Birhanu, Z., Endale, A., & Shewamene, Z. (2015). An ethnomedicinal investigation of plants used by traditional healers of Gondar town, North-Western Ethiopia. *Journal of medicinal plants studies*, *3*(2), 36–43.

Brooks, K.N., Tayaa, M. (2002). Planning and Managing Soil and Water Resources in Drylands: Role of Watershed Management. Proceedings of the International Arid Land Consortium (IALC) Conference and Workshop, October 20–25, 2002. http://www.ialcworld.org/conference/Pres-pdf/brta1p1.pdf

Butt, B. (2016). Conservation, Neoliberalism, and Human Rights in Kenya's Arid Lands. *Humanity: An International Journal of Human Rights, Humanitarianism, and Development*, *7*(1), 91–110.

Büscher, B., Sullivan, S., Neves, K., Igoe, J., & Brockington, D. (2012). Towards a synthesized critique of neoliberal biodiversity conservation. *Capitalism nature socialism*, *23*(2), 4–30.

Chaplin-Kramer, R., Sharp, R. P., Weil, C., Bennett, E. M., Pascual, U., Arkema, K. K., ... & Daily, G. C. (2019). Global modeling of nature's contributions to people. *Science*, *366*(6462), 255–258.

Cherlet, M., Hutchinson, C., Reynolds, J., Hill, J., Sommer, S., & Von Maltitz, G. (Eds.). (2018). *World atlas of desertification: Rethinking land degradation and sustainable land management.* Publications Office of the European Union.

Coady, M. D., Parry, I. W., Sears, L., & Shang, B. (2015). *How large are global energy subsidies?.* International Monetary Fund.

Convention on Biological Biodiversity (CBD). (2020). Report of the regional consultation on the Post-2020 Global Biodiversity Framework for Africa, Addis Ababa, 2–5 April 2019 (online https://www.cbd.int/doc/c/4d65/91f8/656151e96c315bed75d87cb8/post2020-ws-2019-03-02-en.pdf)

Costanza, R., & Daly, H. E. (1992). Natural capital and sustainable development. *Conservation biology*, *6*(1), 37–46.

Costanza, R. (1997). d' Arge R, deGroot R, FarberS, GrassoM, Hannon B, LimburgK, NaeemS, O' Neill RV, ParueloJ, Raskin RG, Sutton P, van den Belt M. The value of the world' s ecosystem services and natural capital. *Nature*, *387*(6630), 253.

Dale, A., Fant, C., Strzepek, K., Lickley, M., & Solomon, S. (2017). Climate model uncertainty in impact assessments for agriculture: A multi-ensemble case study on maize in sub-Saharan Africa. *Earth's Future*, *5*(3), 337–353.

Dasgupta, S., Laplante, B., Murray, S., & Wheeler, D. (2011). Exposure of developing countries to sea-level rise and storm surges. *Climatic Change*, *106*(4), 567–579.

Dasgupta, P. (2021). The Economics of Biodiversity: the Dasgupta Review.

Daskin, J. H., & Pringle, R. M. (2018). Warfare and wildlife declines in Africa's protected areas. *Nature*, *553*(7688), 328–332.

Davies, J. (2017). Biodiversity and the Great Green Wall: managing nature for sustainable development in the Sahel. *Ouagadougou: IUCN*, *xiv*.

d'Amour, C. B., Reitsma, F., Baiocchi, G., Barthel, S., Güneralp, B., Erb, K. H., ... & Seto, K. C. (2017). Future urban land expansion and implications for global croplands. Proceedings of the National Academy of Sciences, 114(34), 8939-8944.

Demissie, T. A., Saathoff, F., Seleshi, Y., & Gebissa, A. (2013). Evaluating the effectiveness of best management practices in Gilgel Gibe Basin watershed-Ethiopia. *Journal of Civil Engineering and Architecture*, *7*(10), 1240.

Decher, J. (1997). Conservation, small mammals, and the future of sacred groves in West Africa. *Biodiversity & Conservation*, *6*(7), 1007–1026.

De Graaf, G., & Garibaldi, L. (2014). The value of African fisheries (FAO Fisheries and Aquaculture Circular No. 1093). *Rome: FAO.*

De Groot, R. S., Blignaut, J., Van Der Ploeg, S., Aronson, J., Elmqvist, T., & Farley, J. (2013). Benefits of investing in ecosystem restoration. *Conservation Biology*, *27*(6), 1286–1293.

Deutz, A., Heal, G. M., Niu, R., Swanson, E., Townshend, T., Zhu, L., ... & Tobin-de la Puente, J. (2020). Financing Nature: Closing the Global Biodiversity Financing Gap. *The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability)* https://www. nature. org/enus/what-we-do/our-insights/reports/financing-nature-biodiversity-report.

Devi, R., Tesfahune, E., Legesse, W., Deboch, B., & Beyene, A. (2008). Assessment of siltation and nutrient enrichment of Gilgel Gibe dam, Southwest Ethiopia. *Bioresource Technology*, *99*(5), 975–979.

De Waroux, Y. L. P., & Lambin, E. F. (2012). Monitoring degradation in arid and semi-arid forests and woodlands: the case of the argan woodlands (Morocco). *Applied Geography*, *32*(2), 777–786.

Dimopoulos, D. (2018). *External risks impacting on the scuba diving industry in the East African Marine Ecoregion* (Doctoral dissertation).

Directorate-General for Communication European Commission. (2017). Larger than elephants: inputs for an EU strategic approach to wildlife conservation in Africa. *Botswana documents.*

Dos Santos, S., Adams, E. A., Neville, G., Wada, Y., De Sherbinin, A., Bernhardt, E. M., & Adamo, S. B. (2017). Urban growth and water access in sub-Saharan Africa: Progress, challenges, and emerging research directions. *Science of the Total Environment*, 607, 497–508.

Dowie, M. (2011). *Conservation refugees: the hundred-year conflict between global conservation and native peoples.* MIT press.

Dudley, N. (Ed.). (2008). *Guidelines for applying protected area management categories.* IUCN.

