



Biodiversity and the Great Green Wall:

Managing nature for sustainable development in the Sahel

Jonathan Davies



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This publication has been made possible by the support of the Global Environment Facility (GEF) and the World Bank Group (WBG)

Published by: IUCN, West and Central Africa Programme (PACO), Ouagadougou, Burkina Faso

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Citation: Davies, J. (2017). *Biodiversity and the Great Green Wall: managing nature for sustainable development in the Sahel*. Ouagadougou, Burkina Faso: IUCN. xiv + 66 pp.

ISBN: 978-2-8317-1861-3

DOI: 10.2305/IUCN.CH.2017.10.en

Cover:

1	2
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Layout/printed by: Graphi Imprim - Tél.: +226 25 31 12 34

Available from: IUCN (International Union for Conservation of Nature) Central and West Africa Programme (PACO)
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www.iucn.org/resources/publications

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<http://www.oss-online.org/>

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Acronyms and abbreviations

AFR100	African Forest Landscape Restoration Initiative
BRICKS	Building Resilience through Innovation, Communication and Knowledge Services
CBD	Convention on Biological Diversity
CBNRM	Community Based Natural Resource Management
CILSS	Permanent Inter - States Committee for Drought Control in the Sahel
GGW	Great Green Wall
GGWI	Great Green Wall Initiative
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
LD	Land Degradation
LDN	Land Degradation Neutrality
SAWAP	Sahel and West Africa Programme
SDG	Sustainable Development Goals
SLM	Sustainable Land Management
IUCN	International Union for Conservation of Nature
NGO	Non-Governmental Organisation
OSS	Sahara and Sahel Observatory
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
WAP	W-Arly-Pendjari complex
WDPA	World Database on Protected Areas

Foreword

The Great Green Wall is one of the main vehicles for delivering the Sustainable Development Goals and the Rio conventions in the Sahel. Biodiversity is the foundation of the Great Green Wall in many ways, determining soil productivity and water cycles and providing the foundation for risk management and resilient ecosystems. The Great Green Wall can make a major contribution to achieving many of the Sustainable Development Goals. It is helping to re-focus efforts to combat desertification, to achieve Land Degradation Neutrality, and to improve food and water security in one of the most vulnerable places on earth. In doing so countries will contribute to both climate change mitigation and adaptation and to the restoration and protection of biodiversity.

However the Sahel faces some of the greatest environmental threats in the world, with a potential doubling of the both rural population and of the number of agriculture-dependent people living below the poverty line by 2030. Agricultural productivity in the Sahel is increasing, but not fast enough to keep pace with population growth. As countries invest more in dryland areas, greater threats to biodiversity are anticipated and the region is projected to be more affected by habitat destruction in the coming century than almost anywhere else on earth.

Biodiversity and the Great Green Wall: managing nature for sustainable development in the Sahel demonstrates that biodiversity -in all its richness and abundance- is the foundation on which agriculture, water supply and climate regulation are built. Biodiversity regulates carbon, nitrogen and hydrological cycles and thereby determines the flow of ecosystem services to humanity. Nature's benefits do not come for free and if we fail to protect biodiversity, we will quickly degrade the ecosystems from which nature's benefits are derived. Land degradation in the Sahel has shown just how easily ecosystems can be degraded, and how long it can take to restore them.

This realisation is helping us to rethink the Great Green Wall, along with other ambitious landscape restoration approaches like the Bonn Challenge and the Africa 100 Initiative. Restoring landscapes and ecosystems means restoring the functioning of ecosystems and this depends on restoring and protecting biodiversity, including the vast wealth of species in the soil that are often lumped together as "carbon". The goals of the Great Green Wall require all land users -farmers, herders, forest dwellers and others- to be conservationists. Those conservationists must be enabled to capitalise on their local knowledge in order to protect and enrich the biodiversity on which their livelihoods depend.

Biodiversity and the Great Green Wall helps to demonstrate the complex connections between biodiversity and the benefits that we all derive from nature. The book shows how biodiversity is protected through sustainable land management approaches, for example through protection of soil organic carbon and promotion of agroecology approaches. The book demonstrates how Sahelian farmers and herders can deliver the Great Green Wall as well as national commitments to global aspirations like the Bonn Challenge, the 4/1000 initiative and many more. The book focuses on the Sahel, but its message on sustainably managing land are of global significance.



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Acknowledgements

The author would like to acknowledge the invaluable comments and inputs from the partner institutions and individuals consulted during this study. Particular thanks go to: Taibou Ba, Edmund Barrow, Nabil Ben Khatra, Stephen Danyo, Philippe Dardel, Julian Fennessy, Jean-Marc Garreau, Saverio Kratli, Ndeye Fatou Mar, Félicité Mangang, Bora Masumbuko, Yasmina Oodally, Sébastien Regnaut, Arsène Sanon, Louis Blanc Traoré, and Philippe Zoungrana.

A special thank you to Mike Mortimore, Jules Adjima for the peer reviews and feedback, as well as to the members of the IUCN Editorial Board. They greatly contributed to improve this document.

The author is extremely grateful to Bora Masumbuko for the time she spent coordinating this work.

This study was supported by the World Bank with funds from the Global Environment Facility (GEF). We are also grateful for the support of the implementing partner institutions involved in the BRICKS project under which this study was conducted: the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), and the Sahara and Sahel Observatory (OSS).

The contents of this report are solely the responsibility of the author and should not be interpreted as reflecting the views of any of the individuals or organizations that contributed to the report or any of its elements.

Executive summary

The Great Green Wall of the Sahara and Sahel is an African flagship initiative to combat desertification, reduce poverty, and to address the effects of climate change. The initiative has been envisioned by African leaders and is led by the Africa Union, and is supported by rapidly increasing investment on the ground in many countries. The Great Green Wall is envisioned by many actors as vast mosaic of healthy, productive landscapes from West to East Africa, supporting resilient livelihoods and contributing to multiple environmental and development targets.

Biodiversity and the Great Green Wall explores the dependence of humanity on nature and the importance of biodiversity for wellbeing and sustainable development in the Sahel. The report is written to raise awareness of the critical role for biodiversity in achieving the goals of the Great Green Wall. It presents new evidence of the links between biodiversity, ecosystem services and human welfare, and demonstrates the importance of biodiversity for sustainable agriculture, providing arguments for the connection between the agricultural and environmental sectors.

The report examines how elements of biodiversity conservation can be mainstreamed in all aspects of natural resource management, and how this can be achieved through the Great Green Wall. It examines how Sustainable Land Management (SLM), which is a central pillar of combating desertification, conserves the biodiversity upon which the productivity of agro-ecosystems depend. The report explores how integrating biodiversity into sustainable land management in the drylands of the Sahel requires unique attention to soil water and fertility management. It shows that adapting to the challenges of maintaining soil moisture and soil fertility and minimising evaporative water losses in the drylands requires innovative approaches to protecting ecosystems by conserving biodiversity, including the vast array of biodiversity found in the soil.

The report concludes that nature's benefits, referred to also as ecosystem services, are determined to a large extent by biodiversity. The core message is that human wellbeing and economic development depend on mainstreaming elements of biodiversity conservation in all aspects of natural resource management. As a result, conserving biodiversity through sustainable land management in the Great Green Wall contributes to economic development, job creation and poverty reduction.

The Great Green Wall: restoring ecosystems for sustainable development in the Sahel

Sahelian drylands face a number of economic, environmental and social challenges. Climate change projections, although highly uncertain, point towards major changes in future weather patterns. Poverty is widespread, levels of human development are low, and future population growth is projected to be high. Pressure on natural resources and demand for food, water and energy are growing. Food production is increasing in the Sahel, due to expansion of the area cultivated and modest improvements in productivity. However, productivity gains are not keeping up with growing demand, while at the same time many gains have been achieved using agricultural practices that contribute to land degradation and therefore undermine long-term agricultural output.

The combination of agricultural expansion, changing rainfall patterns, and human settlement all contribute to the risk of desertification and land degradation in the Sahel. This contributes in turn to declining ecosystem functions, which result in reduced agricultural growth, increased human vulnerability, and aggravated risk of drought and other environmental hazards.

Biodiversity in the Sahel

To understand the state and the importance of biodiversity in the Sahel requires looking beyond the most visible species and understanding the wider diversity of species both below and above ground that determine how ecosystems function. The Great Green Wall was conceptualised as a wall of biodiversity that would strengthen resilience at the southern fringe of the Sahara Desert. However, the Wall is about much more than trees and is usually envisioned as a landscape mosaic of sustainable land use, including sustainable crop farming, pasture management, forests, wetlands, conservation areas and more.

A frequently overlooked component of biodiversity is that found in the soil, including bacteria, invertebrates and fungi. This soil biodiversity comprises the largest component of biodiversity in the Sahel, even if it is the most poorly understood. Soil biodiversity is the engine of ecosystem function, determining carbon and nitrogen cycles as well as hydrological cycles, and thereby determining the productivity and resilience of land.

The Sahel and Sahara support an impressive array of biodiversity, including a large number of endemic species: species that are not found elsewhere on the planet. Biodiversity has adapted to the drylands in many different ways, and particularly to the seasonality, scarcity and variability of rainfall. Agrobiodiversity in the Sahel has also adapted to the conditions and is vital for the livelihoods and the resilience of rural dryland populations.

Biodiversity is declining rapidly throughout the Sahel and experts project that the Sahel region will be more affected by habitat destruction in the coming century than almost anywhere else on earth. Human population growth combined with increasing wealth and investment are the major factors behind biodiversity declines in the Sahel. A major factor in biodiversity loss is agricultural expansion and particularly the spread of land management practices that do not conserve soil biodiversity or integrate above-ground biodiversity. Human settlements are also expanding and cast a long shadow on the surrounding environment.

Biodiversity conservation as a foundation for ecosystem services in the Great Green Wall

Land degradation and depletion of soil biodiversity contribute to increased aridity of the land and disruption of water cycles. Over-harvesting of water also has profound environmental consequences, leading to drying up of wetlands and other water sources. These impacts are exacerbated by climate change and contribute to reducing resilience throughout the region.

Traditional farming and herding practices have been well adapted to the challenges of aridity and climate uncertainty in the Sahel but they have been eroded by policies that do not prioritise risk management. Agricultural intensification has been particularly damaging to resilience and biodiversity, although there are signs of a trend towards more widespread support for sustainable intensification and scale up of SLM. Many dryland societies have strong values of environmental custodianship and a rich knowledge of their environment and they rely heavily on a range of biodiversity. Re-enabling communities to use this knowledge can be a powerful way to address biodiversity and to build resilience in the Sahel.

Restoring biodiversity through ecological restoration contributes to major gains in ecosystem services. Soil biodiversity is critical for the supply of ecosystem services, and its protection must be central to achieving Land Degradation Neutrality in the Sahel, and meeting the objectives of the Great Green Wall. Sustainable land management practices protect the ecosystem functions that sustain productivity. Clearing land for cultivation may initially increase food production, but it comes at a significant cost in terms of water supply, climate regulation, carbon sequestration, forest resources, pollination, and many more services.

Biodiversity in the Sahel protects hydrological and nutrient cycles. Vegetation cover can play a major role in reducing surface flows of water and improving infiltration of water, while soil biodiversity improves both infiltration and water storage in the soil. As a result biodiversity directly contributes to reducing the occurrence and the severity of flood and drought. Despite low biomass above ground, the relative proportion of biomass that is below ground is high and there is a tendency to under value soil carbon stocks.

Conserving dryland biodiversity in the Great Green Wall

Sustainable land management and restoration both depend on protection and restoration of biodiversity. Biodiversity conservation cannot therefore be the exclusive preserve of environmental and wildlife agencies, but becomes a shared responsibility of many sectors, including agriculture and water. Agricultural agencies, for example, need to ensure that farming practices protect the biodiversity and ecosystem services on which farming depends. Water agencies similarly need to ensure that water management does not compromise hydrological cycles.

Sustainable agriculture offers one of the most important ways to achieve the goals of the Great Green Wall, by simultaneously protecting biodiversity and ecosystem services, raising agricultural productivity, and promoting the resilience of people and ecosystems. Sustainable land management practices often rely on protecting biodiversity to boost soil organic carbon, soil nitrogen, and soil moisture. Practices like agroforestry and low tillage agriculture are based on indigenous practices that have been revived and improved to protect soil moisture and fertility of crop lands as well as providing supplementary benefits. Other SLM practices, such as contour bunds and zai, also contribute to building up soil moisture and organic matter in order to improve productivity and resilience.

Protected areas, whether owned or managed by communities, State authorities or private land owners, can play a major role in protecting sustainable land management practices that address desertification and drought. The full range of protected area types needs to be considered, which requires an attitude change in the conservation sector to respect the role of protected agricultural lands in conserving biodiversity and ecosystem services. Grazing lands are particularly well suited to being recognised as protected areas, since sustainable management of grassland biodiversity is an important management objective. About 5% of the Sahel -an estimated 224,825 km²- is formally protected which is far below Aichi Target 11 of 17%¹.

Community based conservation measures have a lot of potential to be expanded in the region. Many societies manage their environment to augment its heterogeneity and their conservation and sustainable land management practices can be bolstered through the use of appropriate protected area status. Community conserved areas can also play an important role in protecting agrobiodiversity in the Sahel.

Barriers and opportunities to promoting biodiversity in the Great Green Wall

The drylands of the Sahel are facing an unprecedented rate and scale of change, which offers both threats and opportunities for sustainable development. Population growth and demographic change are causing changes in production patterns, pressure on natural resources, and increasing demands on nature. Whether demographic change and economic growth are a threat or an opportunity depends to some extent on how well sustainability criteria are embedded in agricultural production and other aspects of development.

Given the high level of uncertainty over climate change, and the likelihood that the climate will also become more unpredictable, traditional mechanisms of risk management are of ever-greater importance. Failure to respect local knowledge and to uphold local resource rights has left many land managers incapable of sustainably managing their land. However, new approaches to local governance and capacity building are leading to widespread revival of traditional risk management strategies. This points the way forward for wide-spread adoption of sustainable land management, which can be more effectively mainstreamed in core agricultural development plans.

Many land managers in the Sahel are constrained by the legacy of low investment in basic development. Stronger human capital, particularly basic education for both women and men, could catalyse wider adoption of sustainable land management practices. This would be supported by building capacity, in institutions and amongst communities, to achieve more equitable local resource governance and secure tenure. Combining support for community institutions with stronger tenure and resource governance may be the strongest foundation for resilient development in the Great Green Wall.

¹ Aichi Target 11. By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Capacity building, awareness raising, and policy guidance are also needed to help public servants embrace a broader vision of the Great Green Wall that expands beyond individual sectors. Landscape management approaches have gained popularity in recent years and they can enable a more balanced and optimal management of resources on a large scale. This is important to achieve the most efficient and sustainable use of land resources that are expected to satisfy multiple competing demands, including production of food and fuel and provision of safe water.

The goals of the Great Green Wall can be undermined by persistent misunderstanding of the drylands. Actors have conflicting visions of development and there is an ongoing bias towards capital-intensive agriculture at the expense of sustainable land management and community resilience and risk management. Particular emphasis is needed on managing biodiversity and soil organic carbon to achieve more efficient management of dryland soil and water.

Overall it is important to popularise an alternative vision of sustainable landscape management that is based on multifunctionality. This means managing land simultaneously for its multiple benefits to society. The Great Green Wall is a powerful opportunity to achieve such a vision, by promoting sustainable land management and restoration on a vast scale. Achieving such an integrated approach will be crucial to achieve the goals of stronger resilience and risk management.

Conserving biodiversity to achieve the goals of the Great Green Wall

To fulfil its goals the Great Green Wall will need to adapt green economic growth to the unique conditions of the drylands, place greater emphasis on sustainable management of biodiversity and ecosystems, and give a higher priority to land health as the basis for food and water security. Countries of the Great Green Wall will also need to place greater emphasis on resilience and risk management that is adapted to the high level of uncertainty found in these dryland environments.

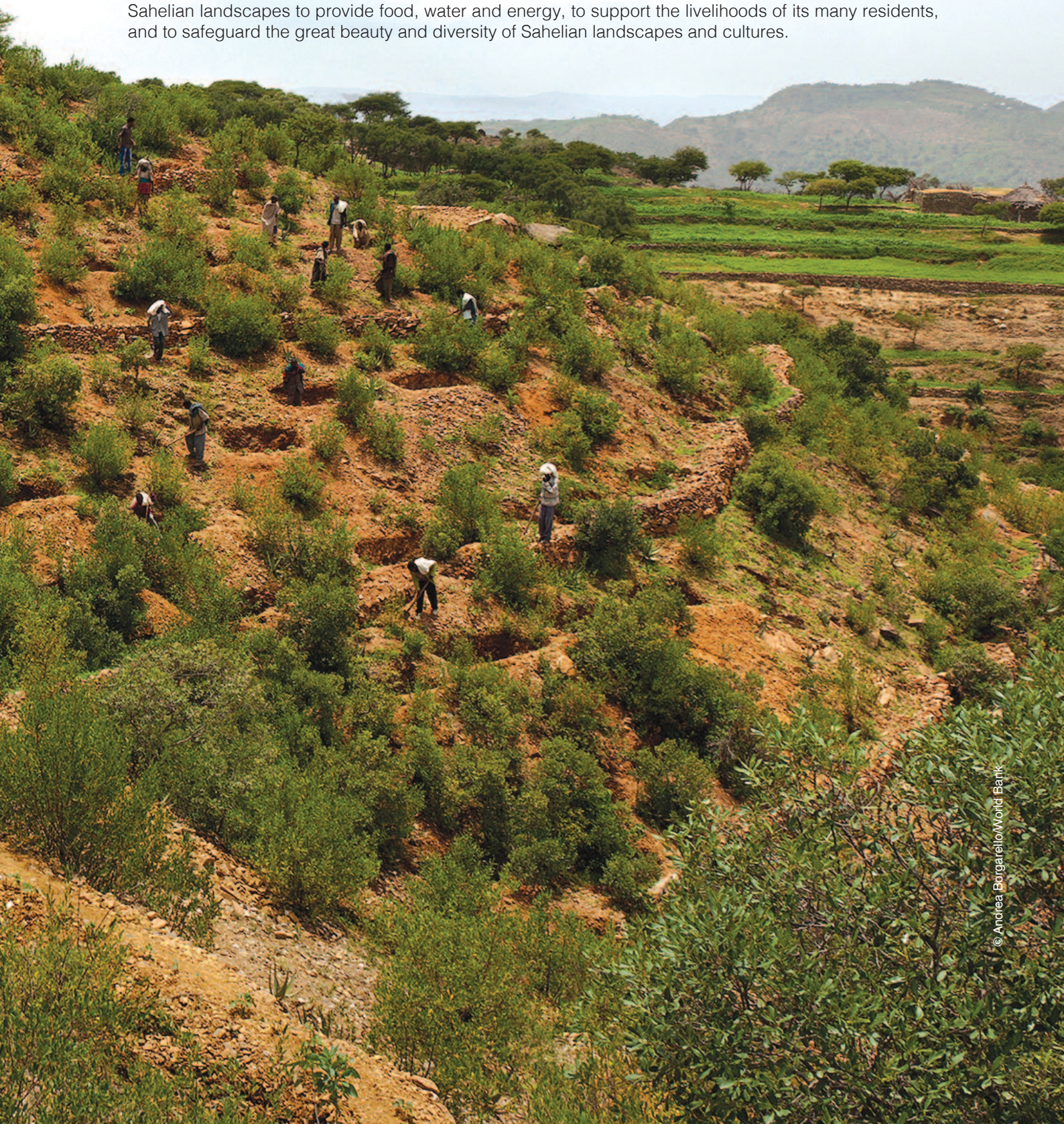
Recommendations for mainstreaming biodiversity to achieve the goals of the Great Green Wall are clustered under the following four areas:

1. **Mainstream Sustainable Land Management in the agriculture sector to achieve Land Degradation Neutrality**, including investments in scaling up sustainable land management and landscape restoration, promoting innovation in small and medium-sized enterprises for sustainable agriculture, and developing financial services that are adapted to the needs of both male and female farmers and pastoralists to enhance their investments in SLM.
2. **Establish institutional arrangements that enable landscape restoration and sustainable management**, including adequately resourced and mandated inter-sectoral coordination mechanisms and local institutions, with access to technical and financial resources and capacity building.
3. **Strengthen governance, tenure and resource rights at the local level**, by promoting local governance over natural resources through participatory planning and devolution of decision-making, building capacity to strengthen local governance and resource tenure, reinforcing the rights of women as natural resource managers and ensuring legal institutions have the resources to support implementation of national land laws.
4. **Monitor biodiversity and ecosystem function to evaluate Great Green Wall investments and policies** through public funding to monitor biodiversity and ecosystem function, investment in measuring soil organic carbon as an indicator of SLM, climate change mitigation and biodiversity, promoting research into the role of sustainable land management in conserving biodiversity, and validating local knowledge on sustainable land management.

Conclusion

The Great Green Wall can deliver against commitments to combatting desertification, including achieving Land Degradation Neutrality, while simultaneously conserving biodiversity, mitigating climate change, and strengthening climate change adaptation. However, the value of biodiversity in sustainable land management and for safeguarding ecosystem services needs to be widely understood in order to identify the best investment options for countries as a whole.

Genuine synergies can be found between environment and development goals that make the Great Green Wall a national investment priority. Much of the territory of the Great Green Wall could eventually be classified as a mosaic of different types of protected area: protected for the sustainable management of Sahelian landscapes to provide food, water and energy, to support the livelihoods of its many residents, and to safeguard the great beauty and diversity of Sahelian landscapes and cultures.





1. Biodiversity and the Great Green Wall

“Biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.” Convention on Biological Diversity 1992

The diversity and abundance of life on earth greatly influences the functioning of ecosystems and the services they provide and is therefore a determinant of natural capital. Biodiversity contributes significantly to human welfare, not simply through provision of consumable goods, but by assuring the supply of a wide range of services, such as soil fertility, water regulation, risk reduction, cultural heritage, and much more.

This report explores the dependence of humanity on nature and the importance of biodiversity for wellbeing and sustainable development in the drylands of the Sahel. It examines how elements of biodiversity conservation can be mainstreamed in all aspects of natural resource management, and how this can be achieved in the Sahel in order to reach the long-term goals of the Great Green Wall of the Sahara and Sahel Initiative. The report examines the relationship between conservation actions and sustainable land management and restoration.

This report is written for government and nongovernmental actors working on the Great Green Wall, including partners of the World Bank GEF “Sahel and West Africa Program” (SAWAP). It targets national

The benefits of nature that determine human wellbeing are called ecosystem services and the flow of ecosystem services is determined to a large extent by biodiversity.

ministries responsible for agriculture and environment, and provides arguments for the connection between these two sectors. The report is also written for ministries of finance and planning who play a vital role in resourcing the needed interventions. As such the report is written for an audience of natural resource management experts who may be unfamiliar with recent advances in scientific understanding of the connection between biodiversity and sustainable development, particularly in dryland regions.

Human wellbeing depends not only on physical development and human capital (“the economy”), but also on society, which is embedded in, and reliant on, nature.

The benefits of nature that determine human wellbeing are called ecosystem services (Millennium Ecosystem Assessment, 2005) and the flow of ecosystem services is determined to a large extent by biodiversity, as summarised in this report. To understand the role of biodiversity in determining human wellbeing requires a broad perspective that goes far beyond a few iconic species. This report shows that sustainable land management is supported by both the variety and the abundance of life, in soil as well as above ground.

