Economics of drought

Investing in nature-based solutions for drought resilience – Proaction pays

United Nations Convention to Combat Desertification

ECONOMICS OF LAND DEGRADATION INITIATIVE ELD

UNU INWEH

Alliance International Drought Resilience Alliance

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A report published by the UN Convention to Combat Desertification (UNCCD), Economics of Land Degradation (ELD) Initiative and United Nations University Institute for Water, Environment and Health (UNU-INWEH)

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Table of Content

Abbreviations

AI	Artificial intelligence
BCR	Benefit:cost ratio
BMP	Biomass Production
CBA	Cost-benefit analysis
COP	Conference of Parties of a Convention of the United Nations
CSRD	Corporate Sustainability Reporting Directive
CRED	Centre for Research on Epidemiology of Disasters
DLDD	Desertification, land degradation and drought
DRAMP	Drought Resilience, Adaptation and Management Policy Framework
DRM	Drought risk management
ELD	Economics of Land Degradation Initiative
ES	Ecosystem Services
EU	European Union
FÖS	Forum Ökologisch-Soziale Marktwirtschaft
GCF	Global Climate Fund
GFDDR	Global Facility for Disaster Recovery and Reduction
GDP	Gross Domestic Product
GWP	Global Water Partnership
IDMP	Integrated Drought Management Programme
IDOS	German Institute of Development and Sustainability
IDRA	The International Drought Resilience Alliance
IDDRSI	IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI)
IEO	Independent Evaluation office
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
LDN	Land Degradation Neutrality
LPWAN	Low Power Wide Area Networks
NAP	National Adaptation Plans
NbS	Nature-based Solutions
NBSAP	National Biodiversity Strategies and Action Plans
NDC	Nationally Determined Contribution (LDN)
OECD	Organisation for Economic Cooperation and Development
PES	Payments for ecosystem services
PRA	Participatory rural appraisal
PS	Private sector
SAM	Social Accounting Matrices
SEEA	System of Environmental-Economic Accounting
SLM	Sustainable land management
SWAT	Soil Water Assessment Tool
TMG	Think Tank for Sustainability
TNFD	Taskforce on Nature-related Financial Disclosures
UN CBD	United Nations Convention Biodiversity
UNCCD	United Nations Convention to Combat Desertification
UNDDR	United Nations Office for Disaster Risk Reduction
UNECLAC	United Nations Economic Commission for Latin America and Caribbean
UNEP	United Nations Environment Program
UNFCCC-	United Nations Framework Convention on Climate Change
WEF	World Economic Forum
WMO	World Meteorological Office
WOCAT	World Overview of Conservation Approaches and Technologies
WREM	Water-Climate Risk & Environmental Management
WWF	World Wildlife Fund

Foreword

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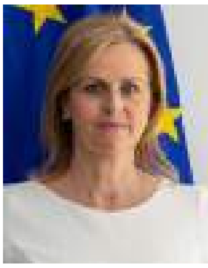

Florika Fink-Hooijer

Director-General of the Environment Department, European Commission

Land is the foundation of life. Investing in it, our survival.

The climate we once envisioned in the distant future is already here. Record-breaking heat, cyclical droughts and floods, and hurricanes, tornadoes and cyclones, once infrequent, are the new 'norm'. Communities throughout the world are confronted with catastrophic weather events, repeatedly re-setting records on every continent. Without a firm commitment through investment, and strategic, coordinated action before disasters, these extreme weather events will continue to increase in number and intensity.

However, our hunger for development and economic growth has not yet been reconciled with our basic needs for survival. Although land is the foundation of life —we depend on it for food, clothing and shelter—up to 40% of land worldwide is considered degraded. Land degradation, drought, and desertification, caused and exacerbated by human activities, threaten our very survival. Droughts are one of the most pressing issues for humankind affecting over 1.8 billion people and leaving no continent untouched. Droughts are increasing in number and intensity each year. Communities worldwide face perpetual water shortage, even in wet years.

Yet, the power to reduce and prevent these impacts is within our reach. Human actions — including urbanisation, deforestation, surface water and groundwater over-abstraction, and human-induced climate change— are depleting our water reserves and altering land cover. As these are human-generated actions, the resultant water shortages and droughts, as well as cyclical droughts and floods, can be averted through investment in strategically planned decisions and actions.

Droughts put a heavy toll on economies costing more than US$300 billion every year. The long-term economic costs associated with droughts and related disasters are often underestimated next to the perceived gains of development. When weighing the costs, it is essential to recall that the impacts of drought are not limited to the immediate crisis. Rather, the impacts continue well into the long-term, impacting economies, spurring migration, and increasing security risks. Proactive drought management yields cost savings. Drought plans and implementation measures are estimated to cost 10 times less than the costs associated with drought damages.

Measures to reduce risk and avert the destructive impacts of climate change must not overlook these long-term costs. Unsustainable land and water management practices and other human actions that increase the frequency and intensity of droughts and accelerate climate change and biodiversity loss must be replaced by pre-emptive, anticipatory action —to ensure our survival. Well-planned, timely investments in such actions are imperative.

As the report promotes, there are many measures to mitigate drought impacts: including sustainable land and water management, reforestation, conservation agriculture, agroforestry, grazing management and other nature-based solutions, coupled with early warning systems, and micro-credit and crop insurance schemes. We know that these measures help avert drought and reduce their impacts, support household livelihoods and income, and reduce long-term economic costs, thereby supporting economies.

These measures improve the capacity of land to capture and store water and to replenish aquifers, they restore soil functions and increase resilience. Proactively managing drought before, during, and after the event through sustainable land and water management delivers a triple dividend of avoiding losses, creating economic benefits, and generating a wide array of social and environmental benefits.

Large-scale adoption of sustainable land management and nature-based solutions to drought is not a standalone transformation, it is an integral part of rethinking how we value land and relearning how to manage land sustainably. When we manage land sustainably, we harvest a multitude of benefits, including drought resilience, food and water security, climate change mitigation and adaptation, biodiversity conservation and more.

Furthermore, we need a whole-of-society approach, where national and local governments develop policy and initiatives jointly with indigenous groups, farmers, landowners, households, civil society, businesses, and academia. This ensures the voices and experiences of all actors and those most impacted by droughts are considered, helping improve coordination on drought preparation, response, recovery, and adaptation.

Building capacities of people and institutions, a favourable enabling environment, a better understanding of the values of nature-based solutions, and greater attention to attracting investments from the private sector are all required to realise the potential of sustainable land management at landscape scales.

The economic evidence presented in this report is clear: the benefits of acting on drought prevention far outweigh the costs. Every dollar invested in nature-based solutions can bring up to US $27 in return to societies and economies. Scaling up implementation and investments in sustainable land management and nature-based solutions for drought resilience makes financial and economic sense. Most nature-based solutions are profitable even without considering their direct drought benefits making them a "no-regrets" solution in drought contexts.

The United Nations Convention to Combat Desertification (UNCCD), Economics of Land Degradation (ELD) Initiative, and United Nations University Institute for Water, Environment and Health (UNU-INWEH) have collaborated to produce this report. Calling for a shift from a reactive approach to a more proactive approach in favour of drought preparedness and resilience, this report advocates for investment in proactive drought management and nature-based solutions to reduce drought risks, build community resilience, and advance towards sustainable development.

There is an urgent need to develop measures to build resilience and avert drought impacts before they strike. This report offers important insight into nature-based solutions and proposes a strong basis for investing in proactive drought management to reduce drought and its impacts globally. We urge you to read this report and join us in taking the measures needed to put these measures into place to better prepare for drought, support drought resilience, and sustainably manage our land. Our survival depends on it.

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Executive summary

Drought is one of the costliest and most pressing threats to societies and economies affecting every continent around the globe and particularly drylands. Already today, droughts affect over 1.8 billion people annually hitting especially women and children and the world's poorest and most vulnerable people. The use of nature-based solutions (NbS) to address drought and challenges such as climate change and loss of biodiversity is gaining traction. NbS involve restoring and conserving nature to address societal challenges and play a critical role in building drought resilience: to prepare, respond and recover, to increase resilience and reduce vulnerability and exposure.

This report makes the economic case for nature-based solutions as part of a proactive approach to drought management. It presents evidence for NbS costs and benefits to show that proaction pays and elaborates transformational pathways to mobilise both public and private investment, strengthen necessary enabling environments and create scalable business cases for NbS to drought. The report supports UNCCD Decision 23/COP15 to examine and identify the financing needs and opportunities for drought risk reduction and resilience-building activities, including partnerships with the private sector.

Underestimated costs and missed opportunities

Global economic losses due to droughts between 2000 and 2019 have been reported at US$128 billion, but this is likely a great underestimate. The UNCCD estimates the cost of drought damages is US$307 billion per year. Costs can escalate due to knock-on effects of drought on different sectors – such as energy and health – and the wider economy. Drought costs are therefore underestimated due to a failure to account for the multidimensional and multiscale effects on society and the environment.

In contrast, the estimated costs of implementing measures as set out by countries in their national drought and related plans amount to an estimated US$210 billion between 2016 and 2030. A nature-positive economy could generate up to US$10.1 trillion annually in business value and create up to 395 million jobs by 2030 and tripling investment in nature-based solutions up to 2030 could generate 20 million additional jobs.

The role of human agency in creating or exacerbating drought is also greatly underestimated. Growing recognition of anthropogenic droughts – for example those caused by ecosystem degradation and changes to micro-climate conditions – is creating new possibilities for human intervention to reduce the severity and impact of drought. NbS to drought are a way to alleviate anthropogenic drought while conferring resilience to meteorological droughts. There is significant and untapped potential for upscaling and implementation.

The area of opportunity for NbS to address drought risks has been estimated at more than 2.5 billion ha globally – equivalent to the land size of the United States, China and Brazil.

Nature-based solutions to drought

NbS to drought involve restoring the hydrological and ecological functions of ecosystems and the health of soils to enhance water storage and supply. When land is maintained in good condition it can generate numerous ecosystem services, including provision of food, fiber, feed, and biomass as well as supporting, regulating and cultural services (e.g., water supply and carbon sequestration). Many NbS to drought are recognised as sustainable land management practices by the UNCCD.