Dudley, N., Bhagwat, S., Higgins-Zogib, L., Lassen, B., Verschuuren, B., & Wild, R. (2012). Conservation of biodiversity in sacred natural sites in Asia and Africa: a review of the scientific literature. *Sacred natural sites*, 45–58.

Dudley, N., MacKinnon, K., & Stolton, S. (2014). The role of protected areas in supplying ten critical ecosystem services in drylands: a review. *Biodiversity*, *15*(2–3), 178–184.

Dudley, N., Jonas, H., Nelson, F., Parrish, J., Pyhälä, A., Stolton, S., & Watson, J. E. (2018). The essential role of other effective area-based conservation measures in achieving big bold conservation targets. *Global ecology and conservation*, *15*, e00424.

Duffy, R., Massé, F., Smidt, E., Marijnen, E., Büscher, B., Verweijen, J., ... & Lunstrum, E. (2019). Why we must question the militarisation of conservation. *Biological Conservation*, *232*, 66–73.

Ekumah, B., Armah, F. A., Afrifa, E. K., Aheto, D. W., Odoi, J. O., & Afitiri, A. R. (2020). Geospatial assessment of ecosystem health of coastal urban wetlands in Ghana. *Ocean & Coastal Management*, *193*, 105226

Equilibrium Research (2020). Making Money Local: Can Protected Areas Deliver Both Economic Benefits and Conservation Objectives. Technical Series No. X, Secretariat of the Convention on Biological Diversity. Montreal, 81 pages.

ELD & UNEP (2015). The Economics of Land Degradation in Africa: Benefits of Action Outweigh the Costs. Available from www.eld-initiative.org.

IEA (2019). World Energy Outlook 2019, OECD Publishing, Paris, https://doi.org/10.1787/caf32f3b-en.

Elliff, C. I., & Silva, I. R. (2017). Coral reefs as the first line of defense: Shoreline protection in face of climate change. *Marine environmental research*, *127*, 148–154.

Elujoba, A. A., Odeleye, O. M., & Ogunyemi, C. M. (2005). Traditional medicine development for medical and dental primary health care delivery system in Africa. *African Journal of Traditional, Complementary and Alternative Medicines*, *2*(1), 46–61.

Emerton, L., Iyango, L., Luwum, P., & Malinga, A. (1999). The present economic value of Nakivubo urban wetland, Uganda. *IUCN, Biodiversity economics for Eastern Africa National Wetlands, Conservation & management programme.*

Emerton, L. (2001). Why forest values are important to East Africa. *ACTS Innovation*, *8*(2), 5.

Emerton, Lucy (2008). Making the Economic Case: A Primer on the Economic Arguments for Mainstreaming Poverty-Environment Linkages into National Development Planning: UNDP-UNEP Poverty-Environment Initiative, Nairobi.

Fa, J. E., Olivero, J., Real, R., Farfán, M. A., Márquez, A. L., Vargas, J. M., ... & Nasi, R. (2015). Disentangling the relative effects of bushmeat availability on human nutrition in central Africa. *Scientific reports*, *5*(1), 1–8.

FAO (2011). Global food losses and food waste—extent, causes and prevention. Rome: UN FAO.

FAO (2017). The Future of Food and Agriculture: Trends and Challenges. Rome: FAO.

FAO (2017). The State of Food Security and Nutrition in the World 2017. Building resilience for peace and food security. Rome.

FAO (2018). The State of World Fisheries and Aquaculture 2018 – Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO.

FAO and ECA (2018). Regional Overview of Food Security and Nutrition. Addressing the threat from climate variability and extremes for food security and nutrition. Accra. 116 pp

FAO, CIRAD, CIFOR and WCS. (2020). White paper: Build back better in a post-COVID-19 world – Reducing future wildlife-borne spillover of disease to humans: Sustainable Wildlife Management (SWM) Programme. Rome.

FAO, IFAD, UNICEF, WFP and WHO. (2020). The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets

FAO (2020b). The state of food security and nutrition in the world 2020: Transforming food systems for affordable healthy diets. Vol. 2020. UN Food & Agriculture Organization, Rome.

FAO (2020c). Global Forest Resources Assessment 2020: Main report. Rome. https://doi.org/10.4060/ca9825en

Farinosi, F., Giupponi, C., Reynaud, A., Ceccherini, G., Carmona-Moreno, C., De Roo, A., ... & Bidoglio, G. (2018). An innovative approach to the assessment of hydro-political risk: A spatially explicit, data driven indicator of hydro-political issues. *Global Environmental Change*, *52*, 286–313.

Flavien, N. B., Vanhove, W., Termote, C., & Van Damme, P. (2016). Importance of traditional protected areas for the collection of medicinal plants, Kongo-Central (DRC). *African Journal of Ecology*, *54*(4), 479–487.

Faust, C. L., McCallum, H. I., Bloomfield, L. S., Gottdenker, N. L., Gillespie, T. R., Torney, C. J., ... & Plowright, R. K. (2018). Pathogen spillover during land conversion. *Ecology letters*, *21*(4), 471–483.

Fletcher, R., Massarella, K., Kotahri, A., Das, P., Dutta, A., & Büscher, B. E. (2020). A new future for conservation: setting out the principles of post-growth conservation.

Feyisa, G. L., Dons, K., & Meilby, H. (2014). Efficiency of parks in mitigating urban heat island effect: An example from Addis Ababa. *Landscape and urban planning*, *123*, 87–95.

Frankfurt Zoological Society (FZS). (2007). Bale Mountains National Park General Management Plan 2007 – 2017. FZS, Ethiopia.

Frick-Trzebitzky, F., Baghel, R., & Bruns, A. (2017). Institutional bricolage and the production of vulnerability to floods in an urbanising

delta in Accra. International journal of disaster risk reduction, 26, 57–68.
Gassner A., Dobie, P., Sunderland, T. (2021). Africa: New Targets to Protect Biodiversity Must Include Farmers and Agriculture. All Africa online magazine (published 3. February 2021) https://allafrica.com/stories/202102040104.html [accessed 15.06.2021]

Garibaldi, L. A., Carvalheiro, L. G., Vaissière, B. E., Gemmill-Herren, B., Hipólito, J., Freitas, B. M., ... & Zhang, H. (2016). Mutually beneficial pollinator diversity and crop yield outcomes in small and large farms. *Science*, *351*(6271), 388–391.