The Great Green Wall (GGW) has emerged in recent years as a major vehicle for combating desertification in the Sahel. It has evolved a long way from its original, narrow, and potentially harmful interpretation as a line of trees from the Atlantic to the Red Sea. The GGW is now viewed by many as an ambitious plan to restore degraded landscapes and to sustainably manage land through a mosaic of land uses. This report will highlight that there are many ways to contribute to the ambitions of the GGW, and contributions must come from multiple sectors, often working in a coordinated and mutually-supportive way.

The Great Green Wall can deliver both environmental sustainability and poverty reduction, and in doing so it will contribute simultaneously to a number of global environmental and development goals. For example, the initiative is explicitly designed to contribute to SDG 1 (No Poverty), SDG2 (Zero Hunger), and SDG15 (Life on Land). The GGW can also contribute to SDG5 (Gender Equality), SDG6 (Clean water and Sanitation), SDG7 (Renewable Energy), SDG8 (Decent work and Economic Growth), and SDG13 (Climate Action).



Figure 1: Contribution of the GGWSSI to delivering the Sustainable Development Goals

Source: IUCN, Jonathan Davies

The goals of the Great Green Wall depend on conserving biodiversity and ecosystem services as the foundation for resilience of both people and nature: biodiversity contributes to economic development, job creation and poverty reduction. As a result the GGW can contribute to a number of Aichi Targets as outlined in Figure 15 in this report. Isolating these goals and ignoring their natural synergy will lead to inefficient use of resources and will grossly undervalue the most sustainable investments. The overall benefits to society of the GGW should be measured completely, and not only the sub-set of benefits within a given sector.

Biodiversity contributes to economic development, job creation and poverty reduction.

The Great Green Wall contributes to conserving biodiversity in a number of different ways, such as by protecting habitat, maintaining landscape connectivity, and protecting some specific species, including agrobiodiversity. The GGW also will conserve important biodiversity that is not explicitly prioritised by the Conservation Sector, such as soil biodiversity. The conservation sector can, in turn, contribute to the goals of the GGW, for example by protecting critical ecosystem services such as water supply or pollination. Different

types of protected area, including protection of agricultural and forest landscapes, could be a significant component of the GGW.

This report elaborates on the role of biodiversity in achieving the Great Green Wall and examines the relationship between conservation actions and sustainable land management and restoration. These should not be represented as two competing alternatives: the objective of sustainable farming is to conserve the biodiversity upon which the productivity of agroecosystems depend. The aim of the report is to raise awareness of the role sustainable land management plays in protecting biodiversity, to broaden perceptions of what the term “biodiversity” means, to raise awareness of the centrality of biodiversity to sustainable land management and landscape restoration, and to provide guidance for mainstreaming biodiversity management in GGW investments and policies.

The objective of sustainable farming is to conserve the biodiversity upon which the productivity of agroecosystems depend.

Restoration, rehabilitation and sustainable management of land²

Sustainable land management

IUCN defines Sustainable management as “management through which the present potential of the resources is used in the best possible way, and does not reduce the availability of the resources.” SLM has been defined as “the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions” (WOCAT, 2007).

Restoration

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. It has been defined as “an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability” (SER, 2004). Ecological restoration includes improving, to the extent possible, biodiversity and indigenous species to support ecosystem functionality.

Rehabilitation

Rehabilitation of ecosystems refers to the re-establishment of part of the productivity, structure, function and processes of the original ecosystem. Rehabilitation may be a step on the way towards full restoration, or it may be the end goal itself.

Landscape

A landscape is a geographical mosaic composed of interacting ecosystems resulting from the influence of geological, topographical, soil, climatic, biotic and human interactions in a given area. The term is frequently used to describe a large area that is defined by both ecological and social factors.

Landscape Restoration

Landscape restoration is the process of regaining ecological integrity and functioning of degraded landscapes. Forest landscape restoration (FLR) is described by IUCN as the process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes.

The report contains an overview of the context in the introduction and the following section on drylands of the Great Green Wall. This is followed by an overview of biodiversity in the Sahel and the benefits of biodiversity to humanity in the Sahel. The report then outlines some of the important approaches to conserving biodiversity and discusses barriers and opportunities to conserving biodiversity in the Great Green Wall. The report concludes with a number of recommendations for action by key stakeholders.

In order to reverse land degradation trends and support the Great Green Wall Initiative, the World Bank/GEF and their partners have established the Building Resilience through Innovation, Communication, and Knowledge services (BRICKS) project and the Sahel and West Africa Program (SAWAP). The BRICKS³ project has been designed to *improve accessibility of best practices and monitoring information within the SAWAP portfolio on sustainable land use and management*. It will improve human well-being and resilience, and ecosystems' health through the implementation of innovative and integrated landscape approaches that contribute to sustainable land management. The SAWAP is a regional investment program that addresses land degradation and climate change issues in 12 countries, namely: Benin, Burkina Faso, Chad, Ethiopia, Ghana, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan and Togo. Its goal is *to expand sustainable land and water management (SLWM) in targeted landscapes and in climate vulnerable areas in West African and Sahelian countries* (World Bank, 2011). BRICKS provides technical support to the SAWAP projects.

² See IUCN Glossary of Definitions: https://www.iucn.org/downloads/en_iucn_glossary_definitions.pdf

³ The BRICKS project is being implemented by the Permanent Inter - States Committee for Drought Control in the Sahel (CILSS), the International Union for Conservation of Nature (IUCN), and the Sahara and Sahel Observatory (SSO).

The present study is conducted as part of the BRICKS project. It will help SAWAP project teams and other actors respond to the following question: *How conserving biodiversity can effectively address and contribute to sustainable land management (and vice versa)?* The SAWAP projects include biodiversity components/activities at different degree of importance; they are stated in the table in annex.

SAWAP country projects can benefit from what biodiversity offers, including biodiversity from the soil, if well understood and managed, as a response to mitigate and adapt to climate change, increase carbon storage, or by reducing the risk of flood and drought, which may lead to disasters.

The results of the study will help SAWAP project teams better consider biodiversity conservation when addressing land degradation issues and the broader sustainable land management approaches, including landscape approach, in their projects and in future investments, while linking them with the GGW. They will also better capitalize their results based on the findings of the study.



2. The Great Green Wall: restoring ecosystems for sustainable development in the Sahel

The idea of a living barrier to resist the perceived advance of the Sahara desert is not new. The concept of a Green Dam was proposed in Algeria in the 1960s and a Green Front in the Sahel was proposed as long ago as the 1950s. The Great Green Wall has been promoted since 2002 and has gained prominence since the establishment in 2007 of the Great Green Wall for the Sahara and the Sahel Initiative. According to its website⁴, the Great Green Wall Initiative “is a pan-African programme launched in 2007 by the African Union (AU). Its goal is to reverse land degradation and desertification in the Sahel and Sahara, boost food security and support local communities to adapt to climate change”. As discussed later, many of the claims about advancing deserts in the Sahel are not supported by evidence and there are efforts to re-envision the Great Green Wall as “a metaphor that depicts a mosaic of sustainable land use and community-based land management practices”⁵.

A metaphor that depicts a mosaic of sustainable land use and community-based land management practices.

The Great Green Wall Initiative involves 20 countries, of which 11 have signed an agreement in June 2010, in Ndjamen, Chad, to create the Great Green Wall Agency⁶. The Great Green Wall runs east to west across Africa through the northern Sahel; an area of arid and semi-arid climate. These areas are classified as drylands by the United Nations Environment Programme, based on their aridity index: a measure of the mean precipitation divided by the potential evapotranspiration (UNEP 1997).

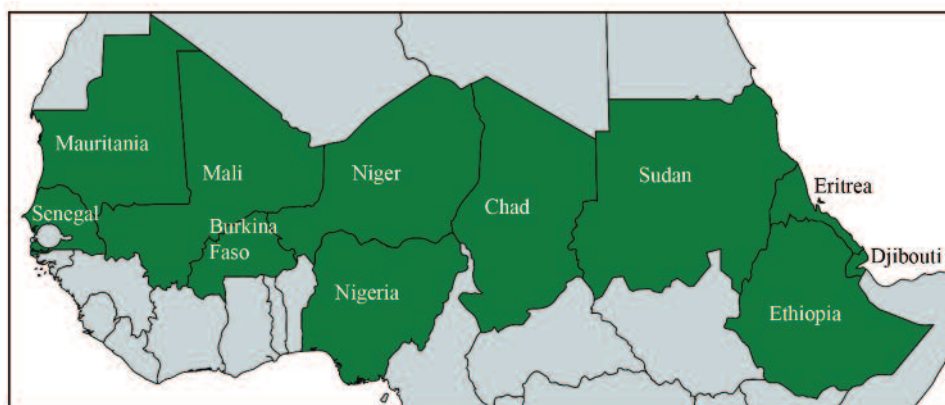


Figure 2: Countries involved in the Pan African Agency for the Great Green Wall

Source: IUCN, Jonathan Davies, created with mapchart.net

2.1. The unique drylands of the Great Green Wall

Drylands are characterised by several unique features that shape their biodiversity and ecology as well as their societies and economies. Water scarcity is the most obvious defining feature, although this can be misleading as the precipitation levels in much of the Sahel can be comparatively high. In such cases aridity is determined not by the precipitation received but by the amount of water that can be lost through evaporation and transpiration; temperature, wind and vegetation cover therefore are determining factors. In addition to water scarcity, the Sahel is characterised by high seasonal variability, with most rainfall occurring in one rainy season, as well as extremely high inter-annual rainfall. It is variability as much as the absolute scarcity of water that determines biological and socio-economic adaptations in the Sahel (Behnke *et al.*, 1993).

It is variability as much as the absolute scarcity of water that determines biological and socio-economic adaptations in the Sahel.

⁴ <http://www.greatgreenwallinitiative.org/> (accessed 08/06/2016)

⁵ There are multiple uses of this phrase by international organisations with no citation of the original

⁶ Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal and Sudan

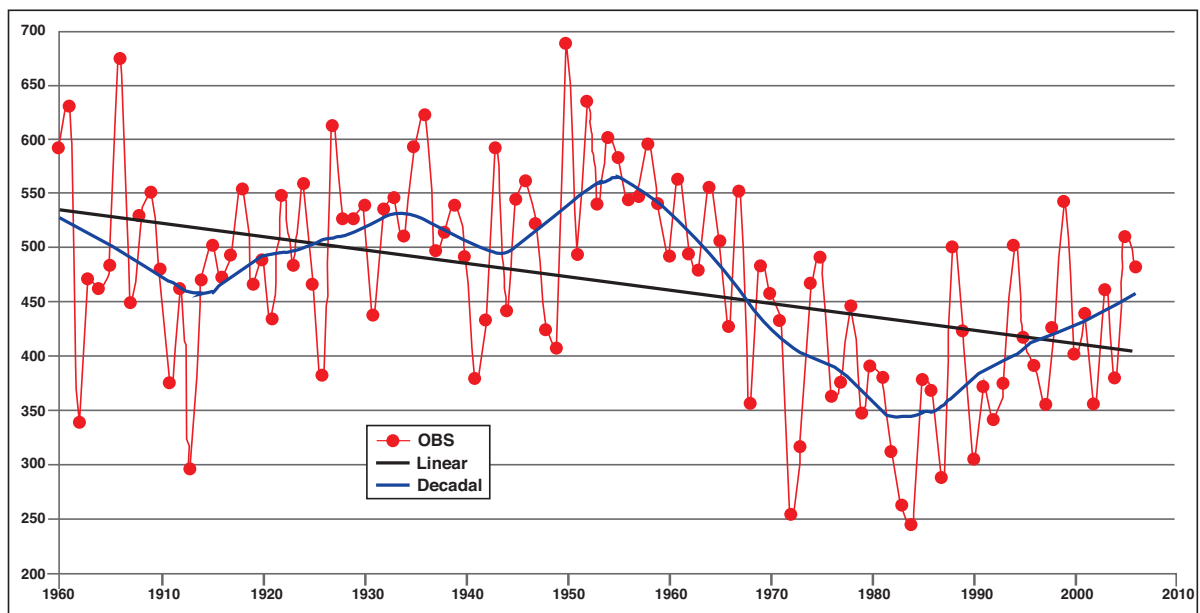


Figure 3: Observed Annual Rainfall in the Sahel, 1900 – 2006

Source: Giannini *et al.*, 2003

Development in dryland regions generally lags behind more humid zones, due particularly to a combination of low and poorly planned investments, lack of understanding of the particular dryland issues, and lack of political will at the national level. Many dryland areas are remote and relatively sparsely populated and their inhabitants are often politically disconnected, which contributes to their neglect by many governments. However, several Sahelian countries have their capital city in the Sahel and therefore remoteness does not account for all development challenges. Economic development is relatively low in most Sahelian countries and overall levels of poverty are high (World Bank, 2016).

Although drylands are often depicted as wastelands with low economic potential, the reality is quite different. Drylands provide multiple ecosystem services, including food production, water supply and climate regulation. Some studies have shown much higher marginal rates of economic returns on investments in drylands compared to more humid areas (UN, 2009).

Large scale agroforestry adoption in Gedaref, Eastern Sudan⁷

Gedaref watershed occupies 720,000 ha of eastern Sudan and was formerly one of Sudan's major food production centres. Decades of unsustainable agricultural practices, including near-monocropping, low nutrient replenishment, clear-cutting of vegetative woody biomass for fuelwood and agriculture, and shortening of fallow periods, have led to widespread soil degradation and decline in farmer's livelihoods. Sorghum yields, Sudan's main staple crop, declined by 1% per year from 1960 to 1980. This has affected food security, ecosystem function and subsequent provision of ecosystem goods and services, and has increased the vulnerability of the rural poor to climatic uncertainties.

In an attempt to reverse this decline, small scale rainfed agroforestry initiatives have been tested, integrating *Acacia senegal* trees in sorghum crop lands. *A. senegal* produces high quality gum Arabic and has been traditionally used in crop fallow systems. The tree is leguminous and therefore fixes nitrogen in the soil, while providing secondary benefits to farmers through the sale of gum.

Modelling exercises have estimated the impact of large scale adoption of *A. senegal* agroforestry on provisioning and regulating ecosystem services. The benefit to farmers of integrating *A. senegal* trees into on 20% of the agricultural land area is estimated at 11,600 SDG/ha (US\$ 1807). The investment cost of adopting agroforestry is recovered within 3-4 years and subsequent annual benefits outweigh management costs. In addition, the benefit of gum arabic production from *A. senegal* in agroforestry systems is estimated at 6500 SDG/ha (US\$ 1012). At the end of the 25-year rotation, the trees may be cut, providing fuelwood valued at 220 SDG per hectare (US\$ 35).

Adoption of agroforestry will result in increased groundwater recharge with an additional 26.5 million cubic meters potentially available to communities within the watershed, with an estimated value (avoided cost of purchasing water) of 16.4 SDG billion (US\$ 2.5 billion). Sustainable land management and reforestation will also sequester an incremental 10 tons CO₂ ha/yr (below and above ground). The total net present value benefit to Sudanese society was estimated at between 11.7 and 23.2 billion SDG (US\$ 1.82 – 3.6 billion) through enhanced groundwater recharge, avoided soil erosion, nitrogen fixation and soil moisture, gum Arabic production and fuelwood in the watershed over 25 years.

Drylands require sustainable development solutions that are adapted to the unique features of dryland ecology, particularly in the natural resources sector. Drylands do not respond to human interventions the way other zones do, and development efforts need to adjust to local conditions. For example, sustainable land management in drylands must

Sustainable land management in drylands must be adjusted to the specific challenges of maintaining soil moisture and soil fertility and minimising evaporative water losses.

be adjusted to the specific challenges of maintaining soil moisture and soil fertility and minimising evaporative water losses. Landscape management plans need to consider the challenges of naturally occurring fires and the important role large herbivores play in maintaining soil and ecosystem health. In practice, unsustainable agricultural development approaches are widespread in the Sahel, and they continue to be favoured over more sustainable options (Davies *et al.*, 2012).

⁷ Ricome, A., Westerberg, V. and Myint, M.M., 2014. An economic valuation of sustainable land management through agroforestry within the watershed of Gedaref State in Eastern Sudan

2.2. Understanding desertification and land degradation in drylands

Combating desertification is one of the primary motives behind the GGW. All GGW countries are signatories to the United Nations Convention to Combat Desertification and, under the convention, they are all self-identified as “affected” by the combined challenges of Desertification, Land Degradation and Drought (DLDD)⁸. Desertification is defined by the convention as “land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities”⁹. It has nothing to do with advancing deserts, nor with the creation of deserts in a scientific sense. The UN classifies dryland in 4 types based on the Aridity Index¹⁰: hyper-arid, arid, semi-arid and sub-humid. Only the first of these types is considered to be true desert by the UNCCD, and this type is not included in the UNCCD definition of desertification. Desertification is defined as land degradation in arid, semi-arid and sub humid lands, not their conversion to hyper-arid. Indeed, true deserts are a valuable biome in their own right, with their own unique biodiversity and they are often in need of protection.

In simple terms, desertification means land degradation in Drylands, and therefore the term can describe land degradation in the Sahel. The UNCCD defines Land Degradation as “reduction or loss... of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes ... arising from human activities”. The true extent of desertification, or land degradation, in the Sahel is a matter of some controversy. Satellite data covering a 20 year period from the mid-1980s show that the Sahel region has got progressively greener, refuting the widely-held belief that the Sahara desert is steadily moving southward. There may be more than one reason for this apparent retreat of the Sahara but it is likely that at least part of the explanation is in long-term cyclical climate patterns, with the Sahel currently enjoying a period of comparatively wet years (Mortimore *et al.*, 2009).

Desertification is defined as land degradation in arid, semi-arid and sub humid lands, not their conversion to hyper-arid.

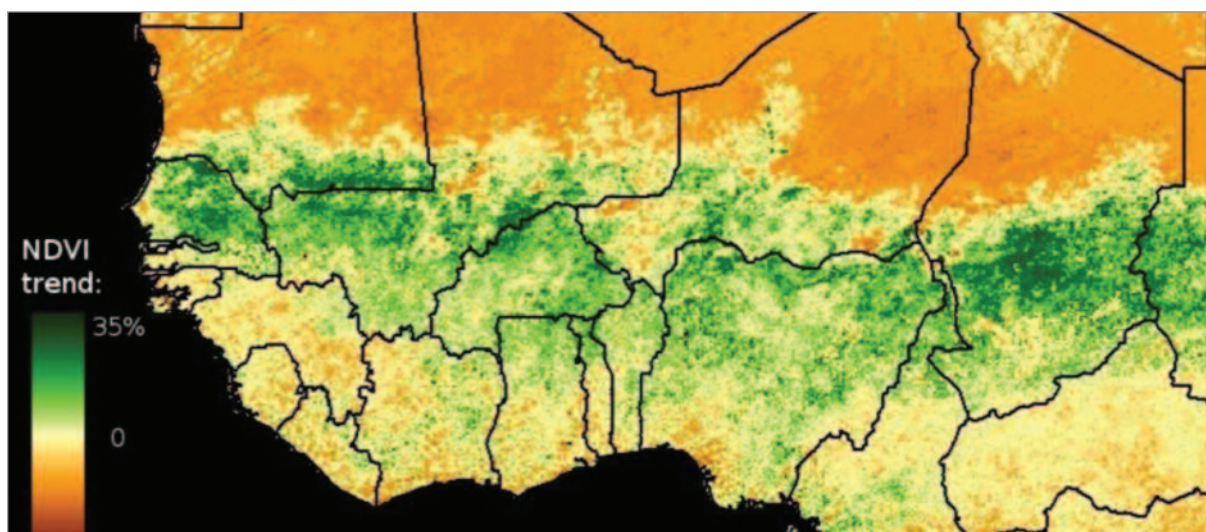


Figure 4: The ‘greening’ of the Sahel, 1982-2006

Source: Mortimore *et al.*, 2009

⁸ <http://www.unccd.int/en/media-center/MediaNews/Pages/highlightdetail.aspx?HighlightID=187>

⁹ UNCCD A/AC.241/27 12 September 1994

¹⁰ The Aridity Index is calculated as the mean precipitation divided by the potential evapotranspiration.

The fact that the Sahara is not currently advancing southwards has led many experts to challenge the concept of desertification and to criticize the Great Green Wall as a vehicle for sustainable development in the Sahel. Experts cite misunderstanding of the concept and the lack of evidence supporting desertification through the region. They show that a high level of climatic unpredictability is normal in the drylands and that this undermines efforts to describe deviation from a “normal” environmental state. Critics have suggested that the concept of desertification has been politically captured by elites who benefit by blaming rural communities for degradation and confiscating land to promote their own investment interests. Even where such acquisitions are not driven by self-interest, they nevertheless perpetuate top-down approaches and investments in agriculture that can undermine local resilience (Behnke and Mortimore, 2015).

Most Great Green Wall countries lack sufficient, objective evidence to support targeting of actions and have they insufficient means of monitoring progress.

Defining and measuring land degradation and desertification can differ greatly according to land use objectives. Part of the disagreement over the extent of desertification is due to lack of consensus over whether crop cultivation is a form of land degradation. Large areas of the Sahel are under crop cultivation, and large areas of dry forest and rangeland have been converted to agriculture in recent decades. However, land may also be farmed sustainably and declaring all crop land as degraded land is misleading with regards to how much land can or should be restored. More nuanced definition is required to assess the state of crop land and the proportion of crop land that is either sustainably managed or degraded with respect to its specific management objective. According to the definition of Forest Landscape Restoration above, restoration of landscapes does not preclude sustainable management of crop lands within those landscapes, although the term rehabilitation may be more useful when describing the re-establishment of productivity, structure and function of agricultural land¹¹.

Despite observations that the Sahel has been getting greener in recent decades, there remain concerns about land degradation in the Sahel. Global estimates of land degradation are converging on between one quarter and one third of all drylands suffering from some form of degradation, although global estimates rely on satellite imaging and therefore do not provide insights into degradation prior to the 1980s (Bai et al 2008; Le *et al.*, 2014). The combination of agricultural expansion, changing rainfall patterns, and human settlement all point to a considerable risk of widespread desertification in the Sahel.

There are significant methodological challenges in monitoring land degradation in drylands that still need to be overcome. Grass-dominated habitats, such as grasslands and savannahs, are poorly monitored using satellite measurements of net primary productivity and degradation by bush encroachment or invasive species is not easily identifiable. Drylands are also non-equilibrium systems where it can be challenging to determine a baseline against which to measure change: ecological variability is a normal feature of drylands. This presents an obstacle to objective assessment and monitoring, particularly where land users and land assessors have different opinions over the desirable state of the land. As a result, most Great Green Wall countries lack sufficient, objective evidence to support targeting of actions and have they insufficient means of monitoring progress.

The Great Green Wall can deliver against commitments to the UNCCD while simultaneously conserving biodiversity, mitigating climate change, and strengthening climate change adaptation.

Land degradation in the Sahel can be minimised through widespread adoption of Sustainable Land Management (SLM) practices and it can be reversed through restoration of landscapes and ecosystems. Together these two broad sets of response can combine to deliver Sustainable development Goal 15, and specifically target 15.3 on Land Degradation

Neutrality (LDN). In the process, the Great Green Wall can deliver against commitments to the UNCCD while simultaneously conserving biodiversity, mitigating climate change, and strengthening climate change adaptation.

¹¹ The IPBES Land Degradation and Restoration Assessment will publish a new definition in 2017 that may facilitate reaching consensus over the terminology.

2.3. The ecology of the Sahel and the forces that shape it

The Sahel spans Africa from the Atlantic coast of Senegal and Mauritania to the Red Sea coast of Sudan, Eritrea and Djibouti. It runs along the southern “shore” of the Sahara Desert and varies in width from a few hundred to over a thousand kilometres. The Sahel region receives a mean rainfall of between 150 and 700mm per annum and is characterized by marked seasonality, with a rainy season extending from July to September. Rainfall is determined by the Intertropical Convergence Zone (ITCZ) and is highly variable and unpredictable. Mean monthly maximum temperatures vary from 33° to 36°C and mean monthly minimum temperatures are between 18° to 21°C (Met Office, 2010).