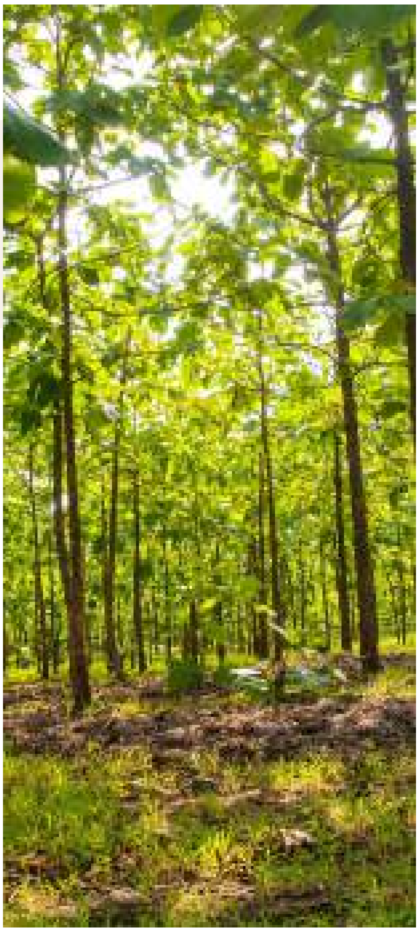
NbS to drought include a variety of water and land management, restoration and conservation options including reforestation, agricultural best-management practices, grazing management, habitat protection, water and water ecosystems management as well as urban green and green infrastructure. NbS to drought fall into two broad groups: Soil solutions and landscape solutions. Soil solutions enhance soil health and soil functions through which local ecosystem services will be maintained or restored, for example enhancing the infiltration of water, increasing soil moisture retention, and reducing runoff. Landscape solutions focus primarily on connectivity and land cover, although many interventions will provide both soil and landscape solutions. Landscape solutions also include empowered communities.

In most cases, NbS to drought will be implemented by land users at a local level, although this could be carried out on a large-geographic scale by large numbers of individual land users, adding up to a significant landscape-scale impact. In some cases, nature-based solutions may be more effective when paired with non-NbS portfolio elements. These characteristics present unique challenges for planning, coordination, and monitoring, and present questions over the role of public and private investments.

The benefits of nature-based solutions for drought resilience and beyond

Nature-based solutions to drought offer no regret options because they generate a triple dividend and two of the dividends can be enjoyed regardless of the occurrence of drought:

1. Reducing drought loss and damage from drought.
2. Increasing the income of land and water users and unlocking development potential.
3. Generating broader co-benefits for climate, nature and sustainable development.



When well designed and adapted to local contexts the vast majority of NbS are economically viable. That means when taking into account overall costs and benefits, NbS deliver positive economic and societal returns for every dollar invested in the range of US$1.4 to up to US$27 typically within 6 or 7 years. Only few examples show smaller or even negative returns.

NbS bring direct benefits for drought resilience in that they reduce damage costs and generally perform better when droughts occur. In the absence of systematic analysis, evidence to support this remains largely on a conceptual level and anecdotal. Some cases suggest that NbS can reduce economic costs of droughts by up to 30%. A large array of country examples substantiates that NbS provide higher, more diversified, and resilient incomes and yields to farmers compared to conventional agro-systems.

Building resilience yields significant and tangible benefits even if a disaster does not happen for many years. NbS bring both economic benefits to drought prone areas and further societal benefits such as carbon sequestration and climate change mitigation, and recovery of biodiversity. NbS can boost agricultural productivity leading to higher yields and better incomes for land users and can contribute to economic growth and employment. Other co-benefits include improvements to water quality, human health and well-being, food and timber production, and recreation. NbS to drought offer a major opportunity to unlock economic growth and build resilience in regions that have become locked into cycles of drought.

Evaluating this array of co-benefits presents a significant challenge to economists. Cost-benefit analysis is an important tool for making the business case for investing in NbS to drought, but analyses are hampered by uncertainties over the benefits, maturation time and cost barriers of NbS, challenges in monetising benefits, and geographic and temporal extrapolations of benefits.

Scaling up nature-based solutions to drought

Scaling up NbS to drought requires creating a favourable enabling environment. Five policy enablers are promising transformative levers: i) rights and rules; ii) responsibilities, iii) incentives, iv) investments, and v) information.

NbS require investment in establishing institutions and building the capacities of those institutions and the people they serve. Proactive drought management requires NbS to be embedded in national drought management strategies and is likely to require transformation of government institutions across several sectors, including the agriculture sector. NbS often demand a higher degree of collaboration and participation, because solutions are delivered on the ground by a large number of resource users. This requires significant local input to design and implementation of solutions which in turn requires building the capacities of land and water managers and their institutions.

Land tenure and water rights are critical factors that affect the agency of land and water users. Land tenure provides the legal basis for enabling better land management and to allow access to resources (e.g. credit and finance) and participation in schemes (e.g. carbon projects). Strengthening local governance is also essential for sustainable land management and the successful implementation and establishment of NbS. Governance can be strengthened by ensuring adequate legal frameworks are established, strengthening property and land rights, empowering local institutions and governance systems, and promoting participatory and integrated planning.

Countries can draw on international commitments to transform drought risks and increase resilience, including the UNCCD with its unique mandate to mitigate the negative effects of drought. The UNFCCC prioritises investment in climate services to predict and adapt to future climate-induced drought risks and to attribute damage and losses to climate changes that have already occurred. Other global policy commitment can be found under the Other global policy commitments can be found among others under the UN CBD as well as the UNDRR and the Sendai Framework for Disaster Risk Reduction.

National policy can be developed to enhance regulation, planning and other institutional arrangements to enable uptake of NbS as proactive drought management measures. Droughts have a multitude of impacts across sectors and drought management requires a society wide effort involving national governments, local governments, businesses, academia, farmers, civil society, and households.

More than 70 countries already have or are in the process of developing national drought plans under the UNCCD Drought Initiative. These plans align with the three pillars of national drought policy and planning as published by the UNCCD: monitoring and early warning, vulnerability and risk assessments, and risk mitigation measures. Nature-based solutions can be a significant part of the third of these pillars and offer the best option for countries to lift themselves out of long-term drought cycles. The progress in developing these drought management strategies underscores the urgency for addressing the financing gap by developing appropriate investment strategies.

Financing nature-based solutions to drought

Investments in drought risk management lie along a spectrum, with traditional investors at one end driven solely by financial returns and philanthropists at the other end who may not wish for any return on their capital. In the middle of this spectrum are impact investors who accept reduced financial reward in return for greater environmental and social impacts. It is this middle ground where companies that balance financial returns with impacts can out-perform companies that remain at the pure financial return end of the spectrum.

Private investors may be deterred from drought-affected areas and countries due to high transaction costs, particularly in remote areas, and a lack of mutual understanding of major obstacles that need addressing.

Promising innovations in the evolving landscape of nature-based solutions include:

- Nature markets reflect increasing applications of voluntary carbon and biodiversity credits with the maturing of the underlying regulatory environment for such schemes.
- More than 100 countries are developing compensation or offsetting policies with regards to nature-based solutions, biodiversity and land, and as part of the mitigation hierarchy.
- Payments for ecosystems services are a proven policy instrument and are a standard repertoire of initiatives around the world.
- Repurposing of harmful subsidies is taking place in several countries to move incentives from production to environmental outcomes.
- Internationally agreed and standardised accounting, monitoring, disclosure and reporting standards are increasing, including the Taskforce on Nature-related Financial Disclosure, the System of Environmental-Economic Accounting – Ecosystem Accounting statistical standard, the EU Corporate Sustainability Reporting Directive and Taxonomy and others.

Finance for proactive drought management is inevitably scarce and the UNCCD estimates that some US$210 billion of investment is required for drought related measures between 2016 and 2030. Investments in drought are currently dominated by the public sector (86%) with most of these funds (80%) allocated to agriculture.

Public-private partnerships offer ways to overcome the challenges of investing in NbS to drought, for example by absorbing costs and sharing risks. Cost-benefit analysis should be used to justify allocation of scarce public funds, and the triple dividend of NbS to drought is a compelling argument. However, countries may struggle to account fully for the costs and benefits of NbS to drought and in most cases data collection is inadequate for tracking drought outcomes. Cost-benefit analysis can therefore be imperfect, but it nevertheless provides a rational framework for evaluation. It is recommended to strengthen methodologies for cost-benefit analysis of nature-based solutions to drought.

Attention is increasingly paid to public-private-philanthropic partnerships for transformative changes in the use of nature. Financial instruments used to invest in NbS include blended finance, water funds established by utility companies and drinks distributors, Payments for Environmental Services including services for buffering drought risks (e.g. groundwater recharge, storage & treatment). Product labelling, certification systems, brand recognition and traceability are also options for securing premiums for sustainably sourced goods that have potential application in drought affected areas.

Main messages and recommendations of the report:

1. Nature-based solutions to drought include many tried-and-tested sustainable land management practices that offer no-regret options for strengthening resilience
2. Investing in land and water management to reduce drought risk makes economic sense
3. Building drought resilience through nature-based solutions requires investment in building capacities of people and institutions
4. Nature-based solutions to drought may require investment to be leveraged through public-private partnerships
5. Investments can be enabled by strengthening evidence and monitoring of the true impact of nature-based solutions
6. Cost-benefit analysis of nature-based solutions to drought need to be further strengthened with improved methodologies and data collection

Purpose of the report

This report presents the case for more proactive drought management and the use of nature-based solutions to increase investments from the public and private sector for reducing drought risks while improving conditions for long-term economic development and ecosystems. The report explores the triple dividends of resilience-building – avoided losses, economic benefits and social and environmental benefits – and how they can reverse the destructive spiral of drought (Heubaum et al., 2022; UNCCD, 2023). The report supports UNCCD Decision 23/COP15 to examine and identify financing needs and opportunities for drought risk reduction and resilience-building activities, including partnerships with the private sector (UNCCD, 2004).

Introduction

Droughts affect over 1.8 billion people annually, causing severe damage and disruptions to economies, societies, and civilisations (UNCCD, 2023). Drought risks and impacts interact with other powerful drivers of socio-economic and ecological change, both deepening social conflicts and insecurity or enabling social institution-building and innovation. In just the last 3 years, extreme droughts have affected every continent of the globe (Rossi et al., 2023). Water deficits are predicted to increase markedly over the next 20 years with currently about 60-75% of people globally experiencing some form of water stress every year (Pek and Salman, 2023; Zaveri et al., 2023). Yet the World Economic Forum highlights water as a key enabler of a transition to a greener economy emphasising its importance for development (WEF, 2022).