Geisler, C. C. (2002). Endangered humans. *Foreign policy*, (130), 80.

Gavin, M. C., McCarter, J., Berkes, F., Mead, A. T. P., Sterling, E. J., Tang, R., & Turner, N. J. (2018). Effective biodiversity conservation requires dynamic, pluralistic, partnership-based approaches. *Sustainability*, *10*(6), 1846.

Gizachew, B., & Duguma, L. A. (2016). Forest carbon monitoring and reporting for REDD+: what future for Africa?. *Environmental management*, *58*(5), 922–930.

GIZ (2021). Ethiopian Protected Areas Creating Value and Supporting Development. The case of Borena-Sayint Worehimeno National Park, Chebera Churchura National Park, Simien Mountains National Park and Bale Mountains National Park.

Global fishing watch: https://globalfishingwatch.org/ data downloaded December 19, 2019

Gosling, S. N., & Arnell, N. W. (2016). A global assessment of the impact of climate change on water scarcity. *Climatic Change*, *134*(3), 371–385.

Jusot, J. F., Neill, D. R., Waters, E. M., Bangert, M., Collins, M., Moreno, L. B., ... & Kadioglu, A. (2017). Airborne dust and high temperatures are risk factors for invasive bacterial disease. *Journal of Allergy and Clinical Immunology*, *139*(3), 977–986.

Hansis, E., Davis, S. J., & Pongratz, J. (2015). Relevance of methodological choices for accounting of land use change carbon fluxes Special Section.

Harrison, I. J., Green, P. A., Farrell, T. A., Juffe-Bignoli, D., Sáenz, L., & Vörösmarty, C. J. (2016). Protected areas and freshwater provisioning: a global assessment of freshwater provision, threats and management strategies to support human water security. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 26, 103–120.

Hathaway, T. (2008). What cost Ethiopia's dam boom. *A look inside the Expansion of Ethiopia's Energy Sector: International Rivers, people water, life.*

Higginbottom, T. P., & Symeonakis, E. (2020). Identifying Ecosystem Function Shifts in Africa Using Breakpoint Analysis of Long-Term NDVI and RUE Data. *Remote Sensing*, *12*(11), 1894.

Hinkel, J., Brown, S., Exner, L., Nicholls, R. J., Vafeidis, A. T., & Kebede, A. S. (2012). Sea-level rise impacts on Africa and the effects of mitigation and adaptation: an application of DIVA. *Regional Environmental Change*, *12*(1), 207–224.

Hein, L., & Gatzweiler, F. (2006). The economic value of coffee (Coffea arabica) genetic resources. *Ecological economics*, *60*(1), 176–185.

Houghton, R. A., & Nassikas, A. A. (2017). Global and regional fluxes of carbon from land use and land cover change 1850–2015. *Global Biogeochemical Cycles*, *31*(3), 456–472.

Hockings, M., Dudley, N., Elliott, W., Ferreira, M. N., Mackinnon, K., Pasha, M. K. S., ... & Yang, A. (2020). Editorial essay: Covid-19 and protected and conserved areas. *Parks*, *26*(1).

Howard, J., Sutton-Grier, A., Herr, D., Kleypas, J., Landis, E., Mcleod, E., ... & Simpson, S. (2017). Clarifying the role of coastal and marine systems in climate mitigation. *Frontiers in Ecology and the Environment*, *15*(1), 42–50.

Herslund, L., Backhaus, A., Fryd, O., Jørgensen, G., Jensen, M. B., Limbumba, T. M., ... & Yeshitela, K. (2018). Conditions and opportunities for green infrastructure–Aiming for green, water-resilient cities in Addis Ababa and Dar es Salaam. *Landscape and urban planning*, *180*, 319–327.

Hove, H., Parry, J. E., & Lujara, N. (2010). Maintenance of hydropower potential in Rwanda through ecosystem restoration. *World Resources Report, Washington DC.*

Hunter, R. F., Cleland, C., Cleary, A., Droomers, M., Wheeler, B. W., Sinnett, D., ... & Braubach, M. (2019). Environmental, health, well-being, social and equity effects of urban green space interventions: A meta-narrative evidence synthesis. *Environment international*, *130*, 104923.

Hulton, G., & World Health Organization. (2012). *Global costs and benefits of drinking-water supply and sanitation interventions to reach the MDG target and universal coverage* (No. WHO/HSE/WSH/12.01). World Health Organization.

Ibisch, P. L., & Hobson, P. (2014). *Marisco: adaptative management of vulnerability and rish at conservation sites. A guide book for risk-robust, adaptative and ecosystem-based conservation of biodiversity.*

IFAD (2011). Rural Poverty Report 2011: Overview. International Fund for Agricultural Development, Rome.

International Hydropower Association (IHA) (2019). 2019 Hydropower status report. Sector trends and insights.

International Hydropower Association (IHA) (2020). 2020 Hydropower status report. Sector trends and insights. https://www.hydropower.org/publications/2020-hydropower-status-report

IMF (2020). Regional Economic Outlook. Sub-Saharan Africa. https://www.imf.org/en/Publications/REO/SSA/Issues/2021/04/15/regional-economic-outlook-for-sub-saharan-africa-april-2021

IPCC (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

IPCC (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 688.

IPCC (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

IPCC (2019). IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press.
ISU 2015. International Sustainability Unit (2015) Tropical Forests, A Review. The Prince's Charities' International Sustainability Unit, London. http://www.pcfisu.org/resources/

IPBES 2016. Preliminary guide regarding diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services (deliverable 3 (d)). IPBES/4/INF/13 - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPBES (2018). The IPBES regional assessment report on biodiversity and ecosystem services for Africa. Hg. v. Archer, E. Dziba, L., Mulongoy, K. J., Maoela, M. A., and Walters, M. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem. Bonn, Germany.