The topography of the Sahel is largely flat and the majority of the altitude lies between 200m and 400m above sea level. It forms a transition zone between the Sahara Desert and the wooded savannas lying further south. This means the ecoregion lies south of the Southern Saharan Steppe and Woodland Ecoregion and north of the West and East Sudanian Savanna Ecoregions, and is dominated by Sahel Acacia wooded grassland and deciduous bushland. The exact vegetation type is largely influenced by a combination of soil type and precipitation (WWF, 2016).

Interventions in the Great Green Wall involve land outside the Sahel zone, including the drier desert regions to the north and the wetter zones, such as the savanna, to the south. They will also include aquatic ecosystems, like the numerous wetlands in the Sahel, and the riparian areas along major water courses, such as the Niger River and Lake Chad. Wetlands and riparian zones play a pivotal role in both the economy and the ecology of the Sahel (Thiombiano and Kampmann, 2010). Wetlands are highly diverse habitats that are home to numerous endemic species and which host many migratory species. These wetlands also store significant amounts of carbon and therefore play a role in regulating greenhouse gases and mitigating climate change.

There are a great number of wetlands in the Sahel, many on a small scale that support much larger areas of arid and semi-arid land. Others are on a vast scale, as in the case of the inland delta of the Niger River, a Ramsar site that covers more than 30,000 km² of Malian territory alone (DNEF, 2014). The boundaries of these wetlands are difficult to determine as they constrict and expand to a large extent according to seasonal weather patterns. However, in all cases their value extends far beyond their boundaries due to their influence on a much wider ecosystem. Additionally these wetland areas are sometimes referred to as areas of “rich patch vegetation”, which reflects their high value in providing ecosystem goods and services throughout the year, and particularly in stress seasons when large numbers of pastoralists may congregate in such areas.

Wetlands in drylands in the Sahel

Wetlands within the drylands of the Sahel are rich areas where water and nutrients accumulate, plant and animal production potential is high, and production risk is low. Wetlands include not only the few large floodplains but also many thousands of smaller humid zones. Northern Niger, for example, has many oases supporting orchards and fruit production. The wetlands also support crop and livestock production, fishing, hunting and tourism, collecting of natural products, and conservation of biodiversity. Crop production in Niger's wetlands takes place on up to 64,000 ha and is estimated at USD200-4,300 per ha. Livestock production in these wetlands has been estimated at USD35 million per year.

Wetlands are economically important to people living in them as well to people living farther away who access them less frequently, such as in times of drought. However, wetlands are under threat due to growing human pressure, climate change, and land use change in their catchments. Improvements are needed in governance of the wetlands, and dryland landscapes more generally, to enable more integrated and participative management. Traditional techniques for utilising the wetlands need to be revived in some cases and an improved balance is needed between the use of wetlands for both production and conservation (Brouwer, 2014).

The ecology of the Sahel has been heavily influenced by, and dependent on, the action of both herbivores and fire. Grazing and burning combine to determine the balance between trees and grasses. As biomass increases in these dry areas the likelihood of fire increases. Fires remove some woody biomass, selecting for those species that are more fire-resistant, and creating conditions in which grasses thrive. Grasses in turn favour the presence of grazing species and the two -grasses and grazers- are co-dependent. However, too much or too little grazing can favour the return of shrubs and trees, particularly those that are herbivore-adapted, and as this woody biomass increases it can inhibit further grass growth. This in turn can lead to a build-up of a fuel load, thereby raising again the likelihood of fire. Historically elephants have played a major role in uprooting trees and influencing the ecology of the Sahel, but in most areas this impact is no longer present. This balance of interactions is highly sensitive to rainfall, which means that small shifts in climate patterns could have a major impact on ecology, particularly in the southern Sahel (Sankaran *et al.*, 2005).

The ecology of the Sahel has been heavily influenced by, and dependent on, the action of both herbivores and fire. Grazing and burning combine to determine the balance between trees and grasses.

Climate change projections for the Sahel region are highly uncertain, especially for precipitation, and models do not agree on whether precipitation will increase, decline, or become more variable. Current data points to a long-term trend of increasing precipitation, as indicated by a substantial re-greening of the Sahel since the early 1980s, although there are a number of possible factors behind this trend (Mortimore, 2009). Global vegetation models project an increase in primary productivity in natural and semi-natural ecosystems in the Sahel due to a combination of increased rainfall and rising CO₂

Climate change projections for the Sahel region are highly uncertain, especially for precipitation, and models do not agree on whether precipitation will increase, decline, or become more variable.

concentrations. This would lead to a greening of parts of the southern Sahara and an increase in woody vegetation in parts of the Sahel (Leadley *et al.*, 2010). Climate warming in the Sahel may lead to higher evaporation rates, which is a major determinant of drylands. As a result the area that is considered as dryland may change and vegetation patterns may shift considerably (Bonkougou, 2004). Climate change is discussed in further detail in Section 3.4.

2.4. Social and economic trends in the Sahel and the implications for biodiversity

The Sahel lies in one of the poorest regions of the world in economic terms, with most of the countries lying in the bottom quartile of per capita GDP (World Bank, 2016). However, poverty in the Sahel is not simply a matter of economic performance and may be better characterised as human development poverty. Dryland regions of West Africa score poorly on indicators like child mortality and literacy. Regional under-five mortality rate in the Sahel is 222 per 1,000 live births, or 600,000 child deaths annually, which makes the region the highest in the world (UNICEF, 2008). Adult female literacy in West Africa is universally low, but the levels plummet in the semi-arid and arid areas. Female literacy is strongly linked to poverty reduction as it is an indicator that can forecast poverty and demographic trends. Families where female literacy is higher have better economic prospects and have a better chance of resisting poverty. While it would be risky to blame environmental degradation solely on poverty, it nevertheless seems plausible that investing in female literacy and other aspects of human development could contribute to mitigating environmental degradation.

Poverty in the Sahel is not simply a matter of economic performance and may be better characterised as human development poverty.

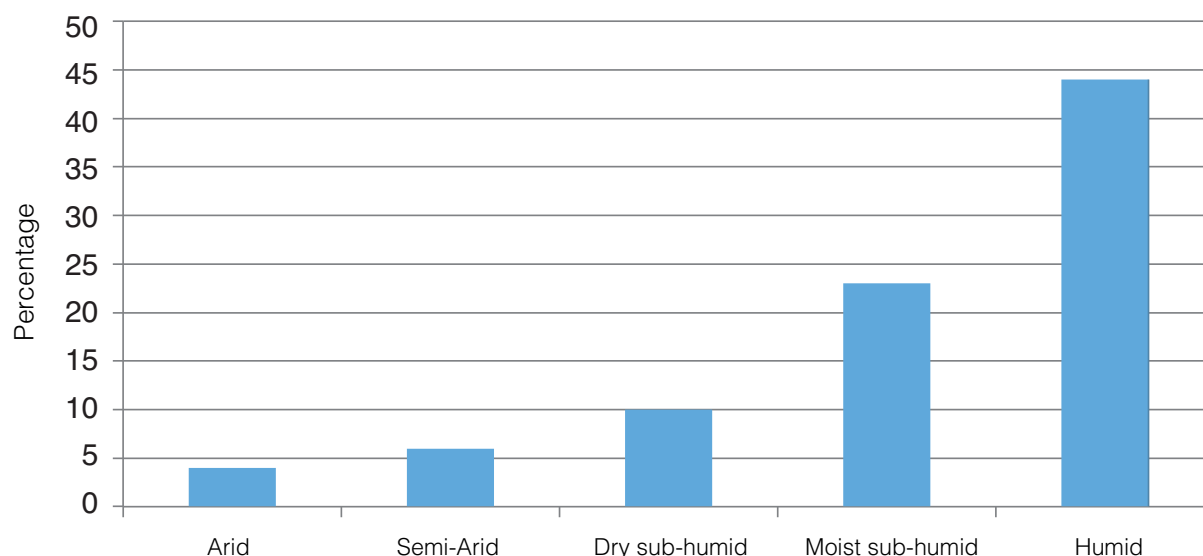


Figure 5: Adult Female Literacy in West Africa

Source: Middleton *et al.*, 2011

Human population density in the Sahel is low, ranging from 1 to 5 persons/km² in the north, to 50 to 100 persons/km² in the south and around some water sources, including the Nile in Sudan. Over 60% of the total population of western Sahelian countries lives in settlements of less than 5 000 inhabitants, mostly engaged in livestock production (Ly *et al.*, 2010). However, there is strong population growth in the drylands and, without significant outmigration, the rural population of dryland countries could grow by between 15% and 100% by 2030 (depending on the country). This would increase pressure on natural resources, and possibly intensify conflicts over land, water and other resources. This will affect resilience and the capacity of government and development partners to manage the impacts of droughts and other shocks (Cervigni and Morris, 2016).

The rural population of dryland countries could grow by between 15% and 100% by 2030.

Agricultural productivity in the Sahel has increased over the past 3 decades, although variability between years remains high. Crop production is dominated by millet and sorghum, which are well-adapted to dry conditions, whereas in the irrigated areas rice is dominant. Maize production has made the most significant increases in productivity per hectare in recent years. Overall increases in crop production in the Sahel have come both from expansion of the area cultivated and from modest improvements in productivity per unit area (United Nations, 2011).

Industrial agriculture, often based on large-scale investments in land clearance and irrigation by agribusinesses, with heavy reliance on machinery and chemical inputs, has played an important role in raising food production. However, it has also contributed to widespread loss of biodiversity and disruption of ecosystem functions and may have contributed to loss of overall resilience to both rural communities and national economies. Industrial agriculture has not adapted well to the high levels of risk found in the drylands, but has undermined traditional farming systems that have been much better adapted to risk. Industrial agriculture has also favoured the use of external inputs over managing soil fertility through sustainable practices. As a result it has contributed to desertification and possibly undermined the long-term agricultural productivity of the Sahel.

Increases in crop production in the Sahel have come both from expansion of the area cultivated and from modest improvements in productivity per unit area.

Alternative forms of more sustainable agriculture are increasingly common in the Sahel and will play a major role in achieving the goals of the Great Green Wall Initiative (this is discussed later in this report). Sustainable forms of agriculture include agroforestry and low tillage cultivation, which work with nature to maintain biodiversity in the field and to protect soil moisture and fertility. Many of these sustainable farming systems have their roots in traditional practices that were well adapted to the conditions of the Sahel. Research and investment in sustainable forms of agriculture is increasing and the practices are becoming more sophisticated, leading some to use the label “sustainable intensification”.

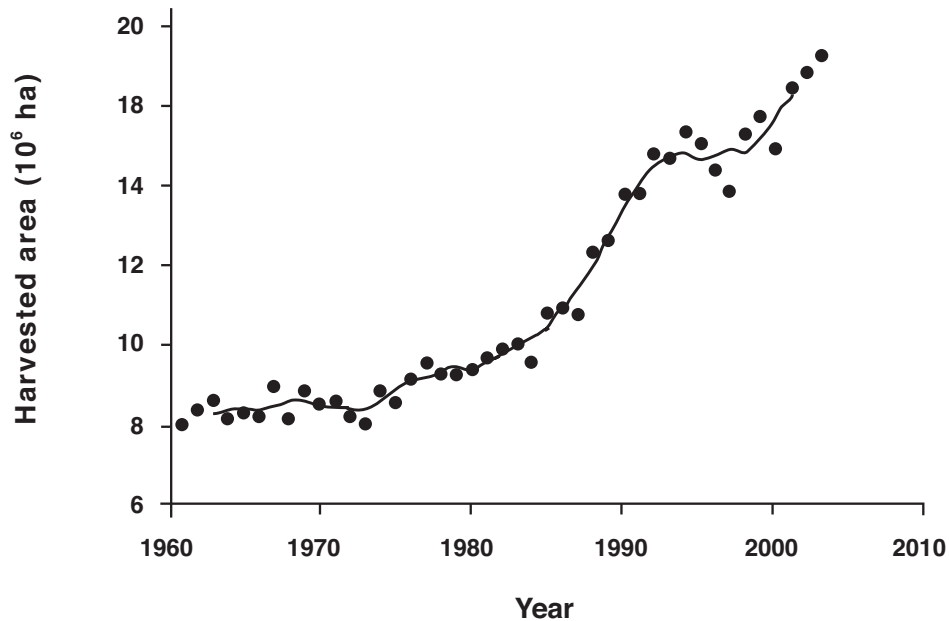


Figure 6: Total area harvested to cereals in the Sahel since 1961 (data from FAOSTAT)

Source: Kandji *et al.*, 2006

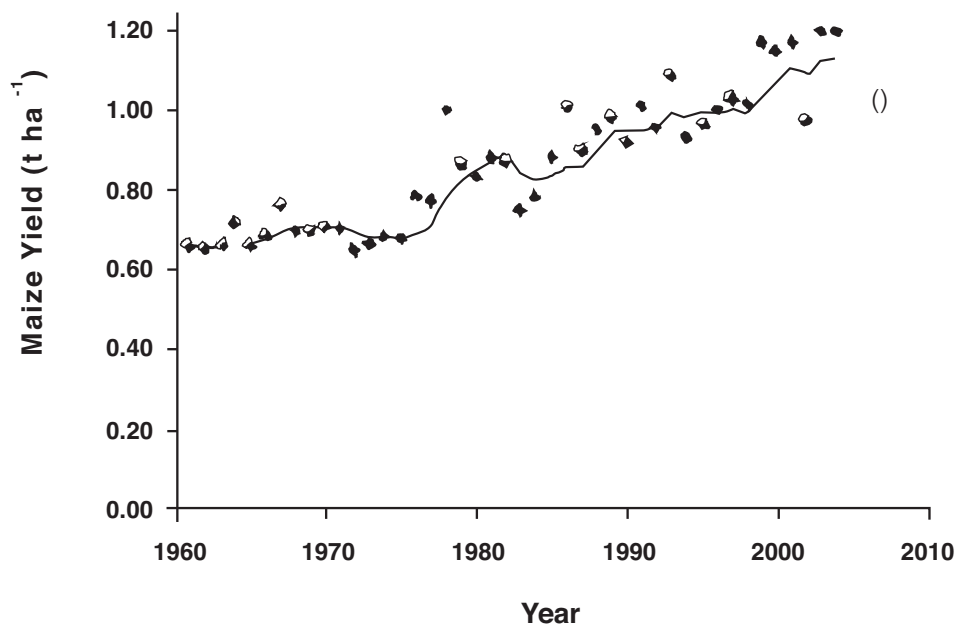


Figure 7: Averaged maize yield for CILSS member countries since 1961 (data from FAOSTAT)

Source: Kandji *et al.*, 2006

The extreme climatic variability of drylands means that producers are exposed to frequent shocks, and particularly drought. Traditional crop and livestock production in the Sahel are highly adapted to such events, for example by using adapted breeds and management practices. Population growth and changing resource pressures are putting extra pressure on natural resources and on established coping strategies. Changes to resource access and availability can be critical, particularly when access to critical seasonal resources is lost, such as non-timber forest products or dry season pastures. Risk management strategies have come under other pressures, for example from market forces or from breakdown in local governance and institutions (Mortimore *et al.*, 2009; United Nations, 2011).

The extreme climatic variability of drylands means that producers are exposed to frequent shocks, and particularly drought.

One of the best adapted land management strategies in the Sahel is pastoralism, which is also the most widespread land use system in terms of territory covered. Pastoral livestock production has been practiced in the Sahel for centuries, using communal rangelands and relying on herd mobility to track resources and manage risk. Livestock fulfil multiple roles in addition to providing food, for example livestock capital is used to generate income, to accrue social debts and obligations, and for many cultural purposes. Pastoralists also rely on rangelands for more than livestock production and play an active role in protection and management of rangeland biodiversity (Davies and Hatfield, 2008). Nomadic livestock keeping is more prevalent in the northern Sahel, whereas further south grazing systems are less mobile and livestock are often integrated with rain-fed and irrigated crop farming.

One of the best adapted land management strategies in the Sahel is pastoralism.

Agriculture in the Sahel can be grouped into three types: livestock only grazing systems; rain-fed mixed crop-livestock systems; and irrigated mixed crop-livestock systems (Ly *et al.*, 2010). The relative proportion of the population engaged in crop farming may be increasing as more rangeland is

converted to cropping and as investments are made in irrigation and in development of drought-resistant crops. In practice there are connections and overlaps between these 3 types of agriculture and historical relationships between livestock herders and crop farmers have enabled resource sharing and other forms of cooperation. There are, nevertheless, indications that these relationships have broken down in many places, often as a result of changes in tenure arrangements and social relationships (Ickowicz *et al.*, 2012).

There are undeniable development opportunities in the Sahel and a significant proportion of the rural population would not be classified as poor in terms of assets or income.

Nevertheless, there is also a major population that is in frequent need of humanitarian support. In 2011 around USD4billion was spent on humanitarian assistance to the Sahel and the Horn of Africa, equivalent to over 10% of total Official Development Assistance to all of Sub-Saharan Africa. This scenario is projected to deteriorate with an anticipated population increase of 65% to 80% by 2030 and considerable increase in the number of people in the Sahel who are exposed to droughts and other shocks (Cervigni and Morris, 2015).

Economic growth and population growth in the Sahel may bring opportunities for trade and for greater value addition, although predictions suggest that economic growth will not be fast enough to outweigh population growth. A shift in the relative balance of rural to urban population is likely, but the absolute population reliant on agriculture and exposed to droughts may still grow. The number of people in the Sahel that depend on agriculture and live below the poverty line is expected to increase by anything from 20 to 100% between 2010 and 2030 (Cervigni and Morris, 2016).

The number of people in the Sahel that depend on agriculture and live below the poverty line is expected to increase by anything from 20 to 100% between 2010 and 2030.

3. Biodiversity in the Sahel

3.1. Dryland biodiversity: adaptation to uncertainty

Biological diversity –or biodiversity– is a term that describes the variety of life on Earth: animals, plants, microorganisms, their habitats, and their genes. The Convention on Biological Diversity defines it as “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” (United Nations, 1992). Biodiversity is crucial for the functioning of ecosystems which provide us with products and services that support life, including oxygen, food, fresh water, fertile soil, medicines, shelter, protection from storms and floods, stable climate and recreation. The relationship among species is of central importance to the benefits that human beings derive from nature. Biodiversity regulates the major ecological cycles of the earth, including the carbon, nitrogen and water cycles, and is at the heart of the ecosystem services generated from nature¹².

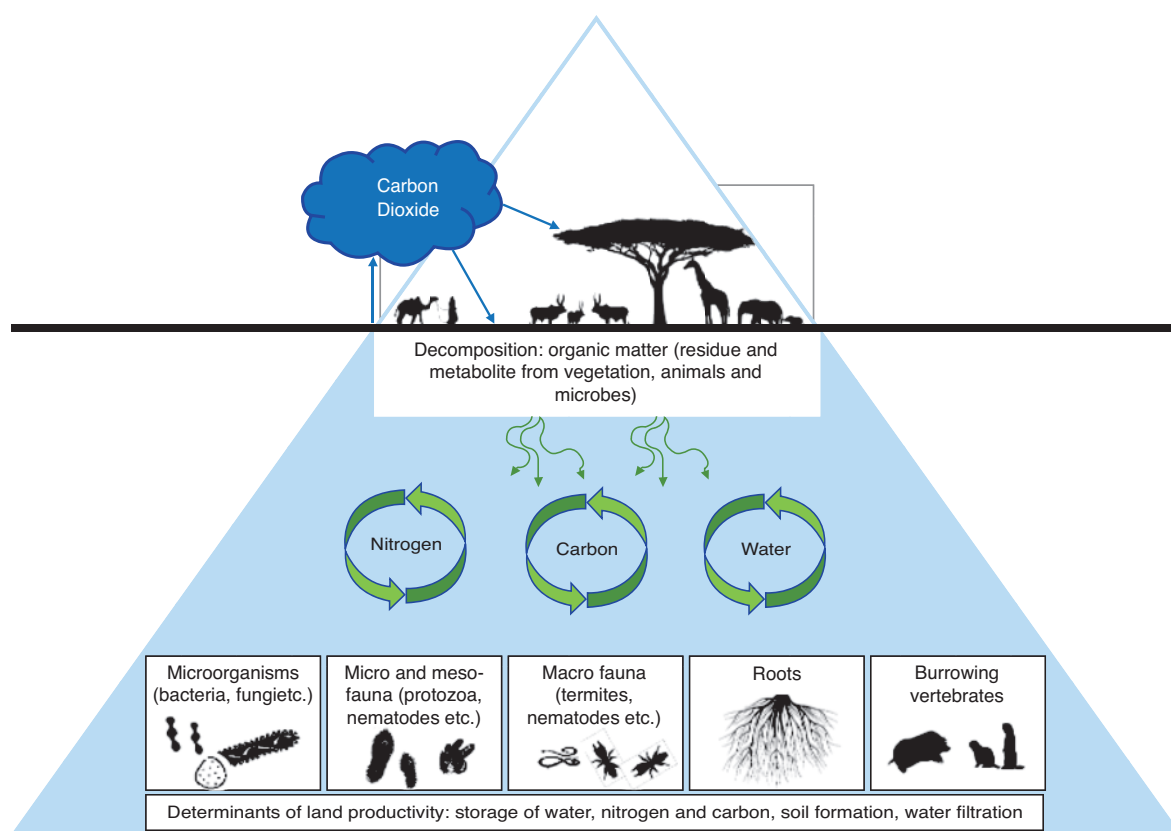


Figure 8: Soil biodiversity and ecosystem function

IUCN, Jonathan Davies

¹²http://iucn.org/backup_iucn/iucn.org/what/biodiversity/about/index.html

Soil biodiversity in the drylands

Soil biodiversity is poorly understood or valued and yet it provides the foundation on which many ecosystem functions rest and which maintains the stability of life on earth. However, as with many other aspects of the drylands, soil biodiversity in the drylands is distinct from that of more humid areas. Soil microorganisms, for example, create unique communities with surface organisms in arid lands which influence inputs and outputs of gases, nutrients and water from soil surfaces, as well as regulating soil stability, weathering, and hydrological and nutrient cycles (Ponting and Belnap, 2012).

Trees in drylands play an important role in maintaining soil biodiversity, for example through symbiosis with soil organisms or through pumping of deep nutrients and moisture to the surface. A number of dryland trees in the Sahel have been shown to exert a positive effect on soil fungi and thus on soil moisture and nutrient content. This relationship is part of the reason that trees are so beneficial to agricultural production and why agroforestry systems can be so productive (Ndoye *et al.*, 2012).

The role played by soil microorganisms changes with aridity, since many microbes and fungi are highly moisture dependent. Invertebrate macro-decomposers, such as termites, are more important for nutrient cycling in drylands. These species recycle organic matter, such as leaf litter, for microbial activity. They can increase the soil's water-infiltration capacity by burrowing and they increase soil moisture by accelerating the decomposition of organic matter. Termites influence the distribution of natural resources such as water and nutrients in the landscape and consequently the diversity of soil microbes, plants and animals (Jouqueta *et al.*, 2011).

When drylands are used for crop cultivation, tillage and pesticide use can lead to a decline in soil-dwelling macro-decomposers and may thereby contribute to a decline in soil fertility and moisture. This partially explains the success of SLM practices that maintain vegetation cover and minimise soil disturbance, for example through low tillage practices, fallows, and maintaining perennial grassland cover.