The effects of drought spread geographically and through time to affect economies and increase security risks and out migration. For example, in Panama drought around the Gatun Lake has resulted in a 33% reduction in the number of daily ship trips. This reduces revenues to Panama from canal operations, normally equal to 6% of its GDP or $2.5 billion per year, raises transport costs for goods globally and disrupts shipping and logistics that increase costs to consumers everywhere (McKinsey & Company, 2023b).

Global economic losses due to droughts between 2000 and 2019 are reported at US$128 billion (CRED, UNDRR, 2020). This is likely a stark underestimate of the real costs. The UNCCD estimates the costs of drought damages to amount to US$307 billion per year (UNCCD, 2024). In contrast, the estimated costs of implementing measures as set out by countries in their national drought and related plans amount to only US$ 210 billion between 2016 and 2030 (UNCCD, 2024). Costs increase due to knock-on effects that occur as value chains and different sectors are affected. For example, a drought may cause power plants to shut down if there is inadequate water in rivers to enable hydropower generation or cooling (Toreti et al., 2024; WWDR, 2024) affecting other economic sectors.

Drought including heavy weather events, has been considered mainly from meteorological, agricultural, hydrological, socioeconomic or ecological aspects. However, fully understanding the costs of drought, and therefore the benefits of reducing drought risks, is constrained by inadequate awareness of the anthropogenic aspects of drought. Anthropogenic droughts are drought events caused or intensified by human activities. They include drought from degradation of ecosystems and changes to micro-climate conditions due to land and water management. Anthropogenic drought occurs when the water supply-demand gap is amplified leading to water bankruptcy and it will become a growing global concern as increasing water demands are compounded by climate change and environmental degradation. Anthropogenic factors are becoming so severe that many regions of the world face perpetual water shortage and effectively face drought even during wet years while unreliable heavy weather events are becoming more frequent (AghaKouchak et al., 2021; Madani & Shafiee-Jood, 2020).

Drought costs are underestimated due to a lack of a systemic view of the multidimensional and multiscale aspects and effects on the environment and society. For example, droughts increase the likelihood of heat stress and wildfires which are usually omitted in drought cost accounting. Drought can reduce water quality affecting human health and the costs are rarely quantified. More broadly anthropogenic drought is a relatively neglected area and yet probably has the greatest economic effects on society and the environment as countries develop and as the damaging effects of climate change increase.

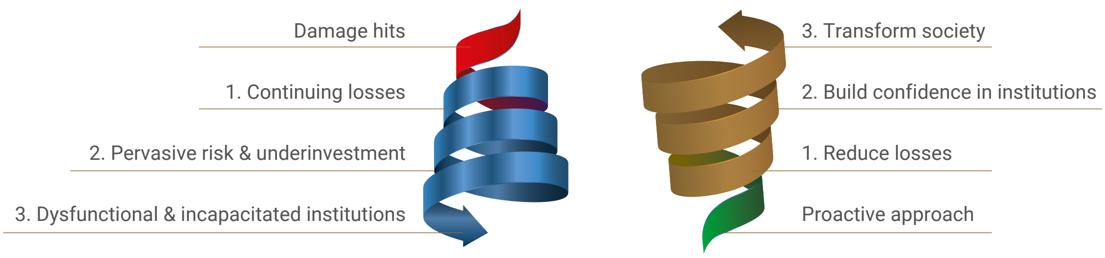
The UNCCD has advocated a shift from a reactive approach to more proactive measures for drought preparedness (Figure 1) (UNCCD, 2022). These include drought early warning systems, measures to remediate drought risks, such as scaling up sustainable land management practices that reduce run off, increase infiltration, and conserve soil moisture. Changes in sustainable land management (SLM[1]) are particularly important for agricultural production systems that bear the brunt of drought effects (GFDRR, 2014). Better water governance and water infrastructure and an enabling policy environment for public-private sector partnerships and investments in proactive drought risk management are also needed.

Even though there is now widespread recognition of the needs for better drought preparedness and risk assessments (UNCCD, 2022), there are still major limitations to understanding, assessing and responding to drought risk and enormous gaps in the required funding (UNEP/WEF/ELD, 2022, 2023; UNCCD, 2024). Few studies on SLM establish links to drought risks and resilience building. In studies of drought risk, details of the socioeconomic factors of meteorological, agricultural or hydrological droughts are ill defined or even not addressed (Hagenlocher et al., 2019). Longer term effects of drought often exceed short term effects (GFDRR, 2014; Wilkinson & King-Okumu, 2019) and tend to be overlooked. Global, regional and national economic decision-makers need to have a clearer understanding of the multidimensional (including the multistakeholder and cultural diversity) aspects involved. Even though two new funds address the funding gap, namely a Loss and Damage Fund for the UNFCCC, and a Global Biodiversity Framework Fund, neither of these offers a proactive agenda on drought.

The concept of nature-based solutions (NbS) has gained popularity in recent years to describe a suite of tried-and-tested actions that restore and protect nature to deliver societal benefits (see later sections and Box 1). There is increasing interest in the use of NbS to address drought and challenges such as climate change and loss of biodiversity (UNEP, 2020; UNEP/WEF/ELD. 2022). One of the reasons NbS are attractive is the range of co-benefits they can deliver—such as biodiversity conservation, climate change mitigation and adaptation, and risk reduction—but this creates a challenge for effectively accounting for impacts.

This report examines the business case for investing in NbS for drought management. Cost-benefit and sensitivity analyses of interventions should consider different degrees of drought exposure and vulnerability and examine the costs of benefits of measures that reduce these factors, and co-benefits (such as increasing soil carbon stocks and biodiversity). Thus, building scenarios into the cost-benefit analyses is a step forward. Anticipating future effects of drought requires new global development pathways and institutional arrangements together with integrated assessment models that can capture more of the social, environmental and economic impacts of drought (AghaKouchak et al., 2021).

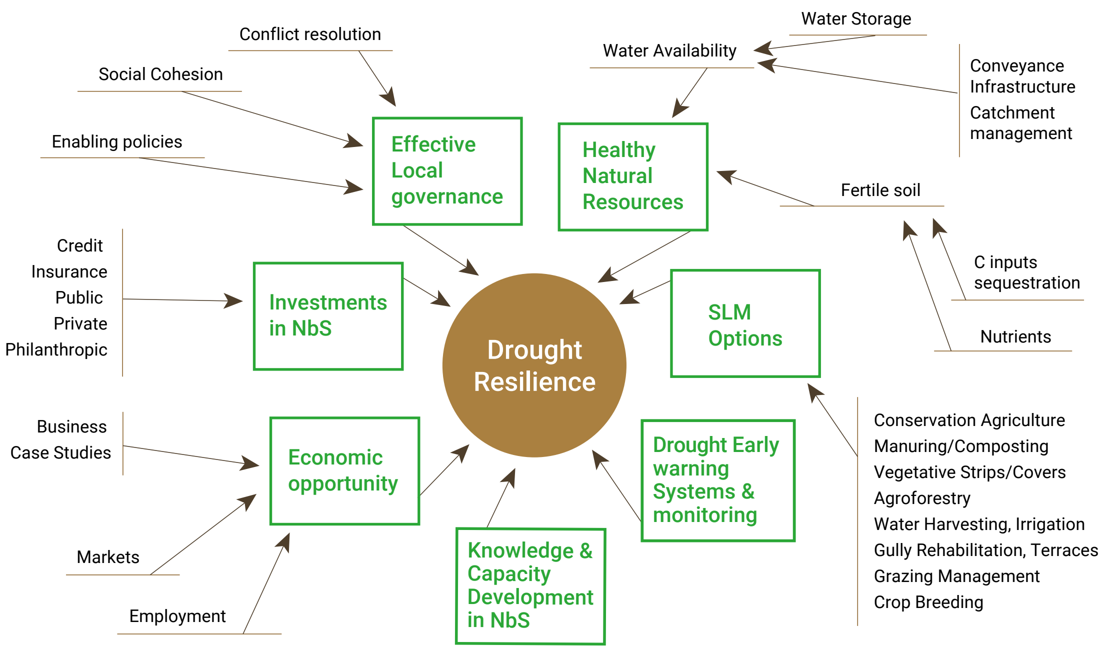
FIGURE 1 **Transforming the effects of droughts through proactive approach** (authors' own elaboration)



There is an abundance of schematics that show that droughts are complex and can affect every part of a society, economy, and ecosystem (Gerber & Mirzabaev, 2017; Reichhuber et al., 2019; Rossi et al., 2023; Toreti et al., 2024). A simplified version of these schemes that focuses on drought resilience guides this report (Figure 2). The main factors (boxes with green text) considered include; local governance (policies, social cohesion, community cooperation and conflict resolution); investments and employment opportunities, knowledge and capacity development of all actors. Better water management and other natural resources including fertile soils can ensure increased productivity and sustainability of land management options that include NbS. Drought early warning systems and monitoring are required for drought preparedness but are not considered in detail in this report. Although not shown in Figure 2 for simplicity, these factors are all interlinked.

Drought resilience is commonly described as the ability of a community or ecosystem to prepare for, respond to, and recover from drought conditions. Drought resilience has been defined as "the capacity of systems (ranging from national, local or household economies to businesses and their supply chains) to anticipate, absorb or buffer losses, and to recover" (Rey et al., 2017). As we reiterate below, NbS to drought can both enhance readiness to respond to drought and pre-empt drought by enhancing resilience, reducing exposure, and remediating drought by reducing the severity of the hazard.

FIGURE 2 **Factors to achieve proactive drought risk management** (authors' own elaboration)



Chapter 1: Transformational pathways for proactive drought risk management

The transformation from a reactive to a proactive approach to drought risk management needs a concerted effort across interlinked factors in Figure 2.The chapter highlights that NbS to drought include many sustainable land management practices (SLM) that are already advocated for drought preparedness along with the co-beneficial factors related to loss of biodiversity and adaptation to, and mitigation of, climate change. The chapter discusses how an enabling long-term policy environment is required that can build on national plans for drought risk management and that can catalyse new 21st century institutional arrangements that involve policy makers, land users, civil society, indigenous people and the private sector (UNDP, 2024). The chapter also discusses new modes of financing for public-private-philanthropic partnerships that can fill the funding gap for the implementation of NbS and for the development of new institutional models and policy and regulatory frameworks. This chapter analyses and presents options to achieve these transformations from these three areas.

1.1 Nature-based solutions and sustainable land management

The concept of nature-based solutions (NbS) has emerged in recent years to address the interdependency of the major challenges of the Anthropocene: mitigating and adapting to climate change, protecting biodiversity and ensuring human well-being (see the definition in Box 1). NbS are actions that work with nature to address societal challenges. Their attraction lies in the delivery of multiple co-benefits, which can include disaster risk reduction, increased resilience, sustainable economic and social development, human and mental health, food security, and water security (Dunlop et al., 2024).