IPBES (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany.

IPBES (2020). Escaping the era of pandemics. Workshop Report. https://www.ipbes.net/pandemics

IUCN ESARO (2020). The state of protected and conserved areas in Eastern and Southern Africa. State of Protected and Conserved Areas Report Series No. 1. Nairobi, Kenya: IUCN ESARO.

Karutz, R., Berghöfer, A., Moore, L.R., van Wyk, E., (2019). A thematic atlas of nature's benefits to Dar es Salaam: Critical reasons for greening the city and for keeping urban and peri-urban ecosystems intact.

Helmholtz Centre for Environmental Research – UFZ ; ICLEI Local Governments for Sustainability – Africa Secretariat, Leipzig, Germany;

Cape Town, South Africa, 76 pp.

Kauffman, J. B., & Bhomia, R. K. (2017). Ecosystem carbon stocks of mangroves across broad environmental gradients in West-Central Africa: global and regional comparisons. *PloS one*, *12*(11), e0187749.

Kerwath, S. E., Winker, H., Götz, A., & Attwood, C. G. (2013). Marine protected area improves yield without disadvantaging fishers. *Nature communications*, *4*(1), 1–6.

Kidane, D., & Alemu, B. (2015). The effect of upstream land use practices on soil erosion and sedimentation in the Upper Blue Nile Basin, Ethiopia. *Research Journal of Agriculture and Environmental Management*, *4*(2), 55–68.

Kopnina, H., Washington, H., Gray, J., & Taylor, B. (2018). The 'future of conservation'debate: Defending ecocentrism and the Nature Needs Half movement. *Biological Conservation*, *217*, 140–148.

Korkovelos, A., Mentis, D., Siyal, S. H., Arderne, C., Rogner, H., Bazilian, M., ... & De Roo, A. (2018). A geospatial assessment of small-scale hydropower potential in sub-Saharan Africa. *Energies*, *11*(11), 3100.

Kwashirai, V. C. (2012). Environmental History of Africa. Center of Environmental History, University of Sussex.

Labouisse, J. P., Bellachew, B., Kotecha, S., & Bertrand, B. (2008). Current status of coffee (Coffea arabica L.) genetic resources in Ethiopia: implications for conservation. *Genetic Resources and Crop Evolution*, *55*(7), 1079.

Lange, G. M., Wodon, Q., & Carey, K. (Eds.). (2018). *The changing wealth of nations 2018: Building a sustainable future.* The World Bank.

Lapworth, D. J., Nkhuwa, D. C. W., Okotto-Okotto, J., Pedley, S., Stuart, M. E., Tijani, M. N., & Wright, J. J. H. J. (2017). Urban groundwater quality in sub-Saharan Africa: current status and implications for water security and public health. *Hydrogeology Journal*, *25*(4), 1093–1116.

Leberger, R., Rosa, I. M., Guerra, C. A., Wolf, F., & Pereira, H. M. (2020). Global patterns of forest loss across IUCN categories of protected areas. *Biological Conservation*, *241*, 108299.

Leendertz, S. A. J., Wich, S. A., Ancrenaz, M., Bergl, R. A., Gonder, M. K., Humle, T., & Leendertz, F. H. (2017). Ebola in great apes – current knowledge, possibilities for vaccination, and implications for conservation and human health. *Mammal Review*, *47*(2), 98–111.

Lewis, S. L., Lopez-Gonzalez, G., Sonké, B., Affum-Baffoe, K., Baker, T. R., Ojo, L. O., ... & Wöll, H. (2009). Increasing carbon storage in intact African tropical forests. *Nature*, *457*(7232), 1003–1006.

Lindsey, P. A., Petracca, L. S., Funston, P. J., Bauer, H., Dickman, A., Everatt, K., ... & Hunter, L. T. B. (2017). The performance of African protected areas for lions and their prey. *Biological Conservation*, *209*, 137–149.

Lopoukhine, N., Crawhall, N., Dudley, N., Figgis, P., Karibuhoye, C., Laffoley, D., ... & Sandwith, T. (2012). Protected areas: providing natural solutions to 21st Century challenges. *SAPI EN. S. Surveys and Perspectives Integrating Environment and Society*, (5.2).

Madzwamuse, M., Rihoy, E., & Louis, M. (2020). Contested conservation: Implications for rights, democratization, and citizenship in Southern Africa. *Development*, *63*(1), 67–73

Mafuta, C., Formo, R. K., Nellemann, C., and Li, F. (eds). (2011). Green Hills, Blue Cities: An Ecosystems Approach to Water Resources Management for African Cities. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal.

Mash, R., Howe, A., Olayemi, O., Makwero, M., Ray, S., Zerihun, M., ... & Goodyear-Smith, F. (2018). Reflections on family medicine and primary healthcare in sub-Saharan Africa.

Mazarrasa, I., Marbà, N., Lovelock, C. E., Serrano, O., Lavery, P. S., Fourqurean, J. W., ... & Duarte, C. M. (2015). Seagrass meadows as a globally significant carbonate reservoir. *Biogeosciences*, *12*(16), 4993–5003.

McClanahan, T. R., Muthiga, N. A., Kamukuru, A. T., Machano, H., & Kiambo, R. W. (1999). The effects of marine parks and fishing on coral reefs of northern Tanzania. *Biological Conservation*, *89*(2), 161–182.

McClanahan, T. R., Graham, N. A., Calnan, J. M., & MacNeil, M. A. (2007). Toward pristine biomass: reef fish recovery in coral reef marine protected areas in Kenya. *Ecological applications*, *17*(4), 1055–1067.

McDonald, R. I., Weber, K. F., Padowski, J., Boucher, T., & Shemie, D. (2016). Estimating watershed degradation over the last century and its impact on water-treatment costs for the world's large cities. *Proceedings of the National Academy of Sciences*, *113*(32), 9117–9122.