Drylands include some of the most biologically diverse places on earth, particularly in the semi-arid and dry sub-humid zones. Much of the biodiversity found in drylands displays unique adaptations to the conditions found there, such as aridity or high climate variability. Dryland features, such as herbivore pressure and fire, have driven further adaptations and as a result there are species found in drylands that are not found elsewhere.

Biodiversity has adapted to the drylands in many different ways, and particularly to the seasonality, scarcity and variability of rainfall.

Biodiversity has adapted to the drylands in many different ways, and particularly to the seasonality, scarcity and variability of rainfall. The reproductive cycles of some organisms have adapted to the short duration of rainy seasons, whilst other species have adapted to the occurrence of extended periods of drought. Drought adaptations include the ability to escape, evade, resist and endure drought (Bonkougou, 2004).

Relationships between species in plant and animal communities have similarly evolved and adapted in the drylands. For example, the scarcity of water and nutrients in the soil have created symbiotic relationships between plants and microorganisms that are central to many critical ecosystem processes in the drylands.

Diversity within the drylands is also driven by physical variations in the landscape, such as topography or soil type. Meanwhile humans have shaped many drylands for centuries. As a result, drylands are not homogenous landmasses but consist of a patchwork of habitats. Some habitats found within drylands, such as oases, are of high ecological and economic value, even if they are found on a small scale, and they support a wide variety of life, often far beyond their boundaries. Many wetlands in the drylands are crucial for the survival of migratory birds. Such patches may also be critical for the survival of human populations (Davies *et al.*, 2012).

3.2. An overview of species diversity in the Sahel

The Sahel region is naturally dominated by grassland and savanna, interspersed with significant areas of woodland and shrubland, and punctuated with many small but important humid patches such as wetlands and seasonal streams. Sahelian landscapes can host a variety of annual and perennial grasses together with a range of acacia and other trees, which are replaced by shrubs in more northerly zones (WWF, 2016).

The Sahel is notable for supporting long range migrations, not only of ungulates but also of many bird species. Wetlands within the Sahel are particularly important for these migrations, which include intra-African migrations as well as populations that move south from Europe and the Arctic. Niger for example has around 1,000 wetlands estimated to support 1.2 million birds every January and February (Brouwer & Mullié 2001). Resident biodiversity and habitat is essential to enable these migrations and therefore changes in biodiversity can have far-reaching consequences. For example, many migratory birds rely on the hatching of alates -winged forms of insects, particularly termites- during the wet season to provide a rich energy source that enables them to complete their migration.

The Sahel and Sahara support an impressive array of biodiversity, including a particularly large number of endemic species: species that are not found elsewhere on the planet. The region includes the Sudanian regional centre of endemism with a high concentration of endemic plants, and western Sudan, for example, is a centre of endemism for gerbils. Several other rodents are endemic to the region along with other mammals, ten endemic reptiles, and two endemic bird species (WWF, 2016). Despite its flat topography, the Sahel includes a few mountains regions that may provide particularly important refuge for endemic and endangered species as well as providing important ecological resources to human populations. The Darfur region of Western Sudan is noted for its mountain ecology, while the far eastern Sahel includes parts of Ethiopia, whose mountains provide abundant water resources. Overall, however, the significance of isolated mountains in the Sahel is poorly researched.

The Sahel and Sahara support an impressive array of biodiversity, including a particularly large number of endemic species: species that are not found elsewhere on the planet.

The southern fringe of the soudano-sahelian ecotype bordering the Guinean and the Congo Basin forests is characterised by a mosaic of grass and tree savanna with 3 to 5% gallery forests. Gallery forests are made up of an assemblage of rainforest species (trees, amphibians, mammals, and insects) that have survived the last episode of forest withdrawal. The gallery forest habitat, which is considered as a biodiversity hotspot, is key to an important array of ecological and economic processes. The forest provides water, rare forest products and plants as well as timber to communities, they bear high cultural and traditional value they also provide refugees and nuclei for natural or assisted habitat and forest regeneration.



Conservation of the West African giraffe

The West African giraffe (*Giraffa camelopardalis peralta*) was historically distributed throughout West and Central Africa. Recent genetic analysis has identified two sub species of giraffe in West Africa: *G. c. peralta* and *G.c. antiquorum*, which alongside *G. c. camelopardalis* make up the newly proposed Northern giraffe species (Fennessy *et al.*, 2016). It is suggested that the ancestor of the West African giraffe moved from East to North Africa and thereafter to the Sahel in response to change in the extent of the Sahara Desert. Its distribution was later determined by the southern limit of the Sahara Desert in the north, the Niger and Benue Rivers and the Upper Guinea rainforests in the south, and the forests and mountains between Nigeria and Cameroon to the east. The giraffe remained widespread throughout the region at the end of nineteenth century, but severe declines have been recorded since the beginning of the twentieth century (Marais *et al.*, 2014).

While the giraffe species as a whole has recently been up-listed to “vulnerable” on the IUCN Red List of Threatened Species, the West African subspecies is in a more serious position. Based on a decline of West African giraffe over time it is listed as “endangered” and is absent from the vast majority of its former range. The Northern giraffe as a whole has been heavily affected by a combination of population growth, civil unrest, illegal hunting, and destruction of habitat, which have exacerbated the impacts of a series of intense droughts.

The last West African giraffe are now largely limited to south-western Niger, where they are under severe pressure from human population growth and rapidly expanding land use change. Human demand for natural resources, including land for agriculture, fuelwood, pastures and water, all compete against the needs of the West African giraffe and generate human wildlife conflict that is not favourable to the survival of the sub-species.

Despite this pressure, the West African giraffe population has risen following a dramatic decline prior to the 1990s. In the mid-1990s the population was estimated at approximately 49 individuals whereas current estimates put the population at just under 550 individuals. Recent population increase is attributed to curtailing of illegal hunting since the 1990s, but as the population rebounds it is facing a new threat of habitat loss. The West African giraffe is beginning to move out of its core area in Niger, making long range movements across Niger and the Nigerian border. As the population expands it is likely to face renewed threats of poaching, and despite the population increase it remains the most threatened giraffe subspecies. Niger has recently developed a second National Giraffe Strategy and Action Plan, the only one in the world, which helps to focus future conservation efforts for the sub species.

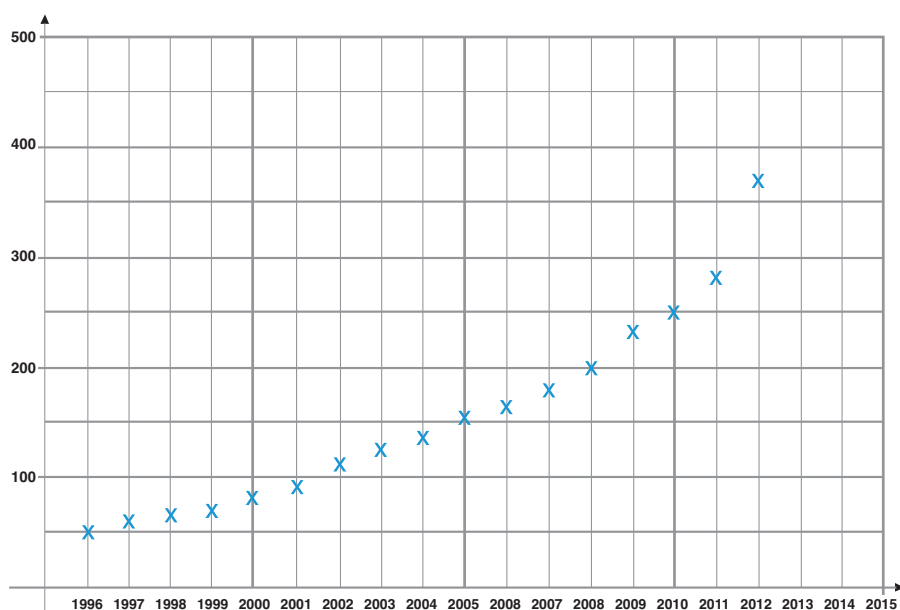


Figure 9: Population change, West African giraffe

Source: GCF, 2016

In addition to higher rates of endemism than formerly recognised, the region is characterised by narrow and fragmented ranges, often limited to “micro-hotspots” of biodiversity, such as seasonal rivers and ponds (Brito *et al.*, 2014). These are areas that are often under the greatest pressure from humans, and yet due to their high value and relative scarcity they can be vital for life on a vast scale. Pastoralist livelihoods, as well as migratory species, depend on these resources and high costs can be incurred when small resource-rich areas are converted to other uses.

Value of Gueltas in the Sahara¹³

Gueltas are mountain rock pools which are dispersed throughout the Sahara-Sahel and are important biodiversity hotspots. A large proportion of Mauritania's wildlife, for example, is found in gueltas, including at least 59 vertebrate species, 78% of Mauritania's endemic species, and an uncounted number of invertebrates. Despite their small size, they are crucial to Mauritania's biodiversity, and their importance as wildlife refuges may be growing as a result of climate change. Up to 64% of gueltas may be unprotected, although the level of protection is high compared to many other ecosystems within the Sahel. Nevertheless, there is high demand for the resources of the gueltas and therefore they face particular pressures.

Gueltas are economically important as watering areas for livestock. Protection of biodiversity in the gueltas therefore needs to be consistent with their main economic functions. One option could be to prioritise high biodiversity value gueltas for stronger protection, or to channel water from gueltas to troughs further away, reducing both human and livestock pressure. There are opportunities to expand non-consumptive uses of the biodiversity of the gueltas, for example through tourism, which might be a useful incentive to communities to improve protection and sustainable use.

Agrobiodiversity in the Sahel is vital for the livelihoods and the resilience of rural dryland populations. Agrobiodiversity is defined by the CBD as “all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes” (CBD COP decision V/5, appendix¹⁴). FAO defines agrobiodiversity as “the variety and variability of animals, plants and microorganisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil microorganisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems” (FAO, 1999).

Agrobiodiversity in the Sahel is vital for the livelihoods and the resilience of rural dryland populations.

Many crop varieties and livestock breeds have developed in the Sahel through a combination of farmer selection and natural selection of species over many hundreds of years.

Many crop varieties and livestock breeds have developed in the Sahel through a combination of farmer selection and natural selection of species over many hundreds of years. They are highly adapted to the specific conditions in which they exist and they are often central to the risk management strategies and local adaptation of rural populations. Comprehensive overviews of agrobiodiversity in the Sahel are not available, but the overall level of agrobiodiversity in Africa is comparatively high, with for example around 150 varieties of cattle, 60 varieties of sheep and 50 of goats (Bonkougou, 2004). Additionally, crop wild relatives contain the genetic material that confers local adaptation, such as resistance to drought and extreme temperature.

¹³Vale C.G., Pimm, S.I. and Brito, J.C., 2015. Overlooked Mountain Rock Pools in Deserts Are Critical Local Hotspots of Biodiversity. PLOS ONE, 10 (2) e0118367. DOI: 10.1371/journal.pone.0118367

¹⁴<https://www.cbd.int/agro/whatis.shtml>

The Bororo Zebu of the WoDaaBe: selection for variability in an extreme environment

Livestock breeds in the Sahel are highly adapted to the extraordinary challenges of their environment. These adaptations come from a combination of natural factors and management practices and the resulting breeds are integral to the culture and history of many livestock keeping societies. The Bororo cattle of the WoDaaBe pastoral community are an example of this. The WoDaaBe pastoral system has been described as “high reliability”, focussing on the proactive management of hazards rather than avoiding them, in order to maintain a steady flow of livestock production. To achieve these goals, livestock breeding is carefully tailored to the environment as well as the production needs. The main goal of the WoDaaBe is to maximize the health and reproductive capacity of the herd throughout the year, ensuring survival of animals through the frequent droughts that they experience. Their management system is similarly adapted, ensuring that cattle eat the most nutritious diet throughout the year (Kratli, 2007).

Among the many adaptations of the Bororo breed is the capacity to selectively graze high quality fodder in high quantities when it is available. This includes genetic adaptation (including the digestive systems and the small size and shape of the mouth) as well as behavioural adaptation (for example efficient trekking and grazing behaviour and diet preferences). The cattle's preferences are manipulated by optimizing grazing patterns and ensuring access to a diversified diet of grasses and browse, in order to correct nutritional imbalances which, particularly during the dry season, could reduce appetites. The dry-season watering regime is similarly adjusted to the cattle's digestive needs, as well as to the needs of the herders to control reproduction.

This production strategy places high demands on the herders as well as the cattle. During the dry season herds are moved away from water points, where pasture is poor, leading to long range movements and reduced water intake (every third day). In order to maintain functional behavioural patterns in the herd the WoDaaBe breeding system focuses on fostering social organization and interaction within the herd. The strategy is to share desirable feeding behaviours throughout the breeding population and to foster its continuity over generations. To achieve this only a small percentage of bulls are used for reproduction (less than 2%) and herders closely observe oestrus to ensure a high percentage of births result from match-making with selected males. This breeding strategy places reliability of the herd's reproductive performance ahead of individual productivity traits.

Many Sahelian trees provide not only food but also medicines, cosmetics, building materials and other resources, many of which have a significant market value. Altogether more than 800 species of edible wild plants have been catalogued across the Sahel.

Not all definitions of agrobiodiversity are as broad as FAO's above and some sources take a narrower view that emphasises the variety of crop and livestock varieties, landraces, and species, and differentiating this from wild biodiversity (Buck *et al.* 2004). However, the interaction between domesticated species and rural landscapes means that the two have often adapted together and many ecosystems can be considered to be modified by human management practices, and therefore to be part of agrobiodiversity. For example, many grasslands have adapted to being managed by pastoralists, to the extent that cessation or disruption of herd management can lead to degradation and loss of biodiversity (McGahey *et al.*, 2013).

The FAO definition of agrobiodiversity includes wild biodiversity that is vital to the livelihoods of many rural communities. This includes a variety of trees that yield edible leaves, roots, fruits and seeds. The baobab, for example, is widely consumed throughout the Sahel in the daily diet, whereas other trees provide resources that are crucial during specific times of the year, including the dry season. Many Sahelian trees provide not only food but also medicines, cosmetics, building materials and other resources, many of which have a significant market value. Altogether more than 800 species of edible wild plants have been catalogued across the Sahel (FAO, 1999).

3.3. The status of biodiversity in the Sahel

Human activity has significantly modified the Acacia bushland of the Sahel over many centuries through the use of fire as a management and hunting tool as well as through cultivation and other interventions. In recent decades, however, the Sahel has witnessed dramatic declines in populations of many of its large mammals. This is largely the result of human activities, including conversion of habitat to crop cultivation and over-hunting. The loss of biodiversity is the long term reduction of abundance and distribution of species, ecosystems and genes and the goods and services they provide (CBD, 2003). Since biodiversity loss is closely associated with human pressure, the impacts are often lower in more sparsely populated areas (WWF, 2016). Nevertheless, some experts project that the Sahel region will be more affected by habitat destruction in the coming century than almost anywhere else on earth, with decreasing species abundance and a number of species extinctions (Leadley *et al.*, 2010).

The Sahel has witnessed dramatic declines in populations of many of its large mammals.

The diversity of larger mammals in the Sahel has declined dramatically over the past two centuries. According to the IUCN Redlist of Threatened Species, the scimitar-horned oryx (*Oryx dammah*), formerly widespread through the region, is presumed to be extinct in the wild and there have been no confirmed reports of any wild oryx since 1988. Several gazelles were formerly widespread, including the critically endangered Dama gazelle (*Gazella dama*), and the vulnerable dorcas gazelle (*Gazella dorcas*) and red-fronted gazelle (*Gazella rufifrons*). These species play an important role in seed dispersal and their decline can have knock on effects on regeneration of vegetation, species composition and structure (Mallon *et al.*, 2015). The desert antelope (*Addax nasomaculatus*) is listed as critically endangered by the IUCN Red List of Threatened SpeciesTM and numbers only around 100 individuals.

Some experts project that the Sahel region will be more affected by habitat destruction in the coming century than almost anywhere else on earth, with decreasing species abundance and a number of species extinctions.

Mega fauna has historically played a major role in shaping biodiversity and influencing ecosystem structure and function in dryland regions. Sahelian megafauna has declined throughout the region and is entirely absent from large areas. A number of species, such as the Western black rhino (*Diceros bicornis longipes*), have already disappeared from the subregion (Emslie, 2011), while the African elephant (*Loxodonta africana*) has declined dramatically.

Elephant numbers have been particularly affected by habitat loss due to conversion of rangelands to crop lands, unregulated deforestation, and by the development of roads that have opened up areas of pristine habitat to hunters. African elephants were widely distributed across the Sudano Sahelian range as recently as the 1950s but their population is increasingly confined to a few protected areas. The protected area complex formed by the Gourma Reserve in Mali and the Partial Sahel reserve in Burkina Faso, for example, hosts the most northern elephant population in Africa with 600 individuals, migrating between the two areas (Bouché *et al.*, 2011).

As the herbivore population has declined, so too has the population of many large predators. Lion (*Panthera leo*) and cheetah (*Acinonyx jubatus*), for example, were formerly dispersed throughout the region but are now categorised as vulnerable, having largely disappeared from the region. Indeed, Lions in West Africa fare less favourably than African lions as a whole and their regional status is classified as Critically Endangered. Lion populations in West Africa are now estimated at 406 individuals (Henschel *et al.*, 2014). Populations of large birds (ostrich, cranes, raptors, bustards) have also declined severely across the Sahel and populations of large raptors have collapsed outside of Protected Areas. Six out of seven species of vulture occurring across the Sahel and savanna zones are threatened (Mallon *et al.*, 2015).

Although concerns are frequently raised over the decline of biodiversity in the Sahel, there are major data gaps that frustrate efforts to estimate the true status. Nevertheless, many of the common drivers of biodiversity loss are present in the drylands, including growing population pressure and increasing economic activities. As dryland areas receive more development investment, greater threats to biodiversity are anticipated. At the same time, climate change is expected to have a significant impact in the Sahel, although the exact impact on biodiversity is difficult to predict with certainty. As discussed later, climate in the Sahel may continue to get wetter, leading to further re-greening of the Sahel with increases in vegetation growth and primary productivity. However, ecological changes are likely to be tempered by the rapidly expanding human population and the increasing demands placed on the environment by a growing human population (Hartley, 2015).

As dryland areas receive more development investment, greater threats to biodiversity are anticipated.

Gonakier Forests of the Senegal River Floodplain¹⁵

The Gonakier Forest ecosystem is found in the Senegal River floodplain in parts of Senegal, Mauritania and Mali. The ecosystem is dominated by the Gonakier tree (*Acacia nilotica*) along with *A. raddiana* and *A. seyal*, with a sparse, grassy understory. The forest is found in flat areas that are subject to annual flooding, typically being inundated by wet season floods between July and November. The periodic floods are vital for providing habitat for fish and migrating birds and for sustaining forest structure and water-dependent biota in the forest and in the wider dryland landscapes through which the river flows.

Gonakier Forests are threatened by land use change, in particular conversion of the forest to agriculture, and by changes to river flow regimes. Land clearing for agriculture has accelerated as the population of Senegal has rapidly grown. Traditionally the forest was cleared to promote pasture and shrub growth for livestock but it is increasingly cleared to make way for flood recession cropping. Intensification of agriculture and expansion of irrigation have led to more rapid transformation. As populations have grown, so has the demand for wood fuel and construction material.

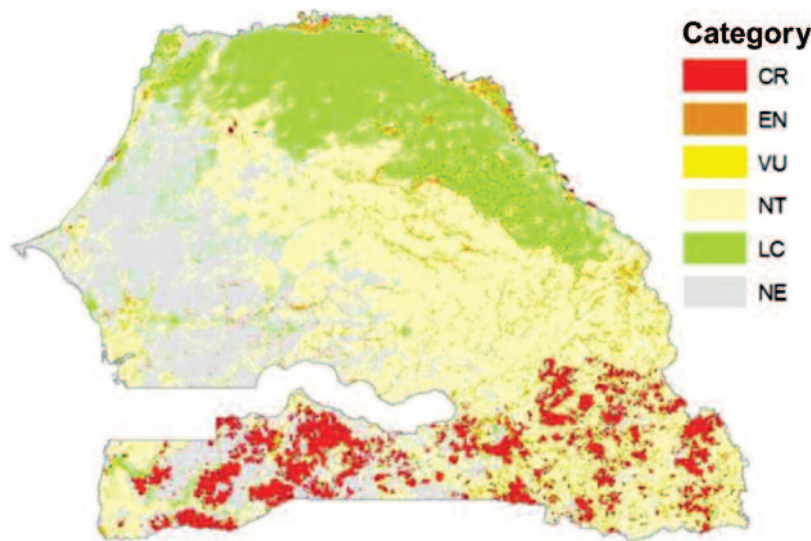
The flow regime of the Senegal River has changed as a consequence of infrastructure development combined with climate change. Senegal's population has grown tenfold since 1900 which has led to a dramatic increase in pressure on its land and water resources. The construction of the Manantali dam in Mali has diverted water upstream for agriculture and has led to a reduction in water flow. Furthermore, precipitation in the Senegal River catchment has declined by 10-50% during the twentieth century. These processes have combined to reduce the distribution of the Gonakier ecosystem, despite the designation of twenty-eight forest reserves prior to 1974.

Degradation or conversion of humid patches within the drylands can have far-reaching impacts on biodiversity, with a knock on effect on biodiversity and livelihoods that are geographically removed from the degraded area. These humid patches are often the most sought-after for economic investment due to the potential for more intensive economic activities. Wetlands understandably play an important role in the survival of biodiversity and in human economic activity in arid and semi-arid regions (Brouwer, 2014), but the impact of their degradation on the wider dryland landscape is seldom considered. The gueltas in Mauritania, already discussed, are under considerable pressure from human exploitation, yet many of the species they support are classified as "Not Evaluated" by the IUCN Red List (Vale *et al.*, 2015).

Degradation or conversion of humid patches within the drylands can have far-reaching impacts on biodiversity, with a knock on effect on biodiversity and livelihoods that are geographically removed from the degraded area.

¹⁵ Keith, D., Ba, T., Tappan, G., 2013. Scientific foundations for an IUCN Red List of Ecosystems. PLoS ONE Supplementary material doi:10.1371/journal.pone.0062111.s002

The IUCN Red List of Ecosystems (RLE) has not yet been widely applied in the Sahel, but a preliminary assessment in Senegal provides an interesting insight into degradation trends (Figure 10). The assessment found a strong decline in agricultural productivity over 20 years, a reduction in forest density, diversity and productivity, and high levels of pollution of water courses. Large areas of the country are classified as Near Threatened (NT), with a large proportion of the relatively more humid south classified as Critically Endangered (CR). A large part of the northern rangelands are classed as Least Concern (LC), although large areas are Not Evaluated (NE), which highlights the challenge of data gaps in the most arid areas. The RLE process has underlined the challenge of working in drylands which are in many cases data deficient. The draft results of the Senegal RLE work confirm the pattern in recent global assessments that indicates land degradation is more of a concern in humid lands and in the more humid parts of the drylands (Bai *et al.*, 2008). However, the analysis also finds discrepancies at the lower scale, where degradation in dryland areas is not picked up in macro-analyses due to issues of scale and data scarcity.



CR: Critically endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least concern; NE: Not Evaluated.

Figure 10: Red List of Ecosystems in Senegal

Source: CSE, 2012

3.4. Drivers of biodiversity loss and land degradation

Human population growth combined with increasing wealth and investment are the major factors behind biodiversity declines in the Sahel. Globally there is a need to increase food production 70-100% in the coming century to satisfy a growing, and increasingly wealthy, population (FAO, 2009). This pattern will be particularly pronounced in the drylands of West Africa, where population growth and the relative rates of economic growth in coming years are likely to be high. Under current agricultural practices and development models this will place more pressure on existing land resources and will lead to further conversion of forest and rangeland. Land use change and conversion were identified by the Millennium Ecosystem Assessment as the leading factors in desertification (MEA, 2005). The way that land is converted and subsequently used for food production could be as important for biodiversity conservation as the creation of protected areas.