Nature-based solutions to drought largely revolve around restoring the hydrological and ecological functions of ecosystems to enhance water storage and supply. This requires a shift towards greater consideration of ecological drought and the impact of changing water supply and demand on vulnerability to drought (Crausbay et al., 2017). NbS for drought can include catchment or watershed management, water harvesting, agroecology and other approaches discussed in greater detail below (García-Herrero et al., 2022).

Box 1: **Nature-based solutions defined**

Nature-based solutions are defined as 'actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits' (United Nations, 2022).

The United Nations recognises that nature-based solutions:

a) Respect social and environmental safeguards, in line with the three Rio conventions, including such safeguards for local communities and indigenous peoples;

b) Can be implemented in accordance with local, national and regional circumstances, consistent with the 2030 Agenda for Sustainable Development, and can be managed adaptively;

c) Are among the actions that play an essential role in the overall global effort to achieve the Sustainable Development Goals, including by effectively and efficiently addressing major social, economic and environmental challenges;

d) Can help to stimulate sustainable innovation and scientific research.

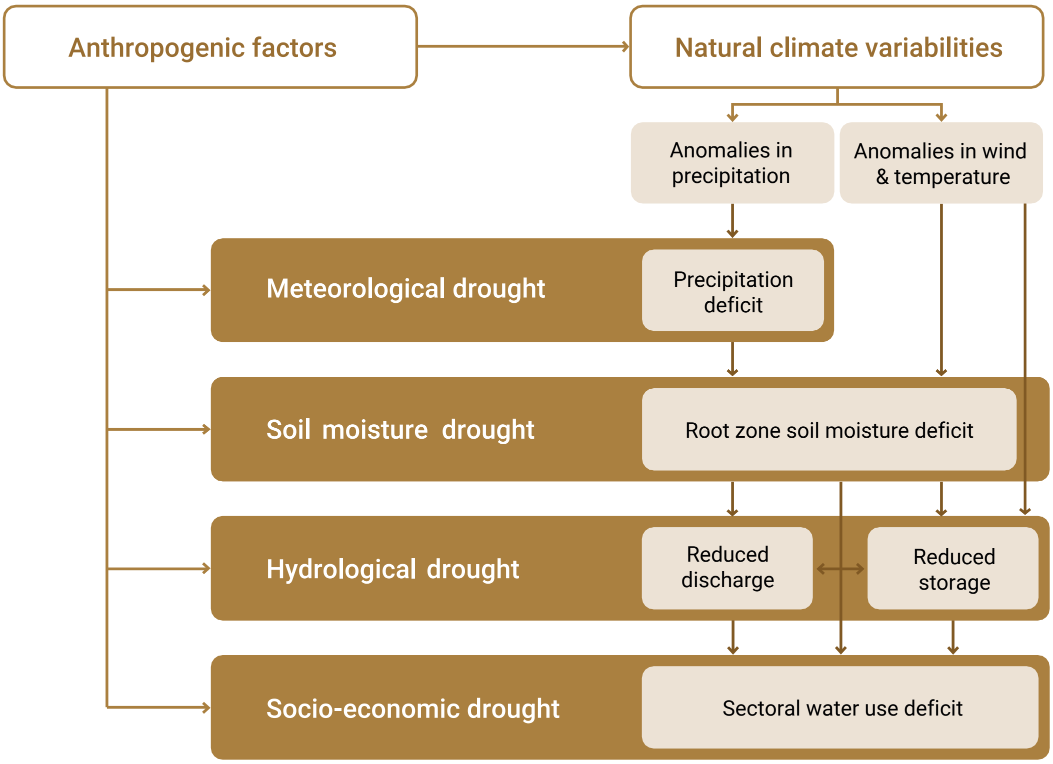
Sustainable Land Management (SLM) is central to the purpose of the UNCCD and is defined as 'the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions'(Critchley et al., 2021). Many SLM practices increase soil organic carbon, elevate soil moisture, or repair hydrologic functions and can be considered nature-based solutions to Drought. Throughout this report the term "Nature-based Solutions to drought" primarily implies sustainable land management options.

1.1.1 Drought: Human causes, human solutions

Despite the frequent reference to drought as 'natural events', anthropogenic drivers of drought are well recognised in the literature and by international institutions. The Intergovernmental Panel on Climate Change recognises that human influence has increased the frequency and intensity of droughts at the global and local scale. These influences include climate change, land cover change, and depletion of water reserves (Reichhuber et al., 2022). Recent droughts in California, Spain, Brazil, China and southern Africa have been attributed to human activities, including urbanisation, deforestation, surface water and groundwater overdraft, and human-induced climate change (AghaKouchak et al., 2021).

Anthropogenic drought is broadly defined as drought events caused or intensified by human activities (see Figure 3). It is determined by the combination of natural water variability, climate change, human decisions and activities, and altered micro-climate conditions due to changes in land and water management. Anthropogenic drought amplifies the gap between water supply and demand and is increasingly leading to water bankruptcy around the world. Many regions currently face perpetual water shortage due to the magnitude and extent of anthropogenic alteration of the hydrologic cycle and the imbalance between water supply and demand such that water scarcity can exist even during wet years (AghaKouchak et al., 2021).

FIGURE 3 **The relationship between natural and anthropogenic drivers of drought and hydrological processes** (Source: Magero et al., 2024)



Addressing the drivers of anthropogenic drought expands the range of options that are available for pro-actively managing drought and has major implications for drought management. The Drought Resilience, Adaptation and Management Policy (DRAMP) Framework recognises the urgent need for drought management policies that mitigate drought impacts by combating land degradation and desertification and implementing principles of integrated water resource management. A pro-active approach to increasing drought resilience is centred on better management of ecosystems and water resources (Crossman, 2019). In addition to the usual elements of disaster risk reduction—to prepare, respond and recover, to increase resilience and reduce vulnerability and exposure—awareness of anthropogenic droughts creates opportunities to transform drought processes by reducing the underlying drivers and remediating drought.

Proactive drought management measures aim to mitigate drought risks and to minimise the scale and severity of drought impacts. They may enhance readiness to respond to drought or pre-empt drought by enhancing resilience, reducing exposure, and remediating drought by reducing the severity of the hazard. For example, proactive drought management includes measures to mitigate the potential impacts when the onset of drought is declared, such as early warning systems, destocking of livestock, introducing micro credit and crop insurance schemes, and projecting food deficits (Cuevas et al., 2024).

Nature-based solutions to drought transform drought risks by alleviating their effects on ecosystems and communities, generating co-benefits for social and economic development. For example, measures to restore local and upstream ecosystem health contribute directly to green water functioning and climate resilience (Zaveri et al., 2023). Other NbS for drought measures include farming practices like conservation and regenerative agriculture, agroforestry, and grazing management: practices which reduce drought risk by reducing the risk of water deficits as well as reducing vulnerability to drought. They also include soil fertility management, water harvesting, climate-smart irrigation systems, construction of post-harvest facilities, gully rehabilitation, terracing, and drought tolerant crop breeding (Cuevas et al., 2024; Davies et al., 2016).

1.1.2 The benefits of NbS to drought: A conceptual introduction

Well-functioning land generates several ecosystem services, including provision of food, fiber, feed, and biomass as well as supporting, regulating (e.g., water supply and carbon sequestration), cultural and spiritual services. Measures to reverse land degradation through sustainable land management (SLM) have been shown to have considerably higher economic, environmental and social returns than the cost of inaction (Mirzabaev et al., 2015).

Table 1 illustrates the breadth of benefits that can be derived from NbS, which include production of trees and pasture, carbon sequestration and storage, provision of habitat and species diversity, increased water availability and quality, water storage, and soil conservation among others.

TABLE 1 Categories of nature-based solutions to droughts (van Zanten et al., 2023; Vigerstol et al., 2023)

NbS to drought	Processes & services	Benefits
Upland forest re-vegetation	Regulating water storage and flow, affecting evapotranspiration, shading, recharging groundwater	Productive services from trees, Grazing, Habitat, Soil conservation Increase water availability & quality
Habitat protection (including protected areas)	Regulating water storage and flow, affecting evapotranspiration, shading, recharging groundwater	Productive services from trees, Grazing, Habitat, Soil conservation Increase water availability & quality
Terraced slope	Enhancing infiltration, affecting evapotranspiration, storing water	Crop production, Soil conservation Increase water storage, availability & quality
River & floodplain restoration	Enhancing Infiltration, storing water, soil formation	Fish & other animals, water storage and supplies, water quality, trapping nutrients
Grasslands management	Enhancing Infiltration, storing water, grazing	Livestock, birds, insects & other animals, water storage and supplies, water quality,
Agriculture (including regenerative agriculture, agroforestry, integrated crop-livestock soil fertility management & others)	Enhancing infiltration, affecting evapotranspiration, storing water, feeding livestock	Crop production, Soil conservation Increase water storage, availability & quality
Inland wetlands (conserve / restore)	Recharging Groundwater, habitat recreation	Increase water storage, availability & quality, wildlife, amenity
Urban green	Affecting evapotranspiration, shading, infiltration, storing water	Increase water storage, availability & quality, wildlife, amenity
Recharge structures & water harvesting	Recharging, Groundwater, habitat recreation	Increase water storage, availability & quality,
Ponds, lake & small waterbodies	Storing and distributing water, flood prevention	Increase water storage, availability & quality,

NbS may consist of portfolios of options including pre and post drought measures. These include a variety of water supply sources and water and land management options, a variety of ways of managing water and land uses, managing and restoring land to conserve water, reductions in water use, and incentives and institutions to help coordinate drought activities among individuals and groups with actions before (preparation), during, and after drought (recovery and adaptation). Portfolios of options can be developed by individual land and water users and managers and local and regional groups of users and managers, as well as governments. Typically, supply and demand management actions are carried out by a variety of groups and individuals before, during, and after a drought. A series of institutions and incentives are usually needed to convene people and coordinate these actions for the long run, described here as "working together". "Working together" is usually the hardest and most important aspect of drought management and drought preparation and is particularly critical for successful NbS applications.

These options can ensure that NbS measures remain relevant during a drought crisis and can help to overcome the challenge of halting and restarting drought preparedness each time a drought strikes. There may be many more pre-drought preparation options than actions available during or after a drought. Pre-drought preparations reduce (and sometimes eliminate) drought impacts, enhance management options during and after a drought, and increase participation in drought management overall (see Table 2).