MacDonald, A. J., & Mordecai, E. A. (2019). Amazon deforestation drives malaria transmission, and malaria burden reduces forest clearing: a retrospective study. *The Lancet Planetary Health*, *3*, S13.

Mahomoodally, F., Samoisy, A. K., & Suroowan, S. (2019). Ethnozoological practices in Rodrigues island of the Mascarene archipelago. *Journal of ethnopharmacology*, *245*, 112163.

Maganga, G. D., Kapetshi, J., Berthet, N., Kebela Ilunga, B., Kabange, F., Mbala Kingebeni, P., ... & Leroy, E. M. (2014). Ebola virus disease in the Democratic Republic of Congo. *New England Journal of Medicine*, *371*(22), 2083–2091.

Mander, M., Asfaw, Z., Emana, B., & Badassa, B. (2006). Marketing of medicinal plants in Ethiopia. a survey of the trade in medicinal plants.

Markandya, A., Taylor, T., Longo, A., Murty, M. N., Murty, S., & Dhavala, K. (2008). Counting the cost of vulture decline – an appraisal of the human health and other benefits of vultures in India. *Ecological economics*, *67*(2), 194–204.

Marselle, M. R., Stadler, J., Korn, H., Irvine, K. N., & Bonn, A. (Eds.). (2019). Biodiversity and health in the face of climate change (p. 490). Springer International Publishing.

Mayaux, P., Pekel, J. F., Desclée, B., Donnay, F., Lupi, A., Achard, F., ... & Belward, A. (2013). State and evolution of the African rainforests between 1990 and 2010. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *368*(1625), 20120300.

MET/NACSO. (2018). The state of community conservation in Namibia – a review of communal conservancies, community forests and other CBNRM activities (Annual Report 2017). MET/NACSO, Windhoek.
http://www.nacso.org.na/sites/default/files/State%20of%20Community%20Conservation%20book%20web_0.pdf

Möller, I., Kudella, M., Rupprecht, F., Spencer, T., Paul, M., Van Wesenbeeck, B. K., ... & Schimmels, S. (2014). Wave attenuation over coastal salt marshes under storm surge conditions. *Nature Geoscience*, *7*(10), 727–731.

Moges, A., & Moges, Y. (2019). Ethiopian Common Medicinal Plants: Their Parts and Uses in Traditional Medicine-Ecology and Quality Control. *Plant Science-Structure, Anatomy and Physiology in Plants Cultured in Vivo and in Vitro.*

Moran, E. F., Lopez, M. C., Moore, N., Müller, N., & Hyndman, D. W. (2018). Sustainable hydropower in the 21st century. *Proceedings of the National Academy of Sciences*, *115*(47), 11891–11898.

Moyo, M., Aremu, A. O., & Van Staden, J. (2015). Medicinal plants: an invaluable, dwindling resource in sub-Saharan Africa. *Journal of Ethnopharmacology*, *174*, 595–606.

Mugisha, P., Kansiime, F., Mucunguzi, P., & Kateyo, E. (2007). Wetland vegetation and nutrient retention in Nakivubo and Kirinya wetlands in the Lake Victoria basin of Uganda. *Physics and Chemistry of the Earth, Parts A/B/C*, *32*(15-18), 1359–1365.

Narayan S, Beck MW, Reguero BG, Losada IJ, van Wesenbeeck B, Pontee N, et al. (2016) The Effectiveness, Costs and Coastal Protection Benefits of Natural and Nature-Based Defences. PLoS ONE 11(5): e0154735. https://doi.org/10.1371/journal.pone.0154735

NASA (2019). Devastation in Mozambique. NASA Earth Observatory. Online publication.
https://earthobservatory.nasa.gov/images/144712/devastation-in-mozambique

Nasi, R., Taber, A., & Van Vliet, N. (2011). Empty forests, empty stomachs? Bushmeat and livelihoods in the Congo and Amazon Basins. *International Forestry Review*, *13*(3), 355–368.

Nasi, R., & Fa, J. E. (2015, September). The role of bushmeat in food security and nutrition. In *Research Gate. XIVWORLD FORESTRY CONGRESS, Durban, South Africa.*

Nel, J. L., Le Maitre, D. C., Roux, D. J., Colvin, C., Smith, J. S., Smith-Adao, L. B., ... & Sitas, N. (2017). Strategic water source areas for urban water security: Making the connection between protecting ecosystems and benefiting from their services. *Ecosystem Services*, *28*, 251–259.

Neumann, B., Vafeidis, A. T., Zimmermann, J., & Nicholls, R. J. (2015). Future coastal population growth and exposure to sea-level rise and coastal flooding-a global assessment. *PloS one*, *10*(3), e0118571.

Newbold, T., Hudson, L. N., Arnell, A. P., Contu, S., De Palma, A., Ferrier, S., ... & Purvis, A. (2016). Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. *Science*, *353*(6296), 288–291.

Nuwer, R. (2020). A radical reset for conservation in Africa. Yes Magazine – Solutions Journalism (December 2020). https://www.yesmagazine.org/environment/2020/12/14/africa-tourism-conservation-communities [accessed 15.06.2021]

Odette, K. N., Ruth, K. M., Blaise, B. K., Clément, B. I., Kabamba, N., Nadège, P. T., ... & Félicien, L. L. (2018). Étude ethnobotanique des plantes utilisées par les Pygmées pour la santé de la reproduction à Mbandaka et ses environs/Province de l'Equateur, RD Congo [Ethnobotanical study of plants used by Pygmies for reproductive health in Mbandaka and surrounding areas/Equateur Province, DR Congo].

Ogada, D., Shaw, P., Beyers, R. L., Buij, R., Murn, C., Thiollay, J. M., ... & Sinclair, A. R. (2016). Another continental vulture crisis: Africa's vultures collapsing toward extinction. *Conservation Letters*, *9*(2), 89–97.

Okigbo, R. N., Eme, U. E., & Ogbogu, S. (2008). Biodiversity and conservation of medicinal and aromatic plants in Africa. *Biotechnology and Molecular Biology Reviews*, *3*(6), 127–134.