Human population growth combined with increasing wealth and investment are the major factors behind biodiversity declines in the Sahel.

Simplifying the factors behind biodiversity loss and land degradation has its own inherent risks and can lead to misguided investments and policies. Figure 11 illustrates the main drivers and pressures that combine to contribute to land degradation. Policy and institutional factors can be important underlying driving forces, but these are often influenced by a combination of weak resource rights and governance, weak influencing capacity of rangeland stakeholders, and insufficient or inaccurate data, information and knowledge on drylands (Mortimore *et al.*, 2009). These factors can in turn be influenced by broad-spectrum human development failures, such as low levels of education or insecurity.

These drivers and pressures contribute to biodiversity loss in a number of ways. They may contribute to a decline in the extent, condition or sustainable productivity of ecosystems, as most obviously seen when land is cleared for agriculture or urban development. Some drivers and pressures contribute directly to species extinction while others lead to erosion or deficiency of the genetic pool. They may also contribute to a decline in the abundance, distribution or sustainable use of biodiversity.

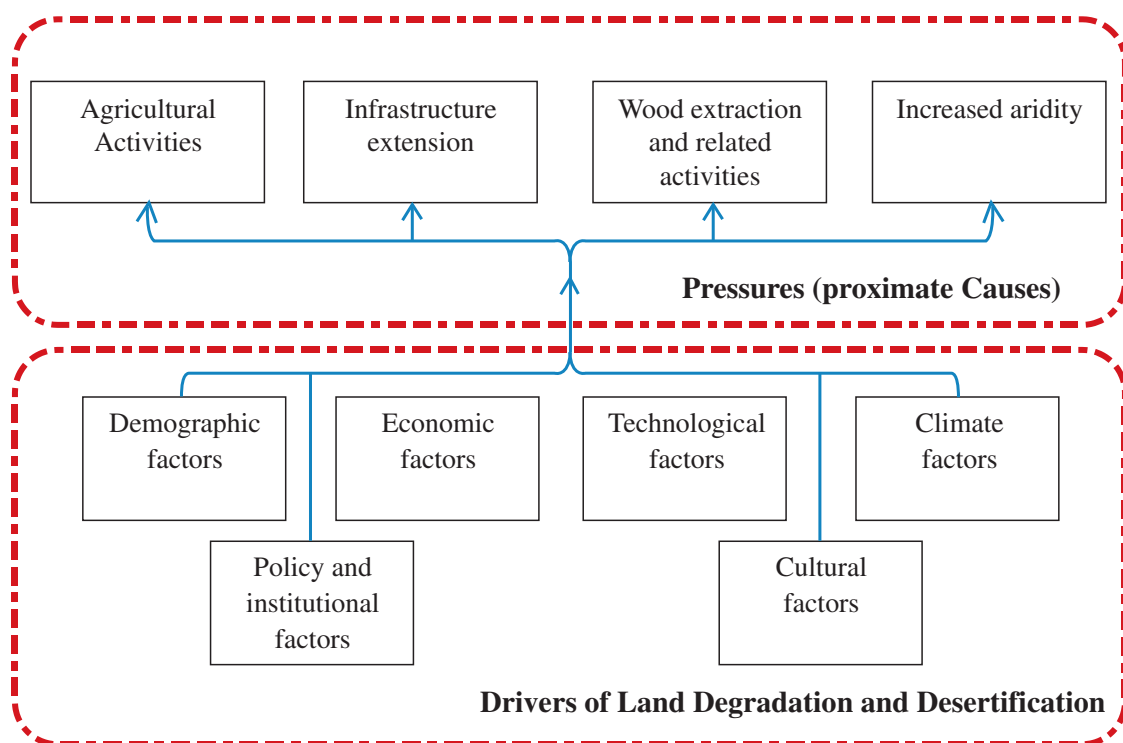


Figure 11: Proximate and underlying driving forces of land degradation

Source: Geist and Lambin, 2004

Pressures (proximate causes)

1. Agriculture

Agriculture is one of the leading causes of land degradation in the Sahel, contributing to widespread clearance of land, over-exploitation of soil, and a downward spiral of productivity, poverty and biodiversity loss. Conversion of forest and rangelands to crop farming is driven by increasing demand for food and low rates of productivity growth on existing farmland. The case of Lake Tabalak in Niger illustrates how land use can be driven by a number of competing factors. Over the past century the area has been converted from a tree-covered depression with a traditional well, to a 1,150 ha lake in the 1970s, to a pastiche of horticulture in the present day, reflecting changes in prevailing policy and investment priorities. Access to, and use of, natural resources has changed and the pastoralists who used to rely on the water and fodder now procure these resources from the resident population. At the same time, wildlife populations have plummeted, including the seasonal presence of migratory birds (Brouwer, 2014).

Agriculture is one of the leading causes of land degradation in the Sahel, contributing to widespread clearance of land, over-exploitation of soil, and a downward spiral of productivity, poverty and biodiversity loss.

Industrial agriculture is often cited as a major driver of land degradation, and in addition it typically consumes high levels of fossil fuel, water and topsoil at unsustainable rates. Industrial agricultural has often replaced locally-adapted farming practices in which farmers sought to protect soil organic matter and moisture. It has frequently replaced local crop breeds that are highly resistant to drought with “improved” breeds that offer higher total productivity when sufficient chemical inputs are used, but which are more likely to fail in drought years, leaving farmers exposed to dangerous risks of poverty and destitution. Industrial agriculture has also tended to exploit scarce resources like water at high intensity on very small areas of land (i.e. through irrigation projects) leaving the much larger landscape more water-stressed. Drylands are defined by the high tendency to lose water through evapotranspiration and industrial farming is often guilty of greatly increasing such losses (Horrigan *et al.* 2002; Pretty *et al.*, 2011).

Degradation of rangelands is frequently attributed to over-grazing, although “grazing mismanagement” is often a more appropriate term, since the total number of livestock is not always the problem. Many rangeland ecosystems depend on herbivore action to maintain specific plant communities and degradation can occur when herbivore action is removed or reduced, or when grazing pressure is sustained without rest, even at very low levels. Grazing mismanagement can therefore be an outcome where herd management strategies are compromised, for example when herd movements are restricted. Disruption of herding practices is common in places where key seasonal resources, such as wetlands, have been made inaccessible, for example due to crop cultivation or protected areas (McGahey *et al.*, 2008; Davies *et al.*, 2010; Behnke *et al.*, 1993).

2. Infrastructure

Infrastructure development directly contributes to land degradation, for example through clearance of land and deliberate removal of biodiversity. Human settlements not only impact on their immediate location but can also cast a long shadow on the surrounding environment, particularly when urban populations rely on the natural environment for fuel wood or other resources. This is not only a problem with a few large cities, but is a major impact from the large-scale, unplanned proliferation of small rural settlements in the Sahel. Roads similarly can have hidden impacts, for example by cutting migratory corridors or by increasing access to remote areas and thereby increasing market access for the extraction of biodiversity, or increasing incursion by outsiders.

Human settlements not only impact on their immediate location but can also cast a long shadow on the surrounding environment, particularly when urban populations rely on the natural environment for fuel wood or other resources.

Water infrastructure needs particular attention in drylands due to the impact it can have on biodiversity and on livelihoods. Investments in water infrastructure are popular in dryland areas due to the perceived scarcity of water. Investments can include drilling to extract ground water, including fossil aquifers, but can also include a range of approaches to harvesting water, from large scale dams to small scale micro-catchments and planting pits. In all cases, infrastructure is designed explicitly to ensure that water is more available in certain areas, and in most cases this disrupts the hydrological cycle, with potential down-stream consequences. At the same time, water infrastructure can act as a catalyst for other development including urbanisation and therefore careful regulation and planning is needed. When water infrastructure is installed without adequate foresight and without regulation of use it has often led to unintended changes in resource rights and land use and has contributed to land degradation (Davies *et al.*, 2016).

When water infrastructure is installed without adequate foresight and without regulation of use it has often led to unintended changes in resource rights and land use and has contributed to land degradation.

3. Wood and other natural resource extraction

The heavy reliance on wood fuel in the Sahel ensures that wood extraction is a significant cause of degradation and biodiversity loss. Forests are also cleared for small and large scale farming, including for production of commercial crops. Over-extraction of wood is also driven by external pressures, including global demand for wood. In addition to reliance on wood, many people harvest non timber forest products and wildlife from the Sahel, for food, medicine, construction and other uses. The reliance on biodiversity for economic purposes is a leading threat to biodiversity in the region (Brito *et al.* 2014). Hunting and poaching are contributing to significant species losses and these losses are closely correlated to population growth (Brashares *et al.*, 2004).

The reliance on biodiversity for economic purposes is a leading threat to biodiversity in the region.

Extraction of mineral resources, including fossil fuels, is rapidly expanding and placing direct pressure on species through habitat fragmentation and degradation (Brito *et al.*, 2014). Open-cast mining for heavy metals can have major consequences for biodiversity that are hard to reverse. Mining also contributes to biodiversity

loss through the uncontrolled exploitation of natural resources by miners, for example through hunting. Strong investment in mineral extraction, particularly from China, is leading to a mineral boom and emergence of growth corridors in which improved infrastructure is having a knock on effect on agriculture and other economic activities (Mallon *et al.*, 2015).

4. Increased aridity

There is a two-way relationship between land degradation and aridity. Aridity can increase in drylands as a result of changing land and water management practices, and should not be automatically attributed to climate change. Throughout the Sahel, aridity is determined by both the level of rainfall and the proportion of rainfall that is retained within the system. Areas of comparatively high precipitation will be classified as drylands if their potential to lose water through evaporation and transpiration is equal to or greater than approximately 1.5 times the mean precipitation. As already discussed, numerous natural factors influence water loss and run-off, including soil type, vegetation cover, prevailing temperature and wind, and the seasonality of rainfall. Increased aridity can contribute to biodiversity loss and land degradation by affecting the survival of species and modifying nutrient cycles. It can lead to loss of wetlands and other habitats that are vital for the survival of species, including local and migratory bird populations (Adams *et al.*, 2014).

Aridity can increase in drylands as a result of changing land and water management practices, and should not be automatically attributed to climate change. Throughout the Sahel, aridity is determined by both the level of rainfall and the proportion of rainfall that is retained within the system.

Drivers of land degradation and desertification

1. Demography

Rapid population growth in the Sahel has hindered efforts to reduce the impact of humans on biodiversity, and has slowed down efforts to improve human well-being, leaving many people dependent on natural resources for food, fuel and income. The population in West Africa is expected to double by 2025 based on current growth rates and will contribute to growing pressure to exploit land and produce food. At the same time, rates of urbanisation are high throughout West and Central Africa. OECD reports that the urban population of the Sahel is around 42%, with 22 cities of over 1 million inhabitants and more than 150 towns of over 100,000 (OECD, 2015).

Numerous writers have commented on the impact of population growth on sustainable land management practices, like crop fallows (Boserup, 1981), and the tendency to let short-term needs over-ride long-term considerations of sustainability. Higher population density, combined with agricultural technologies, such as new crop varieties and access to fertiliser, have been projected to reduce fallow periods and contribute to soil degradation (Burgess, 1991). However, other commentators dispute this view and point to the growing number of examples of sustainable intensification, based on resilience-building approaches that promote dryland-adapted farming. Their opposing view is supported by evidence of re-greening of areas of the Sahel where population density is greatest.

The urban population of the Sahel is around 42%, with 22 cities of over 1 million inhabitants and more than 150 towns of over 100,000.

Population growth outside the Sahel region can have a knock on effect through the migration of people into drier areas, often exploiting systemic weakness in land tenure to acquire land and convert it to new uses. This can also exacerbate conflict in the Sahel, which can have consequences for biodiversity, for example by disrupting rules and regulations over sustainable resource.

2. Economy

There are a number of economic factors that drive the pressures on land and biodiversity. Economic drivers are inextricably linked to population growth in the Sahel, which is raising demand for food, water and other natural resources. Economic development also raises the demand for ecosystem services by industry and for generation of power for both domestic and industrial use. Considering the low position of Sahelian countries in global wealth ranking, economic development is welcome progress and could be seen as an opportunity to promote more sustainable development approaches. However, current increases in wealth and in market access are contributing to poorly regulated growth in the exploitation of natural resources, in ways that are often unsustainable. The consequences of economic development, such as the increased investment in land use in the Sahel that closely follows development of roads, is not well monitored (Leadley *et al.*, 2010).

Increases in wealth and in market access are contributing to poorly regulated growth in the exploitation of natural resources, in ways that are often unsustainable. The consequences of economic development, such as the increased investment in land use in the Sahel that closely follows development of roads, is not well monitored.

Demand for power is growing and several countries have raised their output of electricity through construction of dams. Many of the largest dams in West Africa have been built to supply electricity, but dams have also been built for domestic, industrial and mining water supply and for crop irrigation. A more recent trend is the construction of numerous smaller reservoirs to meet these other water demands. Over-harvesting of water can have profound environmental consequences, as illustrated by Lake Chad, which has shrunk to around 5% of its volume since the 1960s due to over-abstraction and diversion of water for agriculture combined with land degradation and changing rainfall (Mallon *et al.*, 2015).

3. Technology

Technology can have either positive or negative impacts on land degradation through changes in the way land is managed or restored as well as through externalities from industry. Agricultural technologies can have important consequences for the way land is farmed, for example increasing the use of chemical inputs, changing crop varieties and livestock breeds, and modifying management practices such as the extent of mechanisation. Increasing mechanisation and increased use of irrigation can be major contributors to land degradation, although smaller-scale use of these technologies may be more consistent with sustainable intensification (Cervigni and Morris, 2016). Inadequate application of new technologies is often a contributor to degradation and biodiversity loss, for example, through pollution, salinization or through increased losses of water (Geist and Lambin, 2004).

Sustainable intensification is a technology-based means of simultaneously meeting food security targets and environmental goals.

On the other hand, sustainable intensification is a technology-based means of simultaneously meeting food security targets and environmental goals. Sustainable intensification has been found to increase yields per hectare, for example by combining new and improved crop varieties with new agronomic and agro-ecological management. Food production has also been diversified with a new range of crops and livestock adding to existing staples and vegetables under cultivation (Pretty *et al.*, 2011). Technological advances could also help reduce food wastage, thereby increasing efficiency of production and reducing the demand to convert further land for agriculture. FAO estimates that total food losses in sub-Saharan Africa and South/Southeast Asia are approximately 120-170 kg/year which is between a quarter and a third of all production. The majority of this is lost between production and retailing with less than 10% wasted by consumers (FAO, 2011).

The impact of technology on land degradation or restoration is complex and there are many indirect factors. For example, improved access to mobile phone technology gives some farmers improved access to credit and savings or to market information. Improved internet access gives farmers and extension workers more immediate access to innovations or advice. New and future technologies may offer many solutions for further innovation in SLM and restoration. Technology alone cannot be expected to always provide beneficial outcomes for sustainable land management, but where SLM is a policy and investment priority, technology can play a powerful supporting role.

4. Climate Change

Africa's climate has warmed by approximately 0.7°C during the 20th century and rainfall has decreased over much of the Sahel. However, climate change projections for Africa are not well defined, partly due to the long-term variability. Climate change scenarios indicate future warming across Africa ranging from 0.2°C per decade (low scenario) to more than 0.5°C per decade (high scenario). The semi-arid margins of the Sahara are one of the areas of greatest projected warming, with warming likely to be above the global average. This means a temperature increase between 3 and 4 degrees by the end of the century with respect to the last twenty years of the 20th century (Christensen *et al.* 2007).

Rainfall projections are more problematic and there is little consensus on whether the region will get wetter or drier. This may reflect variability across the Sahel, and the coastal countries of the western Sahel are expected to see a reduction in precipitation while the Ethiopian highlands are likely to receive more rain. There is generally expected to be an increase in the intensity of extreme weather events, although no consensus among models whether extremely dry or extremely wet seasons are likely to become more common. However it is virtually certain that extremely hot seasons will become more frequent in the future (Christensen *et al.* 2007).

Some analysts consider the region to be one of the most important Earth System tipping points, where climate change will lead to fundamental shifts in climate regime, ecosystem productivity, biogeochemical cycles, and human well-being (Lenton *et al.*, 2008). Estimates indicate that drylands could contract by up to 30%, or expand by up to 40%. The increase in the frequency and severity of extreme weather events in the Sahel is likely to amplify other environmental and development challenges and compound the effects of rapid population increases.

Recent research modelled the future impact of land use change and climate change on ecosystem services in West Africa, including carbon storage, water provision and vegetation productivity. Key findings for the region include (Hartley *et al.*, 2015):

- Increase in carbon storage of forests under the effects of climate change, although this will be counter balanced by human degradation of forest (high confidence);
- Increase in vegetation productivity, with the exception of southern Nigeria, where land use scenarios predict a high level of human activity, and the western Sahel, where a drying signal is found in the climate projections (low confidence, but plausible);
- Northward shift of ecosystems in central and eastern West Africa, including increases in the tree fraction of ecosystems in Cameroon and Central African Republic, increases in shrub fraction in the savanna grasslands of southern Chad and northern Nigeria, and increases in the grass fraction on the edge of the Sahara desert in Chad and Niger;
- Projected vegetation shifts in the Sahel, and Sudanian savanna have a low confidence, but are plausible because there is a lack of consensus in model projections of precipitation.

5. Policy

Policy as an underlying driver of land degradation and biodiversity loss is a broad, all-encompassing challenge. Government policies impact on all the other direct and indirect drivers of change and addressing policy failures is major development priority. The term “policy” is broad, and may mean the absence of appropriate laws or regulations, but may also imply a failure to implement those laws that exist. In several countries this may be a particular challenge in drylands where government institutions are comparatively weak. Policy failures may contribute to uncontrolled demographic change, weak governance, and conflict, with knock on effects on biodiversity. Lack of legal protection for important biodiversity or habitats, failure to protect the conservation practices of local communities, and uncontrolled land use change are more direct manifestations of policy failure (Davies *et al.*, 2012).

Agricultural development policies have a major bearing on the Great Green Wall and the conservation of biodiversity in the Sahel. Most countries pursue policies to expand industrial agriculture, for example through subsidies and other incentives or through investment in supporting infrastructure. These policies often support the least sustainable forms of agricultural production at the expense of SLM practices. At the same time, many countries lack adequate policies to improve farmers' access to credit and savings or insurance for crops and livestock. Unsuitable investment policies in the agricultural sector can constrain smallholder farmers from maintaining or adopting SLM. This includes policies to support farmers' to access financial capital as well as policies in support of the development of small and medium sized enterprises in the agricultural sector.

Policy shortcomings are also at the heart of local governance failures and weakness in property rights and land tenure, including former policies to nationalise land and to centralise decision making and budgeting processes. In the case of communal resources, like many grasslands and woodlands, uncertainty over property rights has led to uncontrolled competition over resources and over-exploitation. In many areas, customary rules still govern the use of communal resources, but these institutions are generally weakening as a result of numerous factors, including some of the drivers and pressures outlined here (Herrera *et al.*, 2013).

6. Culture

Cultural factors that drive land degradation and biodiversity loss may be the hardest to define but can include individual behaviours as well as public attitudes, values and beliefs (Geist and Lambin, 2004). Cultural attitudes towards land, and particularly drylands, can influence public policies in the Sahel. For example, there is a widespread belief, despite some evidence to the contrary, that grain production is more efficient than livestock grazing and that pastures should be converted to crop production wherever possible. There is also a widely shared attitude that water is a common good that should be free for all to use; an attitude that is exploited by agricultural enterprises who often enjoy free or subsidized water for large scale irrigation investments. Many dryland societies have strong values of environmental custodianship, but they are changing due to a wide range of forces and often people's values and behaviours change in ways that are to the detriment of nature.

There are a number of positive cultural factors that mitigate land degradation and can be built on to promote restoration and sustainable land management. Sahelian land users have rich knowledge of their environment and they rely heavily on biodiversity. As a result they have developed many practices and customs that enable these resources to be protected and used sustainably. Customary institutions are usually vital for local knowledge to be used effectively, for example to allow users of a shared forest patch to agree on rules for sustainable use and to penalise those who break the rules. Many cases of land degradation are attributable to the breakdown of these customary institutions and the subsequent loss of sustainable management practices.

Other factors in biodiversity loss

Besides the common drivers and pressures outlined above, a number of other factors are prevalent in parts of the Sahel region. Several countries are affected by conflict and war and this could have mixed implications for biodiversity. Conflict can lead to a break down in law and order and this may open the door to over-exploitation and environmental degradation.

It is clear that many inter-related factors drive biodiversity loss and simplistic, single-factor solutions are often inappropriate.

Invasive species contribute to biodiversity loss in some parts of the Sahel but data on the major invasive species is poor. Invasive shrubs, such as *Calotropis procera* and *Jatropha gossypifolia*, and potentially invasive trees like *Senna siamea* and *Azadirachta indica* (neem), have been identified in a number of sites that fall within the Great Green Wall area (IUCN/PACO, 2013). The invasive tree *Prosopis juliflora* is a common concern in many dryland areas of the Sahel, growing in dense, spiny thickets, causing ecological and economic damage and overwhelming native species. *Prosopis* often thrives in areas where native acacia vegetation has been removed and creates a barrier to restoring native vegetation. However, the plant has a number of uses, including for fuel and fodder, and some communities are resistant to efforts at clearing it (Geesing *et al.*, 2004).

Fire is a natural phenomenon in the Sahel that plays a role in maintaining many dryland ecosystems. Certain species thrive in areas that are affected by fire and may be threatened by the cessation of fire. Where biomass has greatly increased, for example due to expansion of woody vegetation, the intensity of fire may increase, causing longer-term damage even to fire-adapted ecosystems. Fire is widely used as a management tool in agriculture, for example to clear fallows or renew pastures, and is also used by hunters to flush out wildlife. Concerns have been raised about misuse of fire by land managers and the implications for species that are less fire-adapted. There are also concerns that patterns of fire will change as a result of climate change. Chad, for example, experienced major droughts in 1984/1985 and in 1993/1994, which caused drying of ecosystems and are reported to have led to an increase in wildfires that destroyed the habitat of certain wildlife species (Boulanodji, 2014).

It is clear that many inter-related factors drive biodiversity loss and simplistic, single-factor solutions are often inappropriate. The drivers of biodiversity loss can be found in almost all sectors and therefore addressing biodiversity loss requires a multi-sectoral response. Biodiversity conservation and indicators of biodiversity loss therefore need to be integrated into a number of sectors, particularly those related to agriculture, land use, climate change, poverty reduction, and food security.



4. Biodiversity conservation as the foundation of ecosystem services in the Great Green Wall

During the course of human history biodiversity has routinely been sacrificed in order to boost key selected provisioning services, most notably food production. Although provisioning of food may be increased up to a point, this is usually at the expense of other ecosystem services. When the full range of ecosystem services are accounted for, maximisation of one ecosystem service at the expense of the others is often undesirable. Overuse and mismanagement of land and ecosystems in the Sahel has been linked to reduction in a range of ecosystem services, including food provision and processing of pollutants (Cohen *et al.*, 2012).

When the full range of ecosystem services are accounted for, maximisation of one ecosystem service at the expense of the others is often undesirable.