Nature-based solutions, which would include many SLM approaches, are similarly credited with generating an array of co-benefits. Sustainable land management practices that would be considered NbS fall broadly into two groups: first we need to look at a landscape approach, while as an outcome soil and water solutions will follow. Soil solutions enhance soil health and soil functions through which local ecosystem functions will be maintained or restored, for example enhancing the infiltration of water, increasing soil moisture retention, and reducing runoff. Landscape solutions focus primarily on restoring biodiversity, ecological connectivity and green cover, although some interventions may provide both soil and landscape solutions (Keesstra et al., 2018).

The multiplicity of co-benefits of NbS make them attractive measures for many landscape managers but can also create barriers to understanding and adoption (or protection in the case of traditional SLM practices that are being lost). While the co-benefits may be enjoyed directly by farmers and pastoralists, the pathway from investment to returns on investment for 3rd parties may be challenging to identify. As a result, investments in land may be biased towards investment in single values that risk eroding the co-benefits (Larbodière et al., 2020).

The advantages of a proactive measure are amplified if it addresses the impacts of drought and additional development needs, such as agricultural productivity (Cuevas et al., 2024; Rossi et al., 2023). Many SLM approaches deliver drought risk reduction either as a primary goal or as a secondary benefit or co-benefit. The nature-based solutions discourse refers to such approaches as "no regret options".

Investments in drought risk reduction are sometimes dismissed by decision-makers as a gamble that only pays off in the event of a disaster, yet the evidence shows that building resilience yields significant and tangible benefits even if a disaster does not happen for many years. Support for drought risk reduction can be strengthened by highlighting the range of benefits described as a triple dividend of resilience (UNCCD, 2023):

1. avoiding losses, including sense of purpose, social, natural and financial, when disasters strike,
2. unlocking development potential by stimulating economic activity by reducing disaster-related investment risks, and
3. social, environmental and economic co-benefits associated with investments.

The second and third of these dividends can be achieved even in the absence of disasters and can help to strengthen the case for investment (Tanner et al., 2016).

TABLE 2 **Nature-based (soft sand background) and traditional elements of drought management portfolios** (expanding on Lund et al., 2018)

Action type	Pre-drought preparations	Drought responses	Post-drought recovery and adaptation
Supply management	Understanding / mapping ecosystems of the area Land management of forests, cropping, land use, rangelands & farming to increase water infiltration, "fertility", soil carbon, and control erosion Cisterns Floodwater spreading ,recharge, & irrigation Increase soil water storage capacity Groundwater recharge Seasonal and episodic wetlands Landscape to retain water & soil moisture	Employ reserve supplies and storage from nature-based solutions	Land management: forest density management and expansion Groundwater recharge – seasonal and episodic wetlands Landscape recovery
	Traditional water storage, conveyance, and treatment infrastructure construction and maintenance Wells, Qanats Regional integration	Drought operations of infrastructure Employ traditional reserve supply, conveyance, and storage elements	Traditional water storage, conveyance, & treatment infrastructure Post-drought recharge Post-drought operation assessment
Demand management	Prevent overgrazing Reduce landscape evapotranspiration Reforestation and ecosystem restoration Water use efficiency Prepare migration responses	Reduce grazing Move or sell livestock Market information & livestock transportation Reduce illegal deforestation	Prevent overgrazing Replenish livestock herds Pasture and habitat restoration
	Long-term water use reductions and water demand management Equitable groundwater use management	Additional drought water use reductions and sharing	Damage assessments and adaptive water use plans
Working together* (NbS and traditional)	Local leadership Understanding cultural, spiritual settings and empowered community structures Water sharing agreements & markets Drought management plans Water & drought finance Drought insurance Accountability, education Financial, regulatory, & policy actions for sustainable mgmt. Research drought action & portfolio performance Reduce conflicts & enforce land management plans	Empowered Community structures Implement drought management coordination. Drought water sharing agreements, markets, compensation Financial aid and water markets Accountability	Empowered community structures Overall drought post-mortem Revise and improve drought management plans and water sharing arrangements Finance for recovery and improved preparation

* "Working together" actions (blue background) apply to both traditional and nature-based solutions.

TABLE 3 **The triple dividend for SLM investments in resilience to drought**
(King-Okumu, 2019; Heubaum et al., 2022; UNCCD, 2023; Tanner et al., 2016)

The First Dividend of Resilience **Avoiding losses**	The Second Dividend of Resilience **Economic benefits**	The Third Dividend of Resilience **Social and environmental benefits**
	Examples	
Saving lives and reducing people affected: Between 2002 and 2021, droughts affected more than 1.4 billion people, causing the death of nearly 21,000 individuals and (CRED/ UNDRR, 2023) Reducing damages to infrastructure and assets and losses: triggered US$170 billion in economic losses (see also knock-on effects) Reducing losses to economies Saving livelihoods and jobs: Small informal firms lose 35% of their sales for every additional water outage (Damania, 2020)	Increased business and capital investment Household and agricultural productivity dividends Land value dividends from protective infrastructure Fiscal stability and future credit including insurance schemes to protect farmers	Co-benefits of DRM investments Economic co-benefits: e.g. water storage pond also enables fish production, irrigation increases productivity Cultural and social co-benefits: e.g. increased transparency and social cohesion, governance Ecosystem-based co-benefits: e.g. watershed protection, climate change mitigation, biodiversity conservation Transport co-benefits: maintenance of waterways and flows to hydropower Agricultural co-benefits: less soil erosion and deforestation, and an increase in socioeconomic status for farmers

Decision makers face considerable challenges in estimating the benefits of drought risk reduction measures, particularly those proactive and pre-emptive measures that may offer the greatest value. At the same time, decision makers also face a challenge in estimating the true cost of drought, which are routinely underestimated. It is well-recognised that the long-term effects of drought are responsible for the majority of the cost (GFDRR, 2014). Comparison of historical data on the performance of the main macroeconomic aggregates of the country versus the most recent forecasts using Social Accounting Matrices (SAM) has been recommended for macro-economic assessment in Post Disaster Needs Assessments (GFDRR, 2014; UNECLAC, 2003).

Box 2: **The costs of drought**

According to officially reported damage costs, global economic losses due to droughts between 2000 and 2019 were in the order of US$128 billion (CRED, UNDRR, 2020). This is very likely a stark underestimate of the real costs since not all damage costs are reported and indirect, longer term, less visible, and knock-on impacts are left out of the equation.

In the US and EU alone, annual losses in the period 1980-2019 are calculated at $6.4 billion for the US (only events with losses greater than $1 billion are reported) and €9 billion for the EU. The 2013-2015 drought in Brazil caused losses of about $5 billion. In Argentina during the 2008–2009, 2011–2012 and 2017–2018 agricultural seasons, the country suffered sharp declines in soybean and maize production with total direct losses of at least $12 billion.

The 2010-2011 drought in the Horn of Africa was estimated to have caused up to 250,000 deaths and to have left over 13 million people dependent on humanitarian aid. In response, some $1.3 billion was spent on drought-relief measures (UNDRR, 2021). In 2023 alone, the southern United States, Central America, Argentina, Uruguay, Peru and Brazil were affected by widespread drought conditions, which led to a 3% loss in gross domestic product (GDP) in Argentina and the lowest levels ever observed in the Amazon River and Lake Titicaca (WMO, 2024).

The UNCCD likely gives a more realistic picture in estimating the global costs of drought damages to amount to a staggering US$307 billion per year (UNCCD, 2024). The overall message is clear: The costs of inaction against drought are substantial.

The Network for Greening the Financial System warns of severe risks for financial markets and banking systems stemming from physical risks of climate change and particularly from droughts and heatwaves, which account for more than 75% of risks. Losses from overall physical risks of climate change could amount to almost 15% of GDP until 2050 with current policies in place. Even a full implementation of current NDC commitments would lead to losses of almost 12% of GDP (NGFS, 2024). Previous modelling calculated a lower risk but differentiated for individual hazards with droughts accounting for more than 4% of GDP loss until 2050. With newer modelling this estimate would be significatenlly higher (NGFS, 2024).

Increased drought and aridity is likely to also have a significant impact on internal migration, particularly in the hyper-arid and arid areas of Southern Europe, South Asia, Africa and the Middle East and South America (Hoffmann et al., 2024).

Most available evaluations have been funded by disaster-oriented programming and have relatively short-term time horizons and use only rapid appraisal techniques, since generally the timeframes of humanitarian projects are too short to apply longer-term evaluation approaches (King-Okumu, 2017; Wilkinson & King-Okumu, 2019). Post disaster needs assessment methods typically use past data and future projections of the following variables over a 5-year period:

- Gross domestic product (GDP) and value-added output ratios
- Public finances / fiscal sector position
- Balance of payments (BoP) on external debt

Information on consumer prices and exchange rates would be needed over the same period (Zaveri et al., 2023). Considering the long-term benefits associated with the triple dividend of drought resilience, more insights are needed to understand the long-term costs of losing that resilience and the triple dividend. The area of opportunity for NbS to address drought risks has been estimated at more than 2.5 billion ha globally – equivalent to the land size of the United States, China and Brazil (Vigerstol et al., 2023).

1.2 Policy and planning: Enabling nature-based solutions to drought

Enhancing implementation and financing of NbS for drought requires an enabling environment of regulatory, policy and planning frameworks, instruments, institutions and capacities at all levels, from local to national to global. Such an enabling environment is paramount for the transformation in the approach to drought management from reactive and crisis-based to more proactive and risk-based. This enabling environment however also needs to be discussed in light of broader discussions around the transformation of land-use systems Abrahão et al., 2024; Palomo et al., 2021). This section introduces existing policy and planning frameworks that give impetus for action and political and institutional building blocks to accelerate change.

1.2.1 Global policies to transform drought risks and increase resilience

The UN Decade on Ecosystem Restoration and the accumulated global voluntary commitment to restore more than one billion hectares of degraded land by 2030 indicate an increasing international awareness for the value of nature and its services. This engagement provides a basis for a series of different but complementary global policy processes and frameworks that address the effects of droughts. Each of these processes guides various types of interventions toward different global policy objectives. Nature plays a critical role in building resilience to drought and the global community becomes increasingly aware of this. NbS are increasingly recognised as an effective approach to complement other drought resilience measures such as crop insurance, early warning systems, and traditional engineering solutions to build drought resilience (Chausson et al., 2020; Sudmeier-Rieux et al., 2021) and this is reflected in the agendas of international institutions.