Okuku, E. O., Bouillon, S., Ochiewo, J. O., Munyi, F., Kiteresi, L. I., & Tole, M. (2016). The impacts of hydropower development on rural livelihood sustenance. *International Journal of Water Resources Development*, *32*(2), 267–285.

Oliver, T. A., Oleson, K. L., Ratsimbazafy, H., Raberinary, D., Benbow, S., & Harris, A. (2015). Positive catch & economic benefits of periodic octopus fishery closures: do effective, narrowly targeted actions 'catalyze'broader management? *PLoS One*, *10*(6), e0129075.

Olivero, J., Fa, J. E., Real, R., Farfán, M. Á., Márquez, A. L., Vargas, J. M., ... & Nasi, R. (2017). Mammalian biogeography and the Ebola virus in Africa. *Mammal Review*, *47*(1), 24–37.

Olivero, J., Fa, J. E., Farfán, M. Á., Márquez, A. L., Real, R., Juste, F. J., ... & Nasi, R. (2020). Human activities link fruit bat presence to Ebola virus disease outbreaks. *Mammal Review*, *50*(1), 1–10.

Orgiazzi, A., Bardgett, R. D., & Barrios, E. (2016). *Global soil biodiversity atlas.* European Commission.

Parkes, B., Cronin, J., Dessens, O., & Sultan, B. (2019). Climate change in Africa: costs of mitigating heat stress. *Climatic Change*, *154*(3), 461–476.

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M., ... & Yagi, N. (2017). Valuing nature's contributions to people: the IPBES approach. *Current Opinion in Environmental Sustainability*, *26*, 7–16.

Pendleton, L., Donato, D. C., Murray, B. C., Crooks, S., Jenkins, W. A., Sifleet, S., ... & Baldera, A. (2012). Estimating global 'blue carbon' emissions from conversion and degradation of vegetated coastal ecosystems. *PloS one*, *7*(9), e43542.Pereira, L. (2017). Climate change impacts on agriculture across Africa. *Oxford Research Encyclopedia of Environmental Science.*

Ploton, P., Mortier, F., Barbier, N., Cornu, G., Réjou-Méchain, M., Rossi, V., ... & Gourlet-Fleury, S. (2020). A map of African humid tropical forest aboveground biomass derived from management inventories. *Scientific data*, *7*(1), 1–13.

Potts, S. G., Imperatriz-Fonseca, V., Ngo, H. T., Aizen, M. A., Biesmeijer, J. C., Breeze, T. D., ... & Vanbergen, A. J. (2016). Safeguarding pollinators and their values to human well-being. *Nature*, *540*(7632), 220–229.

Rakotonandrasana, S. R. (2013). Les plantes médicinales de l'aire protégée de Zahamena (Madagascar) et de ses environs: richesse floristique et endémicité. *Scripta Botanica Belgica*, *50*, 356–362.

Ritchie, H. & Roser, M. (2020). 'CO_2 and Greenhouse Gas Emissions'. Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions [Online Resource]

Sandbrook, C., Fisher, J. A., Holmes, G., Luque-Lora, R., & Keane, A. (2019). The global conservation movement is diverse but not divided. *Nature Sustainability*, *2*(4), 316–323.

Schippmann, U. W. E., Leaman, D., & Cunningham, A. B. (2006). A comparison of cultivation and wild collection of medicinal and

aromatic plants under sustainability aspects. *Frontis*, 75–95.
Schoenbrun, D. L. (1998). *A green place, a good place: Agrarian change, gender, and social identity in the Great Lakes region to the 15th century.* Portsmouth, NH: Heinemann.

Secretariat of the Convention on Biological Diversity – CBD (2020). Global Biodiversity Outlook 5. Montreal.

Sene-Harper, A., Matarrita-Cascante, D., & Larson, L. R. (2019). Leveraging local livelihood strategies to support conservation and development in West Africa. Environmental Development, 29, 16–28.

Settele, J., Diaz, S., Brondizio, E., Daszak, P. (2020). COVID-19 Stimulus Measures Must Save Lives, Protect Livelihoods, and Safeguard Nature to Reduce the Risk of Future Pandemics. IPBES Expert Guest Article. 27.04.2019. https://ipbes.net/covid19stimulus

Seto, K. C., Güneralp, B., & Hutyra, L. R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences*, *109*(40), 16083–16088.

Serdeczny, O., Adams, S., Baarsch, F., Coumou, D., Robinson, A., Hare, W., ... & Reinhardt, J. (2017). Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. *Regional Environmental Change*, *17*(6), 1585–1600.

Shackelford, G. E., Steward, P. R., German, R. N., Sait, S. M., & Benton, T. G. (2015). Conservation planning in agricultural landscapes: hotspots of conflict between agriculture and nature. *Diversity and Distributions*, *21*(3), 357–367.

Siciliano, G., & Urban, F. (2017). Equity-based natural resource allocation for infrastructure development: evidence from large hydropower dams in Africa and Asia. *Ecological Economics*, *134*, 130–139.

Soga, M., & Gaston, K. J. (2016). Extinction of experience: the loss of human–nature interactions. *Frontiers in Ecology and the Environment*, *14*(2), 94–101.

Sowman, M., & Sunde, J. (2018). Social impacts of marine protected areas in South Africa on coastal fishing communities. *Ocean & coastal management*, *157*, 168–179.

Spash, C. L., & Vatn, A. (2006). Transferring environmental value estimates: Issues and alternatives. *Ecological Economics*, *60*(2), 379–388.

Stein, K., Coulibaly, D., Stenchly, K., Goetze, D., Porembski, S., Lindner, A., ... & Linsenmair, E. K. (2017). Bee pollination increases yield quantity and quality of cash crops in Burkina Faso, West Africa. *Scientific Reports*, *7*(1), 1–10.