A wide range of studies worldwide have reported that restoring biodiversity through ecological restoration contributes to major gains in a broad range of ecosystem services (Rey Benayas *et al.*, 2009). For example, rangeland restoration in Jordan has led simultaneously to increases in livestock productivity, increased storage and supply of clean water, reduced siltation of downstream reservoirs, storage of atmospheric carbon, and provision of a number of medicinal plants with high market value (Myint and Westerberg, 2014). In the Sahel restoration of agroforestry landscapes in Sudan generated benefits to farmers of between 5,750 and 19,119 SDG per hectare over 25-years¹⁶. The benefits of widespread adoption of integrated forest landscape restoration to Sudanese society as a whole include enhanced groundwater recharge, avoided soil erosion, increased crop production through nitrogen fixation and soil moisture, and increased production of gum Arabic and fuelwood (Ricome *et al.*, 2014).

Restoring biodiversity through ecological restoration contributes to major gains in a broad range of ecosystem services.

The deliberate reduction of biodiversity in agricultural intensification (for example clearance of forests) may not reduce the specific ecosystem service of interest to the land user (such as food output). Some key functions, such as soil fertility, may be substituted with artificial inputs. Other ecosystem services, such as water regulation and climate mitigation, may be impaired and this represents a cost that is often borne by society as a whole, contributing for example to climate change or off-site water insecurity. On the other hand, traditional land use systems often place high intrinsic value on biodiversity, protecting it for cultural reasons (e.g. maintaining woodland patches or specific sacred or high value trees), protecting it explicitly for the sake of future generations, or protecting biodiversity for the multiple secondary benefits that it provides, such as food, medicine or shade. In other cases, protecting a wider range of ecosystem services may depend on internalising their benefits to the land user, for example by incentivising carbon storage or protection of water sheds. Achieving this may require policies to promote diversification in land uses, such as crop, livestock and tree production, and diversity among land users (Swift *et al.*, 2004).

Restoring biodiversity and protecting habitat has been shown to contribute to improvements in regulating services such as water quality and water flow, as outlined above. Species richness and species diversity both play a role in safeguarding a number of ecosystem services, and habitat maturity may also contribute positively. Species abundance has been shown to contribute to pest regulation, pollination and recreation values whilst species richness has been shown to contribute to services like timber production and freshwater fishing (Harrison *et al.*, 2014).

Traditional land use systems often place high intrinsic value on biodiversity.

¹⁶ At the time of the study 1SDG = approximately 0.2 USD

Soil biodiversity is critical for the supply of ecosystem services, and its protection must be central to achieving Land Degradation Neutrality in the Sahel, and meeting the objectives of the Great Green Wall Initiative. However, soil biodiversity is poorly researched and the relationships with ecosystem services are not well understood. A few individual species may play particularly important roles in some ecosystems, while in others research suggests that overall species richness is the key determinant of service provision. Overall stability of ecosystem services is thought to be strongly related to species richness, and therefore particularly influenced by human interventions above-ground (Wall and Nielsen, 2012).

Soil biodiversity is critical for the supply of ecosystem services, and its protection must be central to achieving Land Degradation Neutrality in the Sahel, and meeting the objectives of the Great Green Wall Initiative.

Soil biodiversity includes microorganisms and invertebrates as well as plants and larger soil-dwelling animals. This biodiversity contributes a number of services to the ecosystem, including decomposition of organic matter, nutrient cycling, nutrient and water pumping, bioturbation (mixing the soil), and suppression of soil borne diseases and pests. Most land users are familiar with the functions of biodiversity, even if they may not be fully aware of how the mechanisms work, and their management practices are often adapted to promote such roles. For example, low-tillage farming protects the mycorrhizal symbioses between plants and soil fungi,

Low-tillage farming protects the mycorrhizal symbioses between plants and soil fungi, helping to mobilise nutrients and improve plant survival in stressed environments.

helping to mobilise nutrients and improve plant survival in stressed environments (Smith and Read, 2008) whereas agroforestry supports the role of rhizobia bacteria in association with leguminous plants in nitrogen fixation.

The relationship between soil biodiversity and ecosystem services is complex. Overall, however, soil biota is essential for primary productivity and therefore for provisioning services such as food production. Soil biodiversity

determines water retention and infiltration rates and therefore influences ground water replenishment and clean water supply as well as regulating the risk of floods and droughts (Wall and Nielsen, 2012). The contribution of soil biodiversity to ecosystem services globally has been estimated at 1.5 to 13 trillion US Dollars annually (Van der Putten *et al.* 2004).

4.1. Nature's benefits to humanity in the Sahel

Biodiversity and ecosystems deliver crucial services to humankind – from food security to keeping our waters clean, buffering against extreme weather, providing medicines to recreation and adding to the foundation of human culture. Together these services have been estimated to be worth over 21–72 trillion USD every year – comparable to the World Gross National Income of 58 trillion USD in 2008. (Nellemann and Corcoran, 2010).

Society and the economy rely heavily on nature and on the supply of ecosystem services, which have been described as "the benefits people obtain from ecosystems" (MA, 2006). These services from nature are usually grouped in four categories as illustrated in Figure 12. As already noted, ecosystem services are largely determined by biodiversity and therefore biodiversity loss can impact on human welfare in many ways: for example, by disrupting soil formation, impairing water cycles, or weakening climate regulation.

Society and the economy rely heavily on nature and on the supply of ecosystem services, which have been described as "the benefits people obtain from ecosystems".

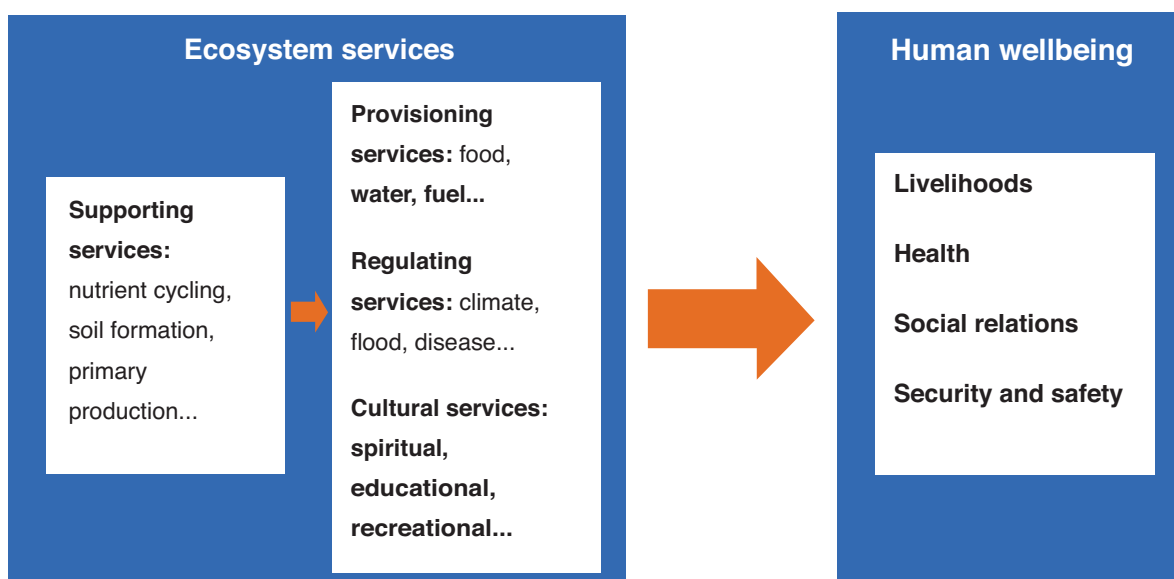


Figure 12: Contribution of ecosystem services to human wellbeing

Source: Davies, J. 2011. Conservation and Sustainable Development: linking practice and policy. Earthscan.

The pattern of biodiversity loss and ecosystem service provision is not a simple relationship. Humans often take advantage of provisioning ecosystem services, such as food and fibre production, at the expense of species richness and abundance: historically speaking, biodiversity loss and increasing provisioning ecosystem services have gone together (MA 2005). However, there are significant caveats to this relationship. First, the relationship does not hold if ecosystems are pushed beyond certain limits, as for example happens through land degradation. In this case, overuse of natural resources leads to losses of biodiversity that can be difficult to reverse, particularly if ecological thresholds are passed. Unfortunately, these thresholds are poorly understood and are often only observed after they have been passed (Leadley *et al.*, 2010).

Clearing land for cultivation may initially increase food production, but it comes at a significant cost in terms of water supply, climate sequestration, regulation, carbon forest resources, pollination, and many more services.

A second caveat to the relationship between biodiversity loss and provisioning ecosystem services is that many costs of biodiversity loss are ignored. Measuring the benefits of provisioning services in isolation discounts the costs to other ecosystem services and greatly under-values biodiversity. For example, clearing land for cultivation may initially increase food production, but it comes at a significant cost in terms of water supply, climate regulation, carbon sequestration, forest resources, pollination, and many more services (De Groot *et al.*, 2010).



4.2. Supporting services

Supporting ecosystem services are those "necessary for the production of all other ecosystem services", such as nutrient recycling or soil formation. Supporting services determine the magnitude of other ecosystems services, for example determining the supply of food or regulating floods (MA, 2005). Trees in agroforestry systems, for example, create and sustain soil conditions that are more favourable to crop production. Trees can boost soil organic matter and leguminous plants increase soil nitrogen, thereby increasing soil fertility (Bayala, 2013). Vegetation cover can play a major role in reducing surface flows of water and improving infiltration of water, thereby supporting hydrological cycles and reducing the occurrence and the severity of flood and drought (UNEP, 2002).

Vegetation cover can play a major role in reducing surface flows of water and improving infiltration of water, thereby supporting hydrological cycles and reducing the occurrence and the severity of flood and drought.

Soils are a key determinant of supporting services in drylands, influencing storage and availability of water and nutrients. Soil forms slowly in the drylands and is determined to a large extent by soil microorganisms and invertebrates, such as termites. Many cropping systems rely on pesticides that destroy soil biodiversity and can compromise the soil forming processes. In most drylands herbivores play a particularly important role in nutrient recycling

and most plant decomposition takes places in the herbivore gut. Where herbivore numbers have declined this role is also restricted, although in many cases the role is performed by domestic herbivores. In more arid areas, soil crusts play a vital role in maintaining soil stability, but also in channelling water, nutrients and seeds to plants clumps and depressions, where they are concentrated (MA, 2005).

4.3. Provisioning services

The Millennium Ecosystem Assessment defines provisioning services as the "products obtained from ecosystems". In the Sahel, besides food crops this includes a host of wild foods and spices, raw materials such as timber and fuel, water, minerals, medicinal resources, and ornamental resources such as handicrafts and jewellery. Drylands supply many important provisioning services, including food, water and energy. Provisioning of energy from the drylands is poorly exploited and great opportunities exist for solar and wind generation (MA, 2005).

Some provisioning services are less widely enjoyed, but can provide locally and seasonally important resources. For example, Gum Arabic, produced from *Acacia senegal* and *Acacia seyal*, has a global market and provides substantial income in the drylands of Sudan and other countries in the Sahel. A number of dryland fruits, including the fruit of *Balanites aegyptiaca*, play a vital role in diets during the dry season. Honey production is widespread throughout the Sahel and provides important incomes that contribute to household resilience and to livelihood diversity. In Senegal, the total value added from the harvest of non-timber, non-fuel forest products has been estimated at CFA4.5 billion (USD7,283,160) or 14% of the reported output of the forest sector in 2000 (IUCN, 2006).

Provisioning services from wetlands in the drylands may be of particularly high value. Wetlands can support life on a vast geographic scale within dryland ecosystems and this role is often overlooked when wetlands are developed to maximise provisioning services locally. Better accounting for ecosystem services in drylands is needed on the relevant scale.

The value of forest restoration in Mali

Kelka Forest, in the Mopti region of Mali, provides multiple benefits to local communities and to society as a whole. The forest occupies more than 300,000 hectares and is an important wildlife habitat, with a high diversity of acacia species. It is also the main source of domestic energy for 60,000 people living in the surrounding 15 villages. The forest also contributes to storing and sequestering atmospheric carbon and maintaining hydrological cycles. The forest's resources and soil fertility are in continuous decline due to a combination of climatic and human induced factors. For example, the availability of firewood has halved over the past 15 years due to a lack of adequate forest and land management.

A local association called Waldé Kelka was established after Mali established its decentralization policy in 1991. The association has enabled greater recognition of local resource management arrangements, transfer of power to local decision making structures, and greater participation of local groups and associations in decision making. Waldé Kelka provides a platform through which community-based restoration and sustainable forest management practices can be coordinated and it has led to the restoration of several forest patches and wetlands. The benefit of reforestation to the Kelka Communities has been estimated at USD94.2 million over a time horizon of 25 years, and the present value of benefits derived from carbon sequestration through reforestation and agroforestry are estimated at USD501.6 and USD57.8 million respectively over the same time horizon¹⁷ (Sidibé *et al.*, 2014).

4.4. Regulating services

Regulating ecosystem services are the "benefits obtained from the regulation of ecosystem processes", and may include water supply, carbon sequestration and climate regulation, waste decomposition and detoxification, purification of water and air, and pest and disease control (MA, 2005). Water infiltration, for example, is closely regulated by vegetation cover and soil biodiversity and thereby determines soil moisture and aquifer recharge. A common, though poorly researched, outcome of land degradation is the depletion of groundwater resources, particularly shallow unconfined aquifers (FAO, 1993).

A common, though poorly researched, outcome of land degradation is the depletion of groundwater resources, particularly shallow unconfined aquifers.

Trees play a number of regulating roles in the drylands, including regulation of soil nutrients, soil carbon and soil water content (Sinare and Gordon, 2015). Trees can create microclimates that are favourable for crop production and can increase the carbon content, and hence fertility, of soils.

They may regulate water availability and some trees increase soil moisture under the canopy, although this outcome is not universal for all tree species. Research has also found that crops grown under certain trees benefit from protection against high temperatures and are less affected by wind (Bayala *et al.*, 2013).

Desertification compromises the climate regulating ecosystem services of the Sahel, by releasing soil organic carbon and carbon sequestration capacity and reducing the total carbon stock in vegetation. However, data on climate regulation in the Sahel is weak and the level of carbon stocks may be underestimated. Although above ground biomass in drylands may be comparatively low, the relative

Although above ground biomass in drylands may be comparatively low, the relative proportion of biomass that is below ground is high and there is a tendency to under value soil carbon stocks.

proportion of biomass that is below ground is high and there is a tendency to under value soil carbon stocks (Bonkougou, 2004). In the driest areas of the Sahel the capacity to sequester carbon may be relatively low as shown by modelling exercises in Senegal. In this case the main contribution to climate change mitigation could be through limiting deforestation (Ballensen *et al.*, 2010).

¹⁷ All figures are based on a 5% discount rate

4.5. Cultural services

The Millennium Ecosystem Assessment defines cultural ecosystem services as the "nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences". This can include contribute to culture and art, spiritual and historical values, recreation, and contribution to science and education. Drylands are part of a shared global heritage that has given birth to major religions and many iconic cultures.

Dryland animals, like the African elephant and the lion, are globally valued and attract significant tourism revenues.

Many of the world's staple crops originate from drylands and many crop and livestock varieties are highly adapted to the arid and highly variable conditions of the drylands. Crop and livestock varieties in the Sahel have been bred for their survivability during droughts, providing reliability in a highly unreliable environment.

The farming systems, local knowledge, indigenous institutions, and local cultures of the drylands are highly adapted to managing risk and ensuring resilience. With many regions predicted to become hotter and more climatically variable the existing adaptations of dryland biodiversity, ecosystems and cultures is a valuable asset that may provide lessons for others outside the drylands.

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Ferlo biosphere reserve

Ferlo is an arid region in Northern Senegal through which the Senegal River flows. It is dominated by Acacia Savanah and grasslands, and is locally referred to as a "sylvopastoral" zone, reflecting the importance of tree and shrub cover and the dominance of pastoralism as an economic activity. The protected areas "Réserve de faune du Ferlo Nord" and "Réserve de faune du Ferlo Sud", established in the early 1970s, together occupy over 12,000 square kilometres. In 2012 Ferlo became Senegal's fifth Biosphere Reserve under UNESCO's "Man and Biosphere Programme". The biosphere reserve covers a total area of 2,058,000 ha. Ferlo is home to emblematic species like the redneck ostrich, the red fronted gazelle and the endangered African blackwood (*Dalbergia melanoxylon*).

The Man and the Biosphere Programme is an Intergovernmental Scientific Programme that aims to establish a scientific basis for the improvement of relationships between people and their environments. It was established to improve human livelihoods and the equitable sharing of benefits, and to safeguard natural and managed ecosystems. This includes promoting approaches to economic development that are socially and culturally appropriate, and environmentally sustainable. In the case of Ferlo this recognises the cultural significance of transhumant pastoralism, the most widespread land use system, which has been responsible for both shaping and conserving Ferlo's biodiversity for many centuries (UNESCO, 2016).

5. Conserving dryland biodiversity in the Great Green Wall

Biodiversity is essential for maintaining ecosystem services and its protection and restoration should be a high priority. Responsibility for conserving biodiversity cannot only lie with environmental authorities and environmental NGOs. Sustainability of crop production depends on soil biodiversity and therefore conservation of this biodiversity can boost the performance of the agricultural sector. Clean and reliable water supply depends on biodiversity, and therefore some aspects of conservation fall under the responsibility of the water sector. If the consumers of dryland ecosystem services -of food, water and energy for example- want to continue enjoying the benefits then conservation of biodiversity becomes a societal responsibility and a shared burden.

If the consumers of dryland ecosystem services -of food, water and energy for example- want to continue enjoying the benefits then conservation of biodiversity becomes a societal responsibility and a shared burden.

This does not mean sharing all responsibilities for all biodiversity: it means ensuring that the biodiversity which determines the flow of each ecosystem service is protected by the institutions responsible for those services. Ministries of Agriculture, for example, have a vested interest in pollinating services, in groundwater recharge, and in carbon and nitrogen cycles, and should look at ways of ensuring these services are sustained. This section outlines several approaches to conserving biodiversity: Sustainable Land Management, landscape and ecosystem restoration, Protected Areas, Community Conservation, and conservation of agrobiodiversity.

5.1. Sustainable Land Management: protecting biodiversity for productive land

Sustainable Land Management (SLM) offers one of the best ways to achieve the goals of the Great Green Wall Initiative, by simultaneously protecting biodiversity and ecosystem services, raising agricultural productivity, and promoting the resilience of people and ecosystems. SLM has been defined as “the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions” (WOCAT, 2007). SLM practices are central to achieving the goals of the UNCCD and for achieving Land Degradation Neutrality.

Many SLM practices have been documented in the Sahel and many of them are based on traditional land management practices that have endured for centuries, although in some cases they have needed reviving and adapting to changing socio-economic, climatic and institutional environments. Well-known SLM practices in the Sahel include agroforestry, Farmer Managed Natural Regeneration (FMNR), Low-External-Input Sustainable Agriculture, fallows, and mobile pastoralism. Many sustainable land management practices revolve around the protection of biodiversity to boost soil organic carbon and moisture (Schwilch *et al.*, 2012). Dryland communities are highly adapted to the uncertainties of their environment and over centuries have developed reliable ways of managing their resources. In addition to highly adapted species, as discussed below, communities have developed institutions and cultural practices to spread risk and promote resilience.

Agricultural intensification policies have led to a decline in some SLM practices, although other factors are also involved such as weak tenure security and breakdown in local governance. Although SLM practices are sometimes seen as “old-fashioned”, they have many benefits, including in some cases higher overall productivity than more intensive land management approaches. SLM approaches not only conserve soil biodiversity but often also protect above-ground biodiversity, such as indigenous trees in agroforestry and agrosilvopastoral landscapes (WOCAT, 2007).

Site-level actions, such as agroecology approaches, often revolve around restoring biodiversity, for example by promoting soil biodiversity to boost fertility and soil moisture. This biodiversity benefits the wider environment and national economies, for example improving hydrological cycles and reducing the risk of flood and drought, or storing carbon and mitigating climate change. At the same time, some SLM practices like agroforestry provide habitat that supports other species, including crop pollinators and migratory birds.

SLM practices are promoted under different guises, including as part of Disaster Risk Reduction strategies and as a component of Climate-Smart Agriculture (CSA). CSA is an approaching to transforming agricultural systems to achieve development goals, including food security, in the face of climate change. Its objectives include sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change, and reducing or removing greenhouse gas emissions (FAO, 2017).

Agroecology in the Sahel

According to a report to the United General Assembly from the UN Special Rapporteur on the right to food agroecology is the “application of ecological science to the study, design and management of sustainable agroecosystems.” It is described as a set of agricultural practices that mimic natural processes to create beneficial biological interactions and synergies. Agroecology provides the most favourable soil conditions for plant growth by managing organic matter and raising soil biotic activity. Core principles of agroecology include recycling nutrients and energy on the farm and minimising external inputs, integrating crops and livestock, and maintaining a diversity of species, genetic resources, and land uses. Agroecology depends heavily on farmers’ knowledge and experimentation, supported with scientific and technological advances (UNGA, 2010).

Agroecology is a broad term that encompasses such practices as Low External Input Agriculture, Agroforestry, Ecoagriculture, and Evergreen Agriculture. It is frequently used in relation to sustainable intensification and ecological intensification, placing an emphasis on optimal management of nature’s ecological functions and biodiversity to improve agricultural performance and farmers’ livelihoods. Agroecology can include maintaining agrobiodiversity, integrated nutrient management, erosion control, and incorporation of multiple-use trees in agricultural systems. Dozens of agroecology approaches and techniques are known and practiced in the Sahel, including the creation of contour bunds and stone bunds to reduce surface water flow, half-moons to capture moisture and nutrients in localised areas, zai holes to place high levels of organic material around planted seeds, composting, and many more (see Liniger et al., 2011 and Debray *et al.*, 2015 for further examples and details).

The use of stone bunds in West Africa to reduce runoff during the rainy season has been shown to increase water retention capacity five to ten times, and to increase biomass production by 10 to 15 times. A meta-analysis of agroecology projects found that they increased food production by an average of 116% in Africa while simultaneously improving the supply of other ecosystem services. A separate study found a similar result across 40 African projects covering 10 million farmers and 12 million hectares. These projects delivered on average more than a doubling of crop yields over a period of 3-10 years, resulting in an increase in aggregate food production of 5.79 million tonnes per year, equivalent to 557 kg per farming household (UNGA, 2010).

5.2. Restoring biodiversity for resilient landscapes and ecosystems

Ecological restoration has been described as the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. It has been defined as “an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability” (SER, 2004). Ecological restoration includes improving, to the extent possible, biodiversity and indigenous species to support ecosystem functionality.

Forest Landscape Restoration (FLR) is defined as “a planned process that aims to regain ecological integrity and enhance human wellbeing in deforested or degraded landscapes”. FLR aims to achieve a balance between human needs and the needs of biodiversity by restoring a range of forest functions within a landscape and accepting the trade-offs that result. Many ecosystems are part of a larger landscape that is under productive management (e.g. wetlands within a broader landscape of rangelands), and they have been significantly modified by that management. The concept of landscape restoration and FLR has therefore become popular to imply restoration of ecosystem functions to a level that sustains human activity (Mansourian *et al.*, 2005).

Landscape restoration initiatives in the Sahel

The Bonn Challenge was launched in 2011 as a global effort to restore 150 million hectares of deforested and degraded land by 2020 and 350 million hectares by 2030. It is described as “an implementation vehicle for national priorities such as water and food security and rural development while contributing to the achievement of international climate change, biodiversity and land degradation commitments”. The Bonn Challenge is primarily designed to scale up the forest landscape restoration approach, which aims to restore ecological integrity at the same time as improving human well-being through multifunctional landscapes¹⁸.

The African Forest Landscape Restoration Initiative (AFR100) is a regional contribution to the Bonn Challenge and is a country-led effort to bring 100 million hectares of land in Africa into restoration by 2030. The initiative was launched at COP 21 in Paris and additionally contributes to the African Resilient Landscapes Initiative (ARLI), an initiative to promote integrated landscape management with the goal of adapting to and mitigating climate change¹⁹.