The **UNCCD** has a unique mandate and role to mitigate the negative effects of drought (e.g. in UNCCD Convention text, Article 2, Objective and Strategic Objective 3 of the UNCCD 2018–2030 Strategic Framework) by enabling land and water management interventions, raising awareness, knowledge sharing and resource mobilisation to strengthen the implementation of these solutions globally. The UNCCD has become one of the key players in global awareness raising and advocacy, policymaking and cooperation in the context of building drought resilience, and that role is further expanding as droughts are becoming more widespread and severe. The Convention process offers a platform for multiple stakeholders to agree on policy and normative frameworks and approaches to enhance action on drought (UNCCD, 2024). UNCCD's role is complementary to, but not superimposable with, those of the sister Rio Conventions.

Box 3: The International Drought Resilience Alliance (IDRA)

The International Drought Resilience Alliance (IDRA) aims at enhancing global resilience to drought by promoting collaboration and the adoption of proactive measures, closely aligning its efforts with global initiatives and goals such as the SDGs. Launched by Senegal and Spain at the UNFCCC COP27, it is a joint effort of countries and organisations. IDRA seeks to shift the global approach from reactive drought management to proactive and preventative strategies, building more drought-resilient societies and ecosystems. To ensure global drought response, IDRA encourages policy coordination by fostering global cooperation among governments, civil society, international institutions, and the private sector. IDRA collaborates closely with the UNCCD and works with over 30 countries and multiple institutions to actions like nature-based solutions for drought resilience. IDRA advocates for increasing financial investments into NbS, including through public-private partnership, international development funds, and innovative financing mechanisms (IDRA, 2024).

The **UNFCCC** prioritises increasing investment in climate services to predict and adapt to future climate-induced drought risks, and to attribute damage and losses to climate changes that have already occurred. The UNFCCC Paris Agreement explicitly recognises in its preamble the importance of the conservation and enhancement of carbon sinks and the importance of ensuring the integrity of all ecosystems. It also highlights in Article 5 the need to protect ecosystems. In this context NbS are receiving increasing attention in the UNFCCC debate (UNFCCC, 2021).

The **UN CBD** (CBD) supports investments in the conservation and sustainable use of all elements of biodiversity (genes, species, ecosystems), also targeting philanthropic donors, business and the finance sector itself. Biodiversity-oriented assessments rarely mention drought and are predominantly concentrated on less drought-prone areas. The 2022 Global Biodiversity Framework (GBF) of the CBD does not mention drought, however NbS are explicitly mentioned in Target 8 of the Framework (CBD, 2022).

Box 4: **Rio synergies through joint action for NbS**

The three Rio conventions-UNFCCC, CBD, and UNCCD offer opportunities for added-value strategies and integrated solutions through optimised use of funds better interlinking of target systems, and cohesive planning at both international and national levels. Transformative and systemic approaches, such as NbS, SLM, and ecosystem restoration, are central to all three conventions. These approaches can be integrated into national instruments and strategies, such as Nationally Determined Contribution (NDCs), National Adaptation Pans (NAPs), National Biodiversity Strategies and Action Plans (NBSAPs), and Land Degradation Neutrality (LDN) targets, ensuring they mitigate conflicting goals in the implementation of the conventions.

In Rwanda, results show that coordinated implementation of landscape-focused activities under the Rio Conventions can reduce transaction costs of and restoration by almost 56%, saving about 45.6 million US dollars per year compared to when the activities under the three Rio Conventions are carried out separately (ELD, 2024).

UNDRR focuses on emergency response and preparedness to minimise damage and losses due to droughts and other disasters (UNDRR, 2021). The Sendai Framework for Disaster Risk Reduction (2015- 2030) recognises the need to shift from primarily post-disaster planning and recovery to the proactive reduction of risks and specifies that strategies should consider a range of ecosystem-based solutions (OECD, 2020).

The UN Convention on the Protection and Use of Transboundary Watercourses and International Lakes (**Water Convention**) provides a unique global legal and intergovernmental framework for climate change adaptation including flood and drought management in transboundary basins. In particular, flood and drought management is included under the programme area 4 on climate change adaptation of the Program of Work of the Water Convention for 2019-2021 (UNECE, 2019). The Water Convention has been supporting countries and regional organisations in adapting to climate change and managing flood and drought risk for 15 years.

Box 5: **Drought portfolio of the Global Environment Facility (GEF)**

The Global Environment Facility (GEF) shares facilities, services and oversight with a range of environmental agreements under the United Nations, and its financing enables countries to address complex challenges and work towards international environmental goals, including combatting drought and improving drought readiness. At COP15, the Parties to the UNCCD invited the GEF to assess the feasibility of creating a new focal area on drought (see: COP15 Decision 9) to increase the visibility and financial resources allocated to drought. As of yet, the GEF did not publish their evaluation, but they did publish relevant evaluations on support to countries to address water security (GEF/IEO, 2024b, 2024a) and also a Strategic Country Cluster Evaluation of the portfolio on Drylands (Carugi, 2024; GEF/IEO, 2024d, 2024c). The GEF Secretariat has lately reported to its Council Members that insufficient support at the global policy level renders the exploration of scope for a dedicated focal area for drought: 'neither feasible nor purposeful' (GEF, 2024). Only about 1% of GEF funds are allocated to droughts (Magero et al., 2024).

1.2.2 National enabling environments for nature-based solutions

Due to their multi-impact and multi-purpose character, both drought risk management and NbS require a whole-of-society effort involving national governments, local governments, businesses, academia, farmers, civil society, including indigenous people and households (Browder et al., 2021). National governments are responsible for the necessary horizontal and vertical integration and work towards policy coherence. Much of the decision-making and implementation of NbS takes place at community level. Different demands on land put pressure on resources and priority impact sectors such as agriculture, water and infrastructure need to be effectively engaged in decision-making processes.

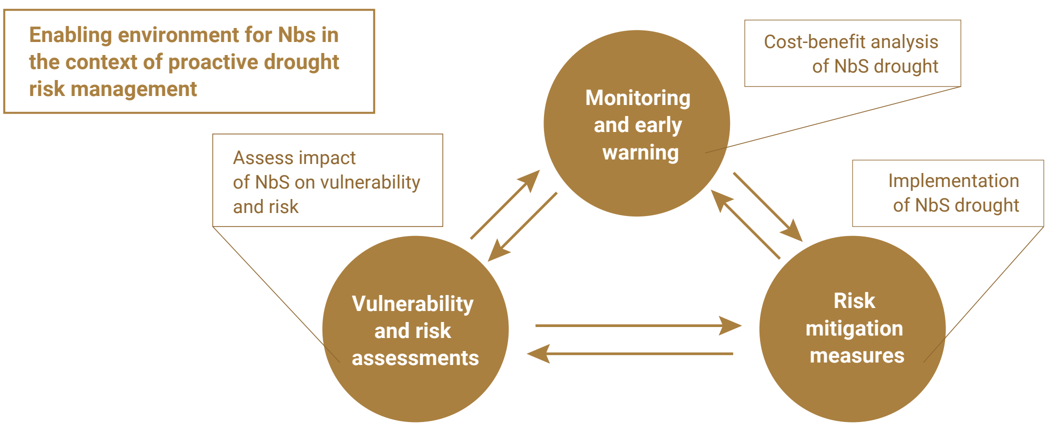
Making changes in institutions and resource management practices requires making political choices. Entrenched interests, differing goals and priorities, path dependencies and insecurity can hinder decision-making and institutional change. The political economy of drought risk and the associated heightened sense of urgency for collective action is an essential factor and lever of change. The starting points for policy and planning are assessments of drought impacts, and vulnerability complemented with economic assessments of the returns on investments in NbS for drought. These raise awareness of the issues at stake and the economic and other benefits of measures for drought preparedness.

National and local level policy, regulation and planning as well as institutional arrangements are recognised as critical enablers for NbS uptake, scaling and finance (Mendonça et al., 2021) but not much guidance is available from science as large knowledge gaps persist (Davis et al., 2024; El Harrak & Lemaitre, 2023). Valuable lessons, however, can also be drawn from related or synonymous concepts such as drought-smart sustainable land management, land restoration, nature and biodiversity conservation, ecosystem services and natural capital.

National strategies for guidance, coherence and coordination

Under the umbrella of the UNCCD and based on previous work of among others the Integrated Drought Management Programme (IDMP) a coherent set of approaches and guidance has evolved to inform and organise national level drought policy and planning. Core concept are three pillars of national drought policy developed by IDMP based on the High-level Meeting on National Drought Policies held in 2013 (WMO & GWP, 2014) (see Figure 4). These also form the basis of the UNCCD drought toolbox which provides a comprehensive set of tools, guidelines, case studies and other resources. The Drought Resilience, Adaptation and Management Policy (DRAMP) Framework specifies the three pillars providing six cross-cutting goals that outline actions to guide the design and implementation of drought policy explicitly including sustainable land management (Crossman, 2018). Under the UNCCD Drought Initiative an 8-step approach offers guidance for the development of national drought plans which is consistent with previous IMDP guidelines (UNCCD, 2018, WMO & GWP, 2014). Measures for accelerating implementation of NbS are predominantly located in pillar 3.

FIGURE 4 **Three pillars of national drought policy and planning and their interrelation with NbS** (authors' own elaboration)



To date, more than 70 countries already have or are in the process of developing national drought plans under the UNCCD Drought Initiative of which 35 are endorsed by the respective governments and published (Tsegai et al., 2021). A preliminary analysis of available plans sends mixed signals (ibid. and backed by other findings, e.g. Masih, 2024; Jedd et al., 2021; Biella et al., 2022. While drought risk reduction at country level is still mostly reactive, 46% to 83% of plans contain proactive NbS relevant elements such as water management, improved agricultural practices, reforestation and land use planning. The term "nature-based solution" was not used in any of the plans (author's own analysis).

An important function of national strategies and plans is to guide long-term action and development and provide business and finance with reliable framework conditions so that they can plan long-term investments and strategic decisions. National drought plans currently provide some but certainly not sufficient guidance and concrete measures that would mobilise place based and external stakeholders' commitment, investments, private sector action and finance for nature-base solutions (author's own analysis; Tsegai, 2021).