Sullivan, M. J., Talbot, J., Lewis, S. L., Phillips, O. L., Qie, L., Begne, S. K., ... Zemagho, L. (2017). Diversity and carbon storage across the tropical forest biome. Scientific reports, 7, 39102. doi:10.1038/srep39102

Sunde, J., & Isaacs, M. (2008). Marine conservation and coastal communities: who carries the costs?: a study of marine protected areas and their impact on traditional small-scale fishing communities in South Africa.

Sunderland, T. C., Ehringhaus, C., & Campbell, B. M. (2007). Conservation and development in tropical forest landscapes: a time to face the trade-offs? *Environmental conservation*, *34*(4), 276–27

Sutcliffe, J. P. (2009). The extent and economic costs of deforestation in south-west Ethiopia: a preliminary analysis. *Forested Landscapes and Livelihoods, NTFPPFM.*

SwissRe (2019) Swiss Re Institute estimates global economic losses of USD 44 billion from catastrophes in the first half of 2019. News release (15.08.2019)
https://www.swissre.com/media/news-releases/nr_20190815_preliminary_sigma_catastrophe_estimates_for_first_half_of_2019.html

Taylor, R. (2009). Community based natural resource management in Zimbabwe: the experience of CAMPFIRE. *Biodiversity and conservation*, *18*(10), 2563–2583.

TEEB (2011). The Economics of Ecosystems and Biodiversity in National and International Policy Making. Edited by Patrick ten Brink. Earthscan: London and Washington.

TEEB-AgriFood (2018). Measuring what matters in agriculture and food systems: a synthesis of the results and recommendations of TEEB for Agriculture and Food's Scientific and Economic Foundations report. Geneva: UN Environment.

Teklehaymanot, T. (2017). An ethnobotanical survey of medicinal and edible plants of Yalo Woreda in Afar regional state, Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, *13*(1), 1 – 26.

Teferi, E., & Abraha, H. (2017). Urban heat island effect of Addis Ababa City: Implications of urban green spaces for climate change adaptation. In *Climate change adaptation in Africa* (pp. 539 – 552). Springer, Cham.

Terraube, J., Fernández-Llamazares, Á., & Cabeza, M. (2017). The role of protected areas in supporting human health: a call to broaden the assessment of conservation outcomes. *Current Opinion in Environmental Sustainability*, *25*, 50 – 58.

Terraube, J., & Fernández-Llamazares, Á. (2020). Strengthening protected areas to halt biodiversity loss and mitigate pandemic risks. *Current Opinion in Environmental Sustainability.*

Thiem, M., & Muduva, T. (2015). Commercialisation of land in Namibia's communal land areas: A critical look at potential irrigation projects in Kavango East and Zambezi regions.

TNC (2015). Upper Tana-Nairobi Water Fund Business Case. Version 2. The Nature Conservancy. Nairobi, Kenya.

Turpie, J.K., Barnes, J., de Longcamp, M. and Paxton, M. (2010). Sustainable Financing Plan for Namibia's Protected Area System. Report commissioned by the Ministry of Environment and Tourism (MET) with funding from the UNDP/GEF supported Strengthening the Protected Area Network (SPAN) MET, Windhoek, Namibia.

Turpie, Jane; Letley, Gwyneth; Chyrstal, Robynne; Corbella, Stefan; Stretch, Derek. (2017). Promoting green urban development in Africa: enhancing the relationship between urbanization, environmental assets, and ecosystem services (English). Washington, D.C.: World Bank Group.

Tyukavina, A., Hansen, M. C., Potapov, P., Parker, D., Okpa, C., Stehman, S. V., ... & Turubanova, S. (2018). Congo Basin forest loss dominated by increasing smallholder clearing. *Science advances*, *4*(11), eaat2993.

Urban Climate Change Research Network (UCCRN) (2018). The Future We Don't Want: How Climate Change Could Impact the World's Greatest Cities. UCCRN Technical Report. Online verfügbar unter https://c40-production-images.s3.amazonaws.com/other_uploads/images/1789_Future_We_Don't_Want_Report_1.4_hi-res_120618.original.pdf, zuletzt geprüft am 16.12.2019.

UN (2011). Global Drylands: A UN system-wide response. Report by UN Environment Management Group. 132 p.

UNCCD (2013). Background Document: The Economics of Desertification, Land Degradation and Drought: Methodologies and Analysis for Decision-Making. Bonn, Germany, United Nations Convention to Combat Desertification.

UNCCD (2017). The Global Land Outlook, first edition. United Nations Convention to Combat Desertification. Bonn, Germany.

UN General Assembly, Transforming our world : the 2030 Agenda for Sustainable Development, 21 October 2015, A/RES/70/1, available at: https://www.refworld.org/docid/57b6e3e44.html [accessed 11 June 2021]

United Nations Convention to Combat Desertification (2017). The Global Land Outlook, first edition. Bonn, Germany.

UNDRR (2019). Global Assessment Report on Disaster Risk Reduction, Geneva, Switzerland, United Nations Office for Disaster Risk Reduction.

UN General Assembly (2015). Transforming our world: the 2030 Agenda for Sustainable Development, 21 October 2015, A/RES/70/1, available at: https://www.refworld.org/docid/57b6e3e44.html [accessed 11 June 2021]

United Nations Development Programme (UNDP) (2016). Climate Change and Labour: Impacts of Heat in the Workplace. Hg. v. United Nations Development Programme (UNDP)

UNEP (2010). 'Africa Water Atlas'. Division of Early Warning and Assessment (DEWA). United Nations Environment Programme (UNEP). Nairobi, Kenya.

UNEP-WCMC and IUCN (2016). Protected Planet Report 2016. UNEP-WCMC and IUCN: Cambridge UK and Gland, Switzerland

UNEP-WCMC WDPA (2020). World Database of Protected Areas. UNEP World Conservation Monitoring Centre. – (regularly updates –

accessed in January 2020).
UNEP-WCMC (2020). Protected Area Profile for Africa from the World Database of Protected Areas, December 2019. Available at: www.protectedplanet.net UNEP-WCMC, IUCN and NGS: Cambridge UK; Gland, Switzerland; and Washington, D.C., USA.