Restoration activities differ depending both on the type of ecosystem to be restored and what condition the degraded ecosystem is in. Restoring forest land from productively managed farmland requires a different approach to restoring crop land that has experienced soil erosion. Some forms of land restoration can be prohibitively expensive, for example when soil is contaminated with heavy metals or salt deposits. However, in many cases degraded land is still being managed, albeit at a lower level of functionality, and restoration is possible by shifting to more sustainable management approaches. For example, land with depleted fertility can be restored through incorporation of organic matter or by integrating crops with leguminous trees.

FMNR is an indigenous practice in the Sahel that is gaining popularity among Sahelian farmers, particularly in Niger.

Natural regeneration is often the most cost-effective way to achieve restoration on a significant scale. Natural regeneration can be achieved through simple forms of protection, such as development of community grazing or forest management plans with patterns of seasonal rest and recovery, or with an initial longer period of rest to kick-start the recovery process. Sometimes exclosures are used for a period of time to protect a degraded site from use while the recovery process gets underway. However, there are cases where natural regeneration is too slow and the process can be accelerated with minimal intervention.

Assisted Natural Regeneration (ANR) uses minimal interventions to help the natural regeneration of degraded land and to restore productive forest and rangeland ecosystems (Shono *et al.*, 2007). Farmer Managed Natural Regeneration (FMNR) is an indigenous practice in the Sahel that is gaining popularity among Sahelian farmers, particularly in Niger. FMNR is an example of assisted regeneration, where farmers manage and protect trees that regenerate naturally on crop lands. In Senegal and Burkina Faso, for example, assisted natural regeneration and reforestation have been used to increase tree cover and restore the land which was degraded by salinization, droughts and deforestation.

¹⁸ <http://www.bonnchallenge.org/content/challenge>

¹⁹ <http://www.wri.org/our-work/project/AFR100/about-afr100>

Disaster Risk Reduction through forest restoration²⁰

Ecosystem-based approaches to Disaster Risk Reduction (eco-DRR) have employed innovation in forest regeneration work to improve drought resistance. Tree species are selected for their adaptation to drought, such as the Jujube tree (*Ziziphus mauritiana*), which is common throughout the Sahel. The tree can grow in poor soils and in areas with rainfall from 250mm to 2,000mm per year, and can tolerate prolonged droughts. Jujubier trees provide nutritious fruit with a market value and can contribute to livelihood diversification and alternative sources of income. Eco-DRR projects have also used the shea tree (*Vitellaria paradoxa*), which is another high-value resource that provides a nutritious fruit and an oil-rich seed with high market value. The shea tree is also drought tolerant and highly adapted to the drylands of the region.

Reforestation efforts in the Sahel are increasingly focusing on the integration of trees into farming landscapes, including integration into crop fields (agroforestry) and pastures (silvopastoralism). Burkina Faso and Ghana now combine large-scale plantation development with small-scale, on-farm regeneration activities. Species type may differ according to the production objectives of the farmer or plantation manager. In Senegal and Burkina Faso, for example, assisted natural regeneration and reforestation have been used to increase tree cover and restore the land which was degraded by salinization, droughts and deforestation. In Senegal, due to salinization, salt-resistant plant species are used in reforestation activities. In northern Burkina Faso, suitably adapted and resilient plant species have been selected by drawing on the local knowledge of communities and used to restore the degraded land in six villages.

5.3. Innovative approaches to protected areas in production landscapes

Protected areas are not currently given significant consideration as a tool to combat desertification in the Sahel. However, the term is frequently misconstrued to mean only state-managed areas that are set apart from production in order to protect nature. This is only a sub-set of the definition of protected area and, in its wider sense as defined by IUCN, protected areas could play a major role in protecting sustainable farming and herding practices that address desertification and drought (Dudley, 2008).

Protected areas could play a major role in protecting sustainable farming and herding practices that address desertification and drought.

There are numerous examples worldwide of protected agricultural landscapes, where the environmental benefits of sustainable farming are protected against encroachment by less sustainable land uses. Protected areas can help to improve management of forests and forest landscapes, watersheds and rangelands in the Sahel. They can be used to conserve natural habitats and biodiversity and the ecosystem services that they provide. Protected areas and the management regimes within them have been used to address land degradation by zoning for different and appropriate land uses, to implement sustainable

²⁰ IUCN, 2016. Regional assessment on Ecosystem-based Disaster Risk Reduction and Biodiversity in West and Central Africa. A report for the Resilience through Investing in Ecosystems – knowledge,



grazing regimes, and to maintain healthy ecosystems that protect vital water sources and slow the spread of invasive species (IUCN, 2011). Protected areas also play an important role in carbon regulation. It is estimated that approximately 15% of carbon is stored in the world's protected areas (IUCN/WCPA, 2007).

Protected areas can be owned or managed by communities, State authorities or private land owners.

Protected areas can be owned or managed by communities, State authorities or private land owners. They may be protected against all exploitation, or they may be protected against certain uses: for example, agricultural heritage sites may be protected against encroachment by intensive farming. Protected areas are often established in critical resources area, such as mountain water towers or riparian zones, and this can be an essential element of integrated landscape management (IUCN, 2011).

Protected Area Categories

IUCN defines a protected area as “a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (Dudley, 2008). Six categories of protected area are currently recognised, classified according to the management objectives:

- Category Ia: Strict Nature Reserve
- Category Ib: Wilderness Area
- Category II: National Park
- Category III: Natural Monument or Feature
- Category IV: Habitat/Species Management Area
- Category V: Protected Landscape/Seascape
- Category VI: Protected area with sustainable use of natural resources

Protected areas have an important role to play in conserving biodiversity and promoting SLM in the Sahel. A range of different categories can be used to establish networks of protected landscapes connected through conservation corridors, for example with stricter controlled areas like reserve forests embedded in a matrix of protected agricultural and pastoral landscapes. Greater use can be made of protected area categories 5 and 6. Category 5 includes areas “where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value”. Category 6 protected areas are created to “conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems” (Dudley, 2008). Grazing lands are particularly well suited to being recognised as protected areas, since sustainable management of grassland biodiversity is an important management objective, and since livestock grazing can be managed in ways that promote rangeland biodiversity (Davies et al., 2012).

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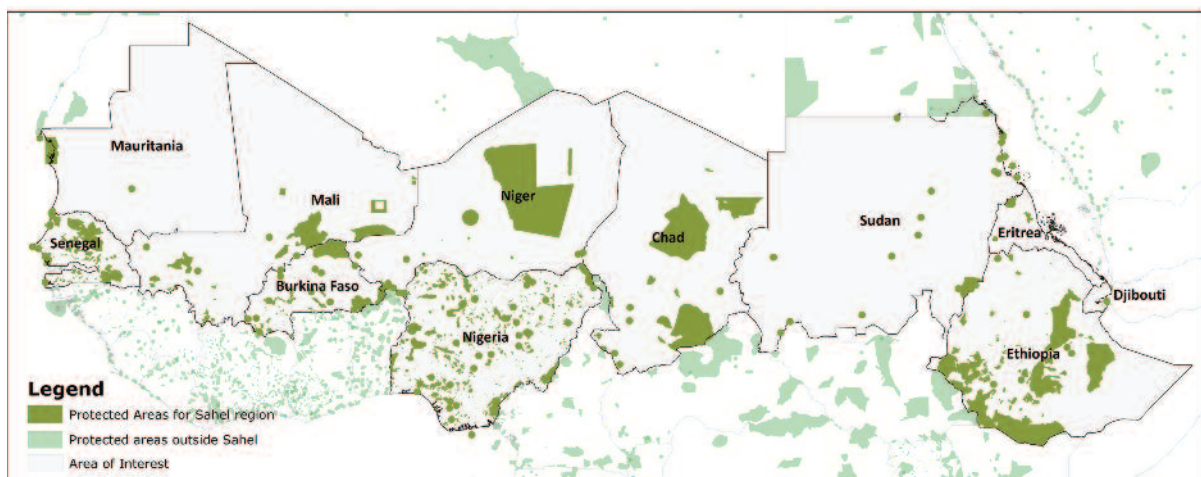


Figure 13: Map of protected areas in the Great Green Wall Initiative countries

Source: IUCN and UNEP-WCMC, 2016, the World Database on Protected Areas (WPA) online, November 2016, Cambridge, UK. Available at www.protectedplanet.net

The World Database on Protected Areas shows more than 2,500 protected areas in West and Central Africa (IUCN and UNEP WCMC, 2013). An estimated 224,825 km² of protected land is found in the Sahel and Sahara region, although this represents only about 5% of the total land area.

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The coverage of protected areas in the region is therefore well below Aichi Target 11 of 17%, despite the relative ease of protecting land that is dominated by biodiversity-friendly pastoral systems. Nevertheless, these protected areas play an important role in conservation of some species. The largest elephant population in West Africa (around 4,500 individuals) is found in the W-Arly-Pendjari (WAP) complex of protected areas between Niger, Burkina Faso and Benin (European Commission, 2010).

Implementing the Convention on Biological Diversity's Programme of Work on Protected Areas and establishing effective protected area networks in the Sahel could contribute simultaneously to the goals of the CBD, UNCCD and the UNFCCC. However, this requires new attitudes to protected areas, involving greater willingness to consider community-led approaches and different and more diverse governance structures, alongside government efforts (Dudley *et al.*, 2014).

Indigenous and Community Conserved Areas (ICCA)

Protected Areas can be owned and managed by governmental agencies, NGOs, communities, indigenous peoples and private parties – alone or in combination. Both IUCN and the CBD recognise the legitimacy of a range of governance types and efforts are being made to expand the recognition of non-state actors as protected area managers. Particular interest is given to Indigenous peoples' protected areas, indigenous peoples' conserved territories and community conserved areas, collectively referred to as Indigenous and Community Conserved Areas or ICCAs.

ICCAs are usually recognised where local communities are closely concerned about the relevant ecosystems for cultural, economic or territorial reasons. Those communities have power in making and implementing important management decisions, through institutions that exercise authority and responsibility and are capable of enforcing regulations. These management decisions and the efforts of indigenous peoples and/or local communities contribute towards the conservation of habitats, species, ecological functions, and associated cultural values, although the original intention might have been related to a variety of objectives, not necessarily directly related to the protection of biodiversity.

ICCAs may meet the protected area definition and standards and they provide effective biodiversity conservation responding to any of the management objectives of the IUCN categories. They can be particularly effective in places where governments are unable to effectively establish or govern protected areas. Although many governments still fail to recognise the legitimacy of ICCAs, there is a trend towards increased inclusion of ICCAs in national conservation strategies (Dudley, 2008).

5.4. Community Conservation: securing rights for sustainable livelihoods

Communities have actively managed natural resources in the Sahel for millennia, drawing on their local knowledge of the environment and acting collectively based on established institutions and cultural practices. These traditions have been widely undermined, for example by changes in the assertion of State power or by changes in societal structure and attitudes. However, throughout the Sahel there are many examples of initiatives to revive, or re-establish, community management of natural resources.

Community conservation approaches include “Community Based Natural Resource Management” (CBNRM). CBNRM approaches have a common principle of devolving some degree of control from government to local citizens. They are intended to strengthen local control and accountability over the use and management of land and other resources. At its heart, Community Based Natural Resource Management is about governance: adapting how decisions are made and who is involved in making and enforcing those decisions. Throughout the Sahel, effective governance of natural resources has been weakened by lack of respect for local rights, lack of legal support for communal management arrangements, and inadequate relationships between the different institutions, both State and non-governmental as well as between States, that play a role in natural resource governance (Roe *et al.*, 2009).

At its heart, Community Based Natural Resource Management is about governance: adapting how decisions are made and who is involved in making and enforcing those decisions.

In the Sahel, community conservation approaches can be used to share benefits from national parks, and therefore they are sometimes designed to appease communities who otherwise incur a cost by living adjacent to those protected areas. This is different to the Southern African approach, whereby rights and decision making powers, as well as benefits from nature, are clearly devolved to communities. However, in both cases there is a change in influence over natural resources and a degree of co-management of natural resources. In both cases there are potential livelihood benefits to local communities, which are intended to act as an incentive for protection of nature. Community conservation can therefore be a strategy for achieving the goals of the CBD, UNCCD and UNFCCC (Roe *et al.*, 2009).

Local knowledge for sustainable development

The Termit Massif in Niger is one of the remaining refuges for several endangered species, including the Dama Gazelle and Addax. The Massif also contains important pastures that are used seasonally by pastoralists. In order to strengthen sustainable management of the Massif, a community management committee was established with members drawn from local leadership, community game guards, and staff of the supporting NGO, the Sahara Conservation Fund.

The role of the Management Committee has been to negotiate mutually supportable goals for sustainable management and development. Water is a critical resource that determines access to the Massif and poorly-informed investments have led to unplanned growth in the number of boreholes. The water points increase the time that livestock can spend in the Massif and leads to overgrazing, habitat loss and desertification. The Management committee establishes regulations for the construction of boreholes in order to manage the land sustainably. The committee therefore relies heavily on the existing knowledge of local stakeholders in order to develop safe water investments, for the benefit of both local communities and wildlife (Rabeil *et al.*, 2014)

Community conservation has proved to be a powerful tool for mobilising local knowledge and capacity for conservation and sustainable management of natural resources. Communities often have a close relationship with their environment and a rich knowledge of certain species. Many societies actively manage their environment to augment its heterogeneity using tools like community protection and fire management. In many cases these customary practices have become weakened and community conservation has declined. Often this is related to changes in the power of communities over their resources, for example as a result of weakening of their tenure rights or emergence of new and influential interest groups.

Many societies actively manage their environment to augment its heterogeneity using tools like community protection and fire management.

Wildfires are commonplace in the Sahel region but they are a natural event and should not necessarily be considered as a hazard. Fire is widely used as a management tool, for promoting pastures, clearing fallow land, and supporting hunting. Fires become a problem when people start to use land in ways that are less fire tolerant, when human settlements proliferate and when ecological changes lead to change in the pattern or severity of fires. This can happen where the quantity of biomass increases sharply, and indeed fire is one of the natural mechanisms that controls the balance between woody and herbaceous biomass in the Sahel.

Revival of community conservation approaches has not reached its potential in the Sahel due to a number of constraints. Communities have seldom managed to legally secure their authority over lands and natural resources and States have not been proactive in creating enabling conditions for the development of community institutions. As a result those institutions have struggled to persist, and in some cases have led to local conflict within the community, particularly where they have led to meaningful income generation (Roe *et al.*, 2009).

5.5. Conserving locally adapted agrobiodiversity

The Sahel region is rich in agrobiodiversity due to the pressure that local populations have faced to adapt to local conditions. A combination of human and natural selection of crop and livestock breeds has led to the emergence of highly adapted species that are tolerant of local environmental stresses and production conditions. Agrobiodiversity in the Sahel is a valuable resource that provides high-value food products combined with a level of reliability that exotic strains seldom reproduce; in particular the ability to provide a modest yield even during drought-affected years.

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Locally-adapted varieties of crops and livestock are disappearing for a variety of reasons, but particularly due to strenuous efforts to replace them with exotic varieties. For many years governments, scientists and agribusinesses have promoted exotic varieties for their perceived benefits, such as greater productivity or disease resistance. About three quarters of genetic diversity of agricultural crops has been lost globally during the last century, and the genetic diversity within the surviving species has declined dramatically (Amend *et al.*, 2008). Exotic varieties are often favoured due to their higher potential productivity, but high yields are dependent on high levels of input, including fertiliser, pesticides and veterinary drugs. These exotic varieties are also often more demanding of water, and more sensitive to water scarcity.

Agrobiodiversity can be conserved in situ through protection of local farming practices, including support for SLM. Some countries have declared key agrobiodiversity areas as “Globally Important Agricultural Heritage Systems”²¹, which can strengthen global recognition of their value and be used as the framework for conservation and sustainable management of associated landscapes, biodiversity, knowledge systems, and cultures. Protected Area status can be used for agricultural landscapes, as discussed above, and in particular categories V and IV. Designation of Biosphere Reserves can also be used in the conservation and sustainable development of areas rich in agrobiodiversity (Amend *et al.*, 2008).

²¹ <http://www.fao.org/giahs/en/>

6. Barriers and opportunities to promoting biodiversity in the Great Green Wall

The goals of the Great Green Wall Initiative can only be achieved by conserving biodiversity since restoration and sustainable land management all contribute to protecting nature. However, this requires a change in the way biodiversity and conservation are perceived, and in particular a stronger recognition of how biodiversity benefits society and how this can be capitalised on. To achieve this will require a change in the way landscapes and ecosystems are managed, for the benefit of society as a whole and not only to achieve individual sectoral priorities. More integrated, intersectoral thinking is frequently advocated in relation to the GGW and the initiative provides the vision around which such integration could realistically be achieved. However, it will require continued leadership at the highest levels combined with innovation in policies and investment.

There are many challenges to achieving the goals of the Great Green Wall Initiative and these also cut across sectors. In this section the challenges are grouped into three broad issues of deeply entrenched misunderstanding, long-term underdevelopment combined, and unprecedented rates of change.

6.1. Misunderstanding risk and resilience in the drylands of the Great Green Wall

Conflicting visions of development

The debate between agricultural intensification and sustainable development is central to the Great Green Wall. A recent World Bank report highlights the need to boost agricultural output in order to make livelihoods more resilient, but also underlines the importance of sustainability, including management of soil fertility and scarce water resources (Cervigni and Morris, 2016). Although governments are becoming more aware of the shortcomings of conventional agricultural investment strategies, sustainable agricultural practices, such as agroecology, remain in the margins and are dwarfed by public investments in unsustainable land management practices.

An alternative vision of sustainable development is needed that is based on optimal production of multiple values and outputs from land.

Instead of treating this debate as a simple dichotomy -either food or nature- an alternative vision of sustainable development is needed that is based on optimal production of multiple values and outputs from land and including more than just agricultural output. This would entail investment in service delivery and market integration based on sustainable land management. It would also require a balanced use of scarce water resources, recognising the food-production potential of irrigation but also the potential cost, at the ecosystem scale, of changing water resource access and availability. Public planning needs to be better informed by assessment and valuation of multiple ecosystem services and public institutions need to be capable of better coordination of landscape management. Ecosystem services can be protected through a combination of regulations and incentives, requiring investment in both policy and markets (Mortimore *et al.*, 2009).

Building resilience and managing risk

The Sahel is characterised by an extremely variable climate and frequent droughts, floods and other risks. Customary land management practices have developed to manage and mitigate these risks, often with the goal of ensuring an adequate yield in the worst years rather than a maximum yield in the best years. Development in the Sahel has frequently focused on different goals and has undermined traditional risk management strategies, for example by replacing drought-tolerant crops with high-potential varieties that yield much less during drought. Agricultural development has also often exposed land users to new and elevated risks, for example by disturbing hydrological cycles and exacerbating the severity of drought, or by creating dependency on unreliable markets.

The Great Green Wall is a powerful opportunity to demonstrate the value of SLM in strengthening resilience and risk management. At the same time, governments can invest more effectively in Disaster and Drought Risk Reduction, particularly by including indicators of water regulating services in land management and recognising that the severity of a hazard, as well as the capacity to manage the hazard, can be strongly influenced by land management practices. Governments can also provide social protection programs, which can provide safety nets to protect the most vulnerable people at lower cost than humanitarian assistance and can build resilience at the household and community level (Cervigni and Morris, 2016).

The GGW is a powerful opportunity to demonstrate the value of SLM in strengthening resilience and risk management.

Efficient management of dryland soil and water

Dryland policies and investments are often driven by misunderstanding of both soil and water in the drylands, and particularly the intersection of the two. It is common to read that “drylands are water scarce” or “characterized by drought”, rather than viewing scarcity and drought as the outcome of poor choices and mismanagement. The result is often over-investment in inefficient and harmful water management practices, for example irrigation practices that increase evapotranspirative losses and lead to an overall drying of landscapes, and the risk of salinization. Failure to manage appropriately soil fertility and soil moisture in combination leads to rapid decline in both and contributes to a loss of resilience.

Management of soil fertility and water, particularly through agricultural practices that emphasise maintenance of organic matter in the soil, can play a major role in achieving the goals of the Great Green Wall Initiative. Protecting soil carbon in the drylands plays a major role in increasing soil moisture and soil biodiversity contributes to increasing infiltration and recharge of aquifers. Soil carbon contributes to overall soil fertility and hence top agricultural productivity and resilience. It also contributes to mitigating climate change and is increasingly seen as a central pillar of national contribution to mitigation, particularly in low-forest cover countries like those in the Sahel.

6.2. Managing the complexity of unprecedented change in the Sahel

Population growth and demographic change

Population growth is projected to be faster than economic growth in the Sahel and this is likely to increase the pressure on natural resources and the overall demand for food and other products. This provides an obvious challenge to sustainable resource management, but also a powerful incentive to greatly improve food productivity in the region. Economic growth will increase purchasing power in the region, and urbanisation will create growing markets for agricultural outputs (Cervigni and Morris, 2016).

Whether demographic change is a threat or an opportunity depends to some extent on how well sustainability criteria are embedded in agricultural production and other aspects of development. Urbanisation and growth of the secondary and tertiary sectors should create opportunities for remittances to rural areas that can finance investment in agricultural production. Lowland managers use these remittances will depend on their capacities, their access to suitable products and services, and whether policies and regulations are in place to support sustainability. In many areas sustainable land management will also depend on the security of land rights, particularly over communal land, and the strength of local governance.

Whether demographic change is a threat or an opportunity depends to some extent on how well sustainability criteria are embedded in agricultural production and other aspects of development.

Economic growth

Economic growth is projected to increase in the Sahel, although not at a faster rate than population growth (Cervigni and Morris, 2016). This is likely to place growing pressure on resources but will also generate capital that can be reinvested in restoration and sustainable management. The Sustainable Development Goals provide a framework for ensuring economic growth, but the breadth of the SDG targets may leave governments making critical choices over how resources are allocated and which targets are prioritised.

Countries should recognise the importance of environmental sustainability to their long term economic growth and should deploy a mitigation hierarchy to avoid, reduce, restore and offset biodiversity loss.

Land Degradation Neutrality, SDG Target 15.3, has been described by the UNCCD as an “SDG accelerator”, implying that by achieving LDN countries will score strongly against multiple other development goals (see Figure 1). Greater emphasis is needed on the multiple benefits of LDN and the Great Green Wall, including the contribution to food production, economic growth, job creation, and others. Investments in infrastructure, power generation, mining etc. are inevitable and are likely to have negative environmental impacts. However, countries should recognise the importance of environmental sustainability to their long term economic growth and should deploy a mitigation hierarchy to avoid, reduce, restore and offset biodiversity loss as appropriate (Figure 14). This is also a principle of LDN according to the UNCCD Science Policy Interface.