National strategies and plans and associated cross-sectoral as well as vertical coordination can be an important vehicle for much needed policy coherence for drought risk management and NbS. NbS are increasingly well mainstreamed in national policy documents even though some plans lack sufficient implementation measures. 91% of nationally determined contributions (NDCs) that were updated in 2021 make reference to NbS both for mitigation and / or adaptation (WWF, 2021). Out of the 35 OECD countries that have national adaptation plans (NAPs), 24 mention NbS (OECD, 2020). NbS are likewise frequently mentioned in national disaster risk reduction frameworks and water strategies (UNDRR, 2024a; OECD, 2020). National biodiversity strategies and action plans (NBSAPs) naturally have strong mentions of NbS and related concepts, some also refer to droughts and increasing guidance is available on enhancing disaster risk reduction within NBSAPs (UNDRR, 2024b).

Box 6: **Informing national policy plans, decision-making and land use practices with economic assessments: Impact testimonial from Georgia on sustainable pasture management**

In response to wide-spread pasture degradation, an ELD study was requested by the Regional Environmental Centre for the Caucasus (RECC) in 2018, as the country needed guidance on how to restore pastureland productivity in a financially feasible manner. The subsequent ELD study, assessed three distinct approaches to regenerating pastureland, namely 1) mainstream "de-stocking" approaches to meet the carrying capacity of land, 2) adaptive rotational grazing, based on Savory's principles of Holistic land management and, 3) long-term enclosures and annual rotations.

The study showed that 1) de-stocking is not financially feasible to pasture users, due to high fixed costs from land rental fees; that 2) enclosures (slow rotation) has prohibitive opportunity costs, while 3) adaptive rotational grazing schemes, can lead to improved pasture biomass without requiring a reduced herd sizes – making it the most economically attractive option for restoring pastures. The study also highlighted that sustainable land management hinges on land tenure reform. The study directly informed the the Georgian National Pastureland Management Policy Document, which further laid the foundation for the first law on pastures. From the economic data and household budgets of over 300 surveys it was possible to show why the existing land tenure arrangement, and de-stocking recommendations (dating from Soviet Union), are incompatible with sustainable rangeland management. The study has been instrumental in facilitating science-based decision-making and policies. Lastly, the study also helped RECC to access funding from GEF to pilot adaptive rotational grazing on a large scale (ELD, 2021).

In conclusion, there is significant scope to increase the inclusion of NbS in more and improved national drought plans. Likewise, there is strong momentum for interlinkages and making use of synergies between the different frameworks concerned with NbS. Decision makers concerned with droughts have a good opportunity to take advantage of this momentum and harness easy wins by promoting NbS for drought in related frameworks such as NDCs, NAPS, and NBSAPs.

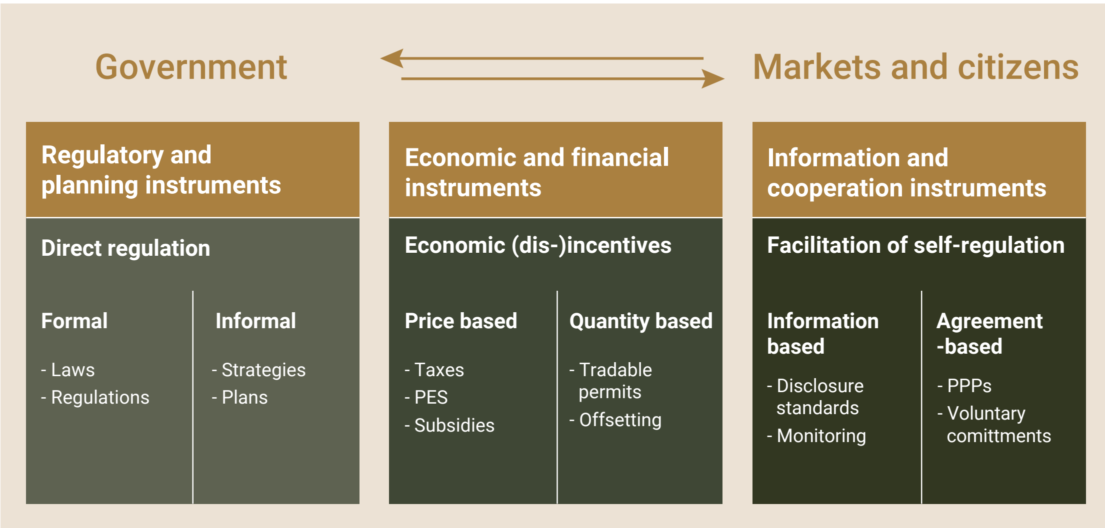
Policy enablers for upscaling and financing of nature-based solutions

In situations where policy makers want to influence land use without direct control, policy instruments can be used to influence other actors' behaviour. Limitations of NbS such as long time scales until benefits materialise, large spatial scales required, dynamic uncertainties and complexity as well as diffused benefits make them less compatible with traditional decision-making systems (OECD, 2020). Additionally, diverse barriers, among them the fact that intact ecosystems provide many of their services free of charge, put them at a systemic disadvantage over conventional (grey) solutions (for a discussion of barriers see section 1.3). Policy instruments are the means to overcome these to create a favourable playing field for NbS.

Transformation literature highlights the need for regulatory and political enabling environments that change the rules of the game such that nature-based solutions can prevail. The key information that decision-makers require, therefore, may not be how land is best used, but how policy mixes are best chosen and how instruments are best designed on the long run. In many national drought policies but also other policy frameworks, this perspective is a blank spot or at best underrepresented risking actual achievement of scale, finance and local stakeholder commitment for NbS. Even in NbS literature, systematic perspectives on policy instruments obtain little attention so far (Davis et al., 2024; Mendonça et al., 2021).

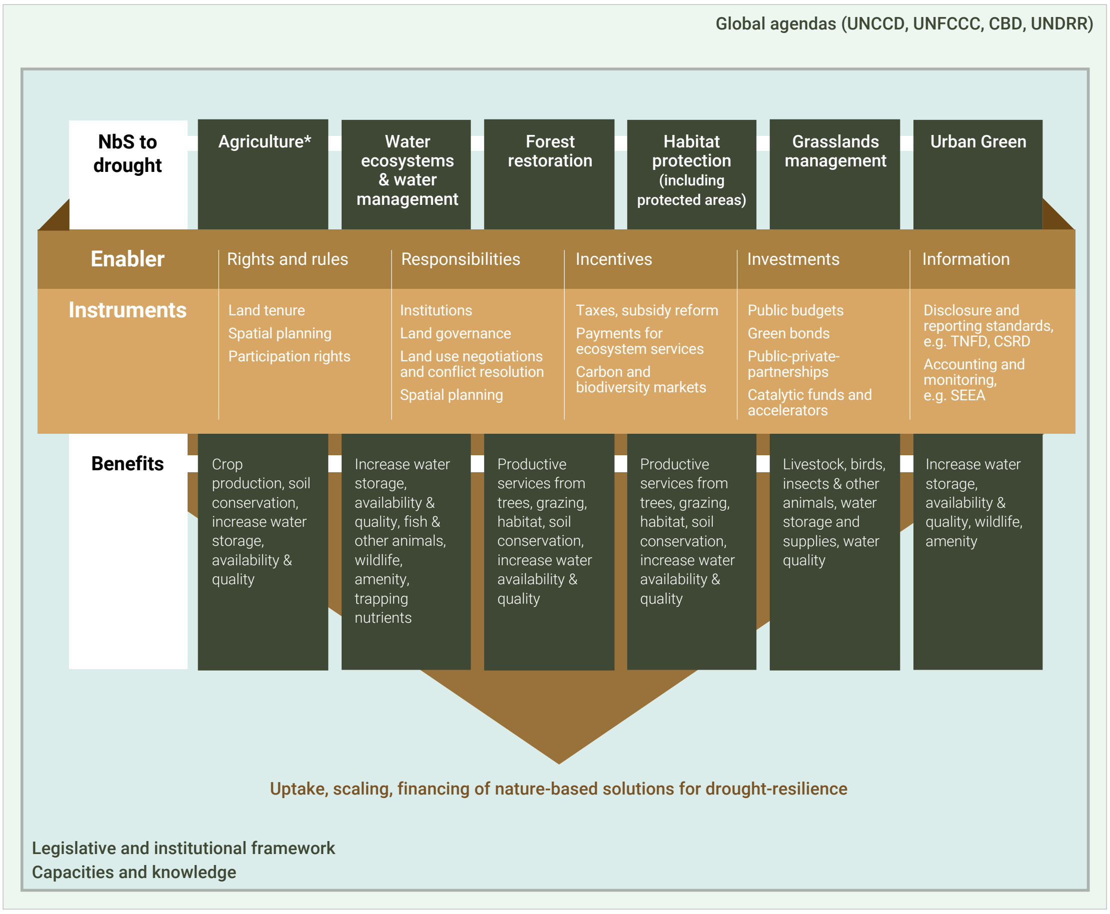
Policy instruments are typically distinguished in three broad categories that span over a continuum of direct regulations of governments to providing economic (dis-)incentives on to facilitating self-regulation of markets and citizens. The three categories are: i) regulatory and planning instruments, ii) economic instruments, and iii) information and cooperation instruments Figure 5 (Davis et al., 2024).

FIGURE 5 **The continuum of policy instruments** (adapted from Barton et al., 2014)



The use of policy instruments has seen a shift away from command-and-control approaches even though they remain the most widely used ones and often form the basis for other approaches, for example secure land tenure rights as a precondition for various economic instruments (Davis et al., 2024; Mendonça et al., 2021). Many encouraging innovations and increasing implementation are taking place in the field of economic and information instruments. This might be explained with reference to policy sequencing that has been initiated in climate policy discussions (Montfort et al., 2023; Linsenmeier et al., 2022; Meckling et al., 2017). It is assumed that a strategic ordering of policies starting with less restrictive approaches and the creation of benefits prepares the ground for stricter regulations and disincentives later.

FIGURE 6 **Policy enablers for nature-based solutions** (adapted from UNCCD 2022)



*including regenerative agriculture, agroforestry, integrated crop-livestock soil fertility management & others

Promising innovations and developments are taking place in the rapidly evolving landscape of policy instruments for nature-based solutions.