United Nations Children's Fund (UNICEF) and World Health Organization (WHO) (2019). Progress on household drinking water, sanitation and hygiene 2000-2017. Special focus on inequalities. New York.

United Nations (2018). Sustainable Development Goal 6: Synthesis Report 2018 on Water and Sanitation. New York.

UN (2019). World Urbanization Prospects. The 2018 Revision (ST/ESA/SER.A/420). United Nations, Department of Economic and Social Affairs, Population Division, New York.

UNOWAS (2018). Pastoralism and Security in West Africa and the Sahel. UNOWAS Issue Paper. Research and Analysis Unit, United Nations Office for West Africa and the Sahel. unowas.unmissions.org

UNWTO (United Nations World Tourism Organization) (2015). Towards Measuring the Economic Value of Wildlife Watching Tourism in Africa – Briefing Paper. UNWTO, Madrid.

UNWTO (United Nations World Tourism Organization) (2018). UNWTO World Tourism Highlights 2018 Edition. UNWTO, Madrid.

Vansina, J. M. (1990). *Paths in the rainforests: toward a history of political tradition in equatorial Africa*. University of Wisconsin Pres.

Valle, D., & Clark, J. (2013). Conservation efforts may increase malaria burden in the Brazilian Amazon. *PLoS One*, *8*(3), e57519.

Van Noordwijk, M., Leimona, B., & Villamor, G. B. (2017). Pro-poor PES designs? Balancing efficiency and equity in local context. *Co-investment in ecosystem services: global lessons from payment and incentive schemes. Nairobi: World Agroforestry Centre (ICRAF)*.

Van Zyl, H. (2015). The economic value and potential of protected areas in Ethiopia. *Report for the Ethiopian Wildlife Conservation Authority under the Sustainable Development of the Protected Areas System of Ethiopia Programme (Independent Economic Researchers, Cape Town, South Africa)*.

Waldron, A., Adams, V., Allan, J., Arnell, A., Asner, G., Atkinson, S., ... & Zhang, Y. (2020). Protecting 30% of the planet for nature: costs, benefits and economic implications. Report prepared for the Wyss Campaign for Nature.

Watson, J. E., Dudley, N., Segan, D. B., & Hockings, M. (2014). The performance and potential of protected areas. *Nature*, *515*(7525), 67–73.

Wessels, K. J. (2009). Letter to the editor: comments on 'Proxy global assessment of land degradation'by Bai et al.(2008).

White, R., Turpie, J., Letley, G. (2017). Greening Africa's Cities: Enhancing the Relationship between Urbanization, Environmental Assets, and Ecosystem Services. World Bank, Washington, DC. © World Bank.
https://openknowledge.worldbank.org/handle/10986/26730 License: CC BY 3.0 IGO.

Whitley, S., & van der Burg, L. (2015). Fossil fuel subsidy reform: From rhetoric to reality. *New Climate Economy, London and Washington, DC. Available at http://newclimateeconomy. report/misc/working-papers. All rights reserved New Climate Economy c/o World Resources Institute*, *10*, 3.

Wilson, L., Secades, C., Narloff, U., Bowles-Newark, N., Mapendembe, A., Booth, H., ... & Tierney, M. (2014). The role of national ecosystem assessments in influencing policy making.

Witter, R., & Satterfield, T. (2019). The ebb and flow of Indigenous rights recognitions in conservation policy. *Development and Change*, *50*(4), 1083–1108.

WHO (2008). WHO Traditional medicines. Fact sheet [Internet]. Geneva (Switzerland): World Health Organization; http://www.who.int/mediacentre/factsheets/fs134/en/

WHO (2019). World health statistics overview 2019: Monitoring health for the sustainable development goals. Geneva: World Health Organization; 2019 (WHO/DAD/2019.1). Licence: CC BY-NC-SA 3.0 IGO.

World Bank (2020). Africa's Pulse, No. 22, October 2020: An Analysis of Issues Shaping Africa's Economic Future. World Bank, Washing-

ton, DC.
World Bank. (2013). The World Bank Annual Report 2013. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/16091 License: CC BY 3.0 IGO.

World Bank. (2017). Guidance note on shadow price of carbon in economic analysis: Nov 12, 2017. Accessed from http://pubdocs.worldbank.org/en/911381516303509498/2017-Shadow-Price-of-Carbon-Guidance-Note-FINAL-CLEARED.pdf.

World Bank. (2019). Africa Program for Fisheries, www.worldbank.org/en/programs/africa-program-for-fisheries, visited on December 19, 2019.

World Fish Center. (2009). Fish and Food Security for Africa pubs.iclarm.net/resource_centre/WF_2466.pdf, downloaded on December 30, 2019.

Wolancho, K. W. (2012). Watershed management: an option to sustain dam and reservoir function in Ethiopia. *Journal of Environmental Science and Technology*, 5(5), 262–273.

Wong, G., Angelsen, A., Brockhaus, M., Carmenta, R., Duchelle, A., Leonard, S., ... & Wunder, S. (2016). Results-based payments for REDD+: Lessons on finance, performance, and non-carbon benefits (Vol. 138). CIFOR.

WRI (2019). Aqueduct Water Risk Atlas: Country ranking for baseline water stress. Updated Version (published in August 2019, accessed in January 2020). https://www.wri.org/applications/aqueduct/country-rankings/

WTTC (World Tourism and Travel Council). (2019). Travel and Tourism Economic Impact 2019. WTTC, London.

WWF (2015). A global assessment of extractive activity within natural World Heritage Sites. London.

Yengoh, G. T., Dent, D., Olsson, L., Tengberg, A. E., & Tucker, C. J. (2015). Limits to the use of NDVI in land degradation assessment. In *Use of the normalized difference vegetation index (NDVI) to assess land degradation at multiple scales* (pp. 27–30). Springer, Cham.

Zenebe, A. (2009). Assessment of spatial and temporal variability of river discharge, sediment yield and sediment-fixed nutrient export in Geba River catchment, northern Ethiopia. Dissertation, Katholieke Universiteit, Leuven.