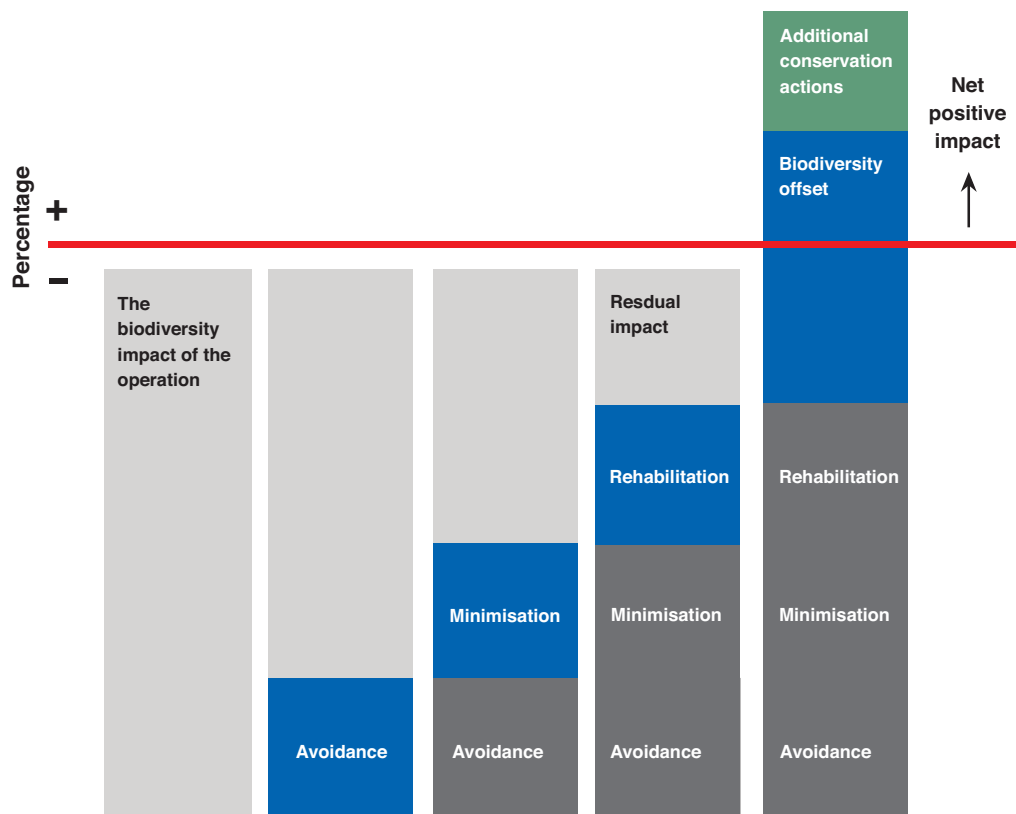


Figure 14: The Mitigation Hierarchy

Source: riotinto.com/sustainabledevelopment2013

Climate change

The Sahelian climate is predicted to become hotter and precipitation will become more unpredictable. There is lack of consensus over whether the climate will become wetter or drier and therefore the projection is one of uncertainty. Although concerns are more likely to be raised in relation to decreasing rainfall, increases in rainfall can also bring new risks, for example greater post-harvest losses or change in patterns of crop and livestock disease. In either case, climate change is one of many profound changes taking place simultaneously in the drylands and strong emphasis will be needed on enabling countries and communities to adapt to them all.

Given the high level of uncertainty, and the likelihood that the climate will also become more unpredictable, traditional mechanisms of risk management are of ever-greater importance. Dryland land management has traditionally been highly adapted to uncertainty and these adaptations need to be reinforced rather than undermined. In particular greater attention is needed to managing water efficiently in dryland ecosystems, for example minimising wastage, runoff and evaporation. Dryland communities have been depicted as among the most adaptable land users, but their capacity to continue to adapt will be strained by the rate and extent of change as well as the degree to which their capabilities are being reinforced. Emphasis is needed on building broad-based adaptive capacities as much as specific climate-adjusted activities. Countries will also need to invest in improved weather forecasting and climate change protections.

Given the high level of uncertainty, and the likelihood that the climate will also become more unpredictable, traditional mechanisms of risk management are of ever-greater importance.

6.3. Adjusting investments to address long-term underinvestment

Human capital

Low human capital is one of the most significant factors in poverty in the Sahel, and poverty reduction cannot be achieved without directly addressing the low penetration of basic social services, including education for all. The relationship between poverty and biodiversity loss, or land degradation, is not simple. While poor communities may rely disproportionately on natural resources for their livelihoods, and may over-exploit those resources, biodiversity loss and degradation may also accelerate as development gathers momentum. Attributing biodiversity loss and land degradation to poverty, without stronger understanding of the relationship, can lead to dispossession of the poor from their land, and could lead to wider adoption of unsustainable land management practices.

Human capabilities influence how people make use of services, how they diversify their livelihoods, and how they govern their resources. For this reason links can be drawn between human capital development and SLM. Strengthening human capital may contribute to SLM adoption, providing other enabling factors are in place. On the other hand, existing local knowledge is a rich resource that can enable SLM independently of other forms of education. Overall, considering the complexity of the challenges facing land managers in the Sahel, it seems likely that strengthening human capital, and particularly access to education for both women and men, could be catalytic in extending the adoption of SLM practices.

Strengthening human capital, and particularly access to education for both women and men, could be catalytic in extending the adoption of SLM practices.

The role of local knowledge and social capital in sustainable management of biodiversity deserves greater attention. Many communities have strong traditions of sustainable natural resource management, for example to coordinate seasonal grazing patterns or the timing of harvesting wild fruit. However, in many cases these institutions may be breaking down as populations grow and as alternative institutions replace them. Many actors advocate for participatory approaches in order to strengthen local institutions and collective action and to strengthen overall local governance. Such approaches may also stand to benefit from overall improvements in human capital.

Land rights and tenure

Weak land tenure is a significant barrier to sustainable management of natural resources in the Sahel. Insecure tenure can be a major impediment to sustainable land management, particularly when it comes to communal resources. It can determine what crops and livestock are produced, how and when land is tilled and harvested, and whether it is viable to invest in the future productivity of land. Farmers throughout the region face the challenge of weak tenure, the roots of which are too complex to address in this report. Most countries in the Great Green Wall Initiative have, at some point in the recent past, instituted policies to nationalise land, usually in the aftermath of colonisation. In several cases this includes more than one period of colonisation which has created a number of layers of land rights. Some countries have also attempted land redistribution and land reform, whilst customary land tenure systems remain widespread and have adapted to the continuously changing legal and political environment. This has led to widespread uncertainty and ambiguity between customary and legal rights, and many opportunities for exploitation by individuals. This is further aggravated by low investment in legal services and weak avenues to redress illicit activities related to land rights (Toulmin and Quan, 2000).

Greater attention needs to be placed on building capacity, in institutions and amongst communities, to achieve more equitable local resource governance and secure tenure.

Land tenure solutions vary from country to country, but often the challenge is one of implementing, rather than establishing, laws. This may reflect gaps in capacity and legal services as well as low understanding, in rural communities, of how to secure rights, including the rights of women and other marginalised groups. Securing communal rights is often more challenging, and generally receives weaker legal support, suggesting that in some cases legal reform may be required. However, publication of the Voluntary Guidelines on Responsible Governance of Tenure (FAO, 2011) has shown the growing interest amongst a number of countries in the region to find solutions to this barrier. As the willingness to strengthen tenure grows, greater attention needs to be placed on building capacity, in institutions and amongst communities, to achieve more equitable local resource governance and secure tenure.

Institutional capacity

Institutions for sustainable land management in the Sahel have a number of shortcomings. Public services are often constrained by inadequate resources and low staff capacity. Policies in favour of sustainable management are often absent or are poorly implemented, and preference is often given to policies that favour less sustainable land management. Effective landscape management requires a degree of integration between sectors, either through improved coordination or through adoption of common indicators across sectors. Intersectoral coordination mechanisms have been proposed in all the Great Green Wall Initiative countries but resources for their implementation are scarce and their capacity is low. Landscape-scale land use planning is seldom practiced due to a combination of weak capacity, low resources and absence of institutional mandates. Community institutions are facing constraints and have been undermined by a combination of low legal recognition, rapid social changes in the community and other factors.

Greater capacity building, awareness raising, and policy direction is needed to help public servants to embrace a broader vision of the Great Green Wall that expands beyond their individual sector.

Growing attention to sustainability, including government support for both Land Degradation Neutrality (SDG Target 15.3) and the Great Green Wall, creates a new policy space within which action for SLM and restoration is being legitimized. The Great Green Wall Initiative countries have proposed intersectoral coordination mechanisms on paper and there is a trend towards improved support for these institutions. Greater capacity building, awareness raising, and policy direction is needed to help public servants to embrace a broader vision of the Great Green Wall that expands beyond their individual sector, for example to include common indicators of biodiversity loss of ecosystem function. Devolution in several countries could offer opportunities for local government to embrace more holistic landscape planning at the appropriate level, and also may provide community institutions with greater influence over natural resource management. Combining support for community institutions with stronger tenure and resource governance may be the strongest foundation for resilient development in the Great Green Wall.



7. Conserving biodiversity to achieve the goals of the Great Green Wall

The Great Green Wall provides a more balanced vision for sustainable development and conservation of the drylands that reflects the social and ecological context. To fulfil its goals the GGW will need to adapt green economic growth to the unique conditions of the drylands, rather than trying to mould drylands to fit an external vision of economic growth. It will need greater emphasis on sustainable management of biodiversity and ecosystems and maintaining landscape connectivity. The GGW will need to prioritise land health as the basis for secure food and water provision as well as numerous other services to humanity. Overall the GGW will need to emphasise resilience and risk management that is adapted to the high level of uncertainty found in these dryland environments. This vision, encapsulated in these four points and elaborated below, can provide a framework to guide policy and investment for the GGW (Davies *et al.*, 2012).

1. Adapting green economic growth to the drylands

Green economic growth that is adapted to the drylands should protect natural assets and maintain the provision of resources and environmental services on which growth and well-being depend. Sustainable development should be adapted to the environmental conditions of Sahel, including high climatic variability, marked seasonality, and high rates of water loss. While adapting to local conditions, development should also identify and pursue the unique opportunities for growth in the region, including the vast and largely un-tapped potential to generate renewable energy. Green growth in the Sahel should recognise the diversity of ecosystem services and ensure a more balanced investment to optimise their delivery rather than maximising individual services. Unless explicitly disproven in specific cases, it should be assumed that the aggregate value to society of multiple ecosystem services in the Sahel exceeds the maximum potential from any single service.

2. Sustainable biodiversity management and landscape connectivity

The importance of biodiversity for food production, water supply, and other ecosystem services in the Sahel, means that conservation strategies need to capitalise on the environmental benefits of different land use systems. Sustainable Land Management, including agroecology and pastoralism, should become an important component of conservation strategies and conservation of biodiversity should become an explicit goal of agricultural development. This will build on local knowledge and institutions, which will be enabled by strengthening community governance and empowering dryland peoples. The vision of conservation in the Sahel should be one of a mosaic of connected sustainable land use systems -pastures, forests, farmlands and wetlands- protected using a variety of institutional arrangements by communities, private actors and the State. In this vision, sustainable farming systems become a tool for conservation and conservation is a tool for sustainable agricultural development.

3. Land health as the basis for secure food and water provision

The goals of the Great Green Wall Initiative depend on sustainably managing land and water in an integrated way that is consistent with dryland ecology. Sustainable management should be guided by science on how to boost soil fertility and soil moisture and how to effectively manage scarce water resources to minimize loss and to optimise returns to water resources at the landscape scale. Land and landscape restoration initiatives should be given greater prominence, informed by improved valuation of the multiple ecosystem services that can be revived. To incentivize this, innovative approaches are needed for compensating ecosystem services and the land management practices that protect them. Improved monitoring on land health is needed to ensure that land is treated as a non-renewable resource, and to ensure management is regulated effectively. This should be coordinated under nationally established Land Degradation Neutrality targets, as per the UNCCD commitments, to achieve a long-term balance between land degradation and land rehabilitation, with a great emphasis on sustainable management.

4. Resilience and risk management in uncertain environments

A fundamental challenge of drylands is to manage risk and maintain resilience of communities and ecosystems. Resilience depends on conservation of dryland biodiversity, both in terms of species abundance and richness. Biodiversity contributes to stronger resilience by providing the building blocks of nutrient and hydrological cycles and by providing resources that support sustainable livelihoods. Risk management and strengthening of resilience should be at the heart of dryland monitoring and should be an explicit target of dryland policy and investment. This needs to include broad based human development, including education, health and security, considering the major development gaps in the Sahel. It will also need significant attention to strengthening governance at all levels, including stronger engagement of men and women in public decision making and safeguarding of their rights to use and to manage natural resources.

7.1. Recommendations for mainstreaming biodiversity to achieve the goals of the Great Green Wall

1. Mainstream Sustainable Land Management in the agriculture sector to achieve Land Degradation Neutrality

The goals of the Great Green Wall Initiative require governments to ensure that land restoration outweighs land degradation, which is also required to achieve Land Degradation Neutrality. The most cost effective way to achieve this is to minimise degradation, particularly through adoption of sustainable land management practices. This requires SLM to move from a marginal activity of the agricultural sector to being mainstreamed in core agricultural investments and policies. Governments may need to rethink how they interpret “agricultural intensification” and do more to measure the overall yield of ecosystem services from land.

- Invest in scaling up SLM as well as further innovation in SLM and restoration practices
- Promote innovation in small and medium-sized enterprises for sustainable agriculture, including input and value chains
- Develop financial services (including credit/savings and insurance) that are adapted to the needs of both male and female farmers and pastoralists to enhance their investments in SLM
- Establish training programmes for farmers and extension agents in SLM
- Provide financial and other incentives for the multiple benefits of SLM, including markets for co-benefits (e.g. non-timber forest products) and payments for ecosystem services
- Monitor the cost of environmental degradation from different farming systems, such as depletion of aquifers or loss of biodiversity, and establish measures to internalise the costs of unsustainable practices.

2. Establish institutional arrangements that enable landscape restoration and sustainable management

Achieving the goals of the Great Green Wall Initiative will require greater integration of landscape management, in order to produce food and conserve biodiversity and ecosystem services simultaneously rather than partitioning landscapes into protected and exploited areas. Protected areas will remain necessary, but more can be established to protect sustainable managed agricultural landscapes. New institutional arrangements are required to ensure that key sectors take responsibility for their impact on other sectors and to enable synergy between sectors in the management of natural resources.

- Ensure that intersectoral coordination mechanisms, as outlined in country Great Green Wall strategies and National Action Programmes to Combat Desertification, are operational, with adequate financial and human resources
- Provide technical and financial resources, including training, at the local government level for integrated landscape planning
- Build capacities and ensure opportunities exist for community involvement in integrated landscape planning
- Improve the management of protected areas in the Sahel and create new protected agricultural landscapes and Indigenous and Community Conserved Areas (ICCAs).

3. Strengthen governance, tenure and resource rights at the local level

Managing land sustainably, and thereby conserving biodiversity, requires security of resource rights, including the right to impose rules and to sanction misuse. This does not necessarily mean private tenure and governments can do more to recognise communal tenure. Strengthening tenure will contribute to better-integrated landscape management since farmers, pastoralists and other local communities typically think about resources in a more holistic, non-sectoral way. Stronger governance will enable local communities to take greater control over natural resource management and restoration and will contribute to resilience at the local level.

- Promote local governance over natural resources through participatory planning and devolution of decision-making to the lowest practical level
- Train both men and women natural resource managers as well as public sector employees in options for strengthening local governance and resource tenure
- Reinforce the rights of women as natural resource managers and adjust policies and investments to the gendered nature of biodiversity benefits and land degradation impacts
- Ensure legal institutions have the resources to support implementation of national land laws, paying particular attention to securing communal resource tenure and recognising customary right and institutions.

4. Monitor biodiversity and ecosystem function to evaluate Great Green Wall investments and policies

Biodiversity is an essential indicator of sustainable land management and this can be monitored in a variety of ways. It can be measured directly by counting key species in the landscape, although there may be challenges in identifying biodiversity that is a true indicator of landscape resilience. Biodiversity can also be measured by proxy, for example by measuring the state of critical ecosystem functions, such as water flows or soil fertility. Improved understanding of the role of biodiversity in achieving the goal so of the Great Green Wall Initiative, through science, training and information, will help to improve the integration of sustainable land management and biodiversity conservation to achieve sustainable development.

- Provide public funding to monitor biodiversity and ecosystem function, using appropriate tools that are simple, low-cost, routine, and can be adjusted to different land-use objectives
- Invest in measuring soil organic carbon as an indicator of SLM, climate change mitigation and biodiversity
- Provide greater research into the role of SLM in conserving biodiversity and the contribution of biodiversity conservation to Great Green Wall Initiative targets and Land Degradation Neutrality
- Validate local knowledge on SLM and local indicators of sustainability according to different land management objectives, and evaluate the contribution of traditional land management practices to the goals of the Great Green Wall Initiative.

7.2. Conclusion

The idea that biodiversity can be freely sacrificed on the road to development is deeply flawed, but reflects the narrow sectoral thinking that traditionally guides development. The value of biodiversity in sustainable land management and for safeguarding ecosystem services needs to be widely understood in order to identify the best investment options for countries as a whole. This decision making cannot be left to individual sectors but needs to be coordinated at the highest level, just as the Great Green Wall has been championed by Heads of State. Some degree of biodiversity loss may be inevitable: roads and cities will be built, and environmentally risky investments are often unavoidable. Nevertheless, there are many approaches to protecting biodiversity that are compatible with development. Conservationists should not disregard such approaches simply because they only conserve some, rather than all, species.

The value of biodiversity in sustainable land management and for safeguarding ecosystem services needs to be widely understood in order to identify the best investment options for countries as a whole.

Genuine synergies can be found between environment and development goals that make the Great Green Wall a national investment priority. Rather than invest separately to deliver goals of the UNCCD, CBD or UNFCCC, priority should be given to investments that simultaneously deliver all three at a lower aggregate cost. The Great Green Wall Initiative is an important vehicle for delivering Land Degradation Neutrality under the UNCCD. It also conforms to Article 8f of the Convention on Biological Diversity, which requires parties to

Genuine synergies can be found between environment and development goals that make the Great Green Wall a national investment priority.

promote the recovery of threatened species through strategies such as the ecosystem approach. The Great Green Wall Initiative can contribute to several of the Aichi Targets, including Target 5 on habitat loss, Target 7 on sustainable agriculture and forestry, Target 9 on invasive alien species, Target 13 on the genetic diversity of domesticated plants and animals, Target 14 on ecosystem services, Target 15 on ecosystem resilience and carbon stocks, Target 18 on local and indigenous knowledge,

and Target 19 on science and knowledge. Rather than allocating land separately for food production, biodiversity conservation, or watersheds, greater priority should be given to investments in the multifunctionality of land. Achieving such an ambition requires supporting institutional mechanisms to be established. It also requires the elevation of LDN to a higher political priority in the countries of the Great Green Wall Initiative.



Figure 15: Contribution of the GGWSSI to the Aichi Targets

Source: IUCN, Jonathan Davies

The Great Green Wall is an inherently biodiversity-friendly initiative and its goals can only be met by conserving biodiversity and protecting ecosystem services. These environmental benefits need to be better understood and valued and conservation of biodiversity in the GGW should not be left to chance. Considering the value of biodiversity to society as a whole, systems of reward are needed to incentivise and compensate protection through sustainable management. More diverse use of the Protected Area system should be explored, taking into account protection of agricultural production landscapes as well as more exclusionary forms of protection. Greater use can be made of protected areas to achieve other development goals, such as Disaster Risk Reduction or ecosystem-based adaptation. With a sufficient

With a sufficient change in perspective, there is no reason why the GGW could not entirely be classified as a mosaic of different protected areas, protected for the sustainable management of Sahelian landscapes to provide food, water and energy, to support the livelihoods of its many residents, and to safeguard the great beauty and diversity of Sahelian landscapes and cultures.

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Annex 1: List of SAWAP projects

Country	Project title	Project Development Objective (as stated in project document)	How specific biodiversity issues are addressed (as part of a component or sub-component of the project)
Benin	Forests and Adjacent Lands Management Project	Assist Benin in its effort to lay the foundation for a collective integrated ecosystem management system of its forests and adjacent lands	The project addresses sustainable management of forest resources, through updating, harmonizing and implementing forest reserves' management plans; restoring degraded areas; managing rangelands and protected zones for long-term forest conservation; and managing Birds Island.
Burkina Faso	Third Community-Based Rural Development Project	Enhance the capacity of rural communities and decentralized institutions to implement local development plans that promote sustainable land and natural resources management and productive investments at commune level	The project manages natural resource and protects ecosystems, especially ecosystems, protected areas and reserves of the PONASI ecological complex (covering protected areas of Po, Nazinga and Sissili) in the south center of the country.
Chad	Emergency Agriculture Production Support Project	Support rural communities and producer organizations in increasing: (i) the production of selected crops and livestock species in selected areas, and (ii) the use of sustainable land and water management practices in climate vulnerable ecosystems	The project will address ecosystem management through the protection of targeted natural ecosystems that contain natural reserves and national parks in four regions.
Ethiopia	Sustainable Land and Climate Change Project	To reduce land degradation and improve land productivity in selected watersheds in targeted regions in Ethiopia	The project will establish and strengthen community level protected areas, conservation zones, communal reserves, groves, wildlife corridors for sustainable nature resource conservation. It will conserve biodiversity at community and individual farm levels, through, among others, the identification of endemic and endangered local plant species, in-situ and ex-situ conservation.
Ghana	Sustainable Land and Water Management Project	1. Demonstrate improved sustainable land and water management practices aimed at reducing land degradation and enhancing maintenance of biodiversity in selected micro-watersheds; and 2. Strengthen spatial planning for identification of linked watershed investments in the Northern Savannah region of Ghana.	The project will use the watershed management approach in order to manage riparian biological corridors, including wildlife, through maintaining and enhancing key habitat values.
Mali	Natural resources management in a changing climate	to expand the adoption of sustainable land and water management practices in targeted climate vulnerable communes in Mali	The project addresses biodiversity through an ecosystem-based adaptation approach. It also supports natural resources management governance at local level by developing and adopting participatory community resource use plans and the revision of the Communes development plans that integrate sustainable land management issues and biodiversity conservation.

Country	Project title	Project Development Objective (as stated in project document)	How specific biodiversity issues are addressed (as part of a component or sub-component of the project)
Mauritania	Sustainable Landscape Management Project under the SAWAP	Strengthen sustainable landscape management in targeted productive ecosystems in Mauritania.	The project will restore degraded Gum Arabic ecosystems. This will contribute to improve biodiversity conservation, soil and water conservation, as well as vegetation and soil carbon storage.
Niger	Third community action program support project	Strengthen local development planning and implementation capacities, including the capacity to respond promptly and effectively to an eligible crisis or emergency, and to improve the access of the targeted population to socio-economic services.	Through sustainable land management practices the project attempts to improve conservation and sustainable use of biodiversity, and ecosystem goods and services. This will be done by improving the effectiveness of protected area systems, and mainstreaming biodiversity conservation and sustainable use into production landscapes and other sectors.
Nigeria	Nigeria Erosion and Watershed Management Project	Reduce vulnerability to soil erosion in targeted sub-watersheds	By using an integrated watershed management approach, the project addresses natural resources and biodiversity degradation, including the specific issue of gully erosion (and other areas affected by erosion) that the project will attempt to solve.
Senegal	Sustainable and inclusive agribusiness development project	Develop sustainable and inclusive commercial agriculture and sustainable land management in project areas.	Classified forests and natural reserves will be protected and sustainably managed through participatory landscape management approach. Sustainable forest management will lead to increased carbon sequestration and other key ecosystem services, thus will restore the capacity of the soil to produce.
Sudan	Sustainable natural resources management project	Increase adoption of sustainable land and water management practices in targeted landscapes of selected States of Sudan	The project will directly address biodiversity conservation issues. Using a landscape approach it will develop participatory sustainable landscape management plans that should help effectively manage water, forest, rangelands and agriculture in buffer zones and protected areas, and protect ecosystem services.
Togo	Integrated disaster and land management project	Strengthen institutional capacity of targeted institutions to manage the risk of flooding and land degradation in targeted rural and urban areas	The project finances participatory activities, with the communities, in and around selected protected areas and forests in order to reduce pressure on forest resources and restore ecosystem services.







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