- Nature markets are growing rapidly reflecting increasing applications of voluntary carbon and biodiversity credits including the much-needed maturing of the underlying regulatory environment for such schemes (Taskforce on Nature Markets, 2022).
- More than 100 countries today have or are developing some forms of compensation and/or offsetting policy with regards to nature-based solutions, biodiversity and land, and as part of the mitigation hierarchy (Bull and Strange, 2018).
- Payments for ecosystems services (PES) are by now a proven policy instrument and are a standard repertoire of initiatives around the world, e.g. the CompensACTION initiative.
- Applications of subsidy reforms or the repurposing of harmful subsidies are still limited even though evidence repeatedly presents both the urgency (UNEP & ELD, 2023) and the feasibility to act on negative and harmful incentives (ELD & FÖS, 2024).
- There is a sharp increase in internationally agreed and standardised accounting, monitoring, disclosure and reporting standards, above all the Taskforce on Nature-related Financial Disclosure, the System of Environmental-Economic Accounting – Ecosystem Accounting statistical standard, the EU Corporate Sustainability Reporting Directive and Taxonomy as well as other taxonomies popping up around the world.

Box 7: **Sustainable land management in the governorates of Béja, Siliana, Kairouan and Kasserine, Tunisia**

The study highlighted the need to create market conditions that value environmentally sustainable agricultural products and invest in sustainable land management. Economic assessments of SLM options to support the national soil and water conservation strategy and policies for agricultural development included examining incentives to support the economic viability of agroecological farming by providing investment support, economic offset mechanisms for incremental costs, and pricing systems that recognise the environmental value of agricultural products (premium pricing). A transition period of between 3-7 years is required to transform olive and cereal production systems. An incentive system was proposed to overcome this barrier for 400 DT/ha/year, with a capital investment subsidy of 500 DT/ha for farms less than 20ha, totaling an estimated ceiling of 7209 DT depending on farm size. Similarly, a price support system for olive and cereal production would booster farm incomes and investment capacity. This could be funded partly by the state or through other forms of financing, such as "payments for environmental services", insurances or a Climate Fund.

Further information on this case study is provided in a separate appendix to this report, downloadable via unccd.int.

Land tenure remains a top priority for enhancing implementation and financing of NbS, among others because it provides the legal basis not only for directly enabling better land management but also as a basis for many economic instruments such as carbon schemes etc. Integrated spatial planning is closely connected to land tenure and gets increasing attention for example in the context of the UNCCD and CBD (e.g. Verburg et al., 2022).

Some proponents opt for new institutional arrangements that are better able to ensure the provision of global public goods which include sustainable land and water management (UNDP, 2024). As public goods are co-owned and essentially non-rival and non-excludable then decisions on their use and protection similarly should be co-owned involving all stakeholders. This concept builds on the pioneering work of Ostrom on the management of 'commons' and is further developed by the concept of common asset trusts (Orstom and Cox, 2010; Costanza et al., 2021). Common asset trusts (CAT) is an option that recognises private and community property rights and can facilitate effective public- private-partnerships. CATs consist of collections of agreements and polycentrically governed institutions in support of a sustainable use of natural resources (Costanza et al, 2021). The 4 Returns framework is a generic integrated (holistic) practical landscape valuation approach based on the UN CBD Ecosystem Approach and now implemented in more than 23 countries (Dudely et al., 2021).

Box 8: **Holistic Landscape Management and Restoration in the Altiplano Estepario, Spain (Wilson et al., 2023)**

The 4 Returns framework is used in the Altiplano in Spain and includes conservation, drought management and regenerative agriculture into a highly degraded and drought-prone region of one million hectares in South-Eastern Spain with quantified benefits for land users, society, private investors and the government. New institutions included an landscape partnership association (AlVelA) that brought together farmers, conservationists, government, entrepreneurs, researchers. This association is part of a broader Regenerative Education Alliance, for better land management formed by eight entities involved in education, ecosystem restoration, and social revitalisation. A unique focus of the 4 Returns framework is uses three geographical landscape zones designed so that local stakeholders can better understand the inter connectiveness landscape in which they live: a natural zone, where protected area managers and practitioners conserve and restore ecosystems, creating landscape connectivity, increasing native biodiversity, a combined zone where farmers transition from monocultures and industrial farming to more regenerative practices, and the economic zone the urban areas are situated and includes activities supporting co-ops and businesses to process and sell regenerative goods at a higher premium and connecting producers to markets. The 4 Returns framework has a time line of minimal 20 years and uses the Theory U as a co-creating method to bring stakeholders together during this period to work on a holistic landscape plan, and implement it. Blogs, articles, of the work in the Altiplano (including in El Pais) have been published such as this visual overview of the area and interviews with stakeholders https://local-heroes-alvelal.webflow.io.

Further information on this case study is provided in a separate appendix to this report, downloadable via unccd.int.

1.2.3 Empowering the local level

The importance of local governance for nature-based solutions

Strengthening the local level is essential for sustainable land management and the successful implementation and establishment of nature-based solutions. Local and indigenous communities provide the necessary on-the-ground expertise, cultural and ancestral knowledge, unique traditions and motivation to maintain and enhance ecosystems. The community level is where the direct interaction between humans and the environment occurs and where large dependencies on natural resources persist. Locals are therefore better positioned to monitor changes in ecosystems and respond quickly to challenges, whether it's invasive species, climate impacts, or land degradation. Nature-based solutions need to be context-specific and tailored to local environmental, social, and economic conditions.

Local communities are in a prime position to co-create and adapt these solutions, ensuring they are effective and culturally accepted. In addition, implementing land management practices and NbS often requires collaboration and trust among stakeholders, which is more easily cultivated at the local level. Community engagement ensures that solutions are not imposed top-down but are co-designed with local stakeholders, increasing their long-term sustainability and acceptance. It is particularly important to ensure women are represented in the co-design process and to ensure that gender needs are emphasised. Women are asymmetrically impacted by drought and local governance should contribute to strengthening their voice and their involvement in implementing NbS. Policies that foster inclusion, build local capacities, and secure land rights can further empower these communities to manage their resources sustainably (United Nations, 2007).

Effective local governance for nature-based solutions to drought needs to follow a "Whole of society approach". This includes engaging marginalised groups, such as indigenous peoples, women, and youth, in transparent decision-making processes. Building inclusive institutions like local councils, cooperatives, or community forest management bodies empowers locals to actively shape land use decisions.

Local governance must also be able to balance trade-offs, which occur because NbS often provide a diversity of different benefits, and not all stakeholders value these benefits in the same way. Addressing them must be approached transparently through credible assessments with full disclosure and agreement among the most affected stakeholders, and with ecological and social safeguards in place that also recognise the importance of integrating gender-responsive safeguards and strategies (IUCN, 2024).

Box 9: **Empowering local communities in Kenya**

The project *Towards Ending Drought Emergencies (TWENDE)* aims to reduce drought-related economic costs by fostering resilience in livestock and other land sectors through sustainable rangeland governance. Interventions included water retention, promoting biodiversity and wildlife corridors, restoration of pastures and conflict resilient ecosystem governance. TWENDE initiatives have introduced peacebuilding programs, community-led grazing committees, and bylaws to restore governance over rangeland resources, previously managed by the Borana elders. As traditional systems weakened, the Government, in partnership with local leaders, implemented a successful disarmament program to neutralise armed cattle rustling, enabling secure access to grazing lands. Official bylaws were established, with neighbouring areas adopting similar practices, promoting widespread governance reform. This model has revitalised rangelands through soil and water conservation, pasture restoration, and enhanced groundwater recharge, fostering resilient ecosystems that support biodiversity, improve livestock productivity, and strengthen food security, water access, and poverty alleviation in ASAL communities. The model will help establish a systematic national approach to national development planning and monitoring.

Further information on this case study is provided in a separate appendix to this report, downloadable via unccd.int.

How should local land governance be strengthened to promote nature-based solutions?

Effective local governance needs supportive framework conditions to promote proactive drought management. As key actors for action towards a proactive, sustainable and future-proof land management in the face of drought, the interests, capacities and trust of the local communities, land users and indigenous peoples need to be placed at the centre of national and municipal policy. Important approaches to strengthen local communities for nature-based solutions are:

1. Enabling laws at national level providing local governance with the authority and the capacities needed to deal with drought is fundamental (Browder et al., 2021).
2. Strengthening Property and Land Rights. Secure land tenure and clear property rights are foundational for sustainable land management and NbS. When communities have legal recognition and secure rights to their land, they are more likely to invest in long-term conservation and sustainable land use practices. This is particularly important for indigenous communities whose land rights are often under threat.
3. Empowering local institutions and governance systems, strengthened through decentralised decision-making and increased resources. Local governments can act as facilitators for NbS, ensuring integration into broader development plans and policies while ensuring community voices are prioritised.
4. Support local governance by empowering local institutions and embedding a comprehensive policy framework in disaster management strategies. A strong coordinating body is essential for drought management to enhance cooperation among the various levels of governments, development partners and non-governmental organisations (IDOS, 2017).
5. Develop context-specific incentive und support structures (e.g., subsidies, PES) – as essential tools for balancing the trade-offs.
6. Promote participatory and integrated planning, monitoring and early warning. Effective communication among relevant stakeholders for the efficient and proper functioning of drought early warning systems

is important. It should be combined with long-term drought resilience and preparedness planning, better targeting, and proactive action. Strong monitoring, evaluation and knowledge management of drought resilience efforts and achievements should also be included in the drought-preparedness framework. Engaging communities in the co-design and planning of NbS ensures that local priorities and concerns are reflected in the projects. Participatory rural appraisals (PRAs), stakeholder meetings, and community mapping are tools that can be used to involve locals in identifying problems, setting goals, and designing solutions that they feel ownership of.

Capacity building and training at the community level are vital along with sufficient time and funds to be allocated to community mobilisation. This includes technical skills in sustainable land management, agro-ecology, conservation techniques, and NbS. Empowering communities through workshops, knowledge exchange, and local leadership programs ensures they can actively contribute to and lead initiatives.

1.3 Financing options for NbS to drought

There are significant costs to both reactive and proactive measures and a major drawback is a lack of finance investments into proactive measures as most funding is currently directed to response and recovery (Pek and Salman, 2023). The implementation of NbS to meet biodiversity, climate change and land degradation for the three Rio conventions is estimated to require an annual investment of some US$ 536 billion by 2030. The UNCCD estimates that some US$ 210 billion of investment is required for drought related measures during 2016-2030 (UNCCD, 2024). Current investments, dominated by the public sector (86%) with only 14% from private sector companies, only amount to some 133 billion per year (UNEP, 2021). Around 80% of the funds dedicated to drought are allocated to agriculture (Pek and Salman, 2023).

In a recent assessment of the landscape of public international funding for nature-based solutions for adaptation, WRI shows that only a small percentage (0.6-1.4% in 2018) of international public climate finance is flowing to NbS for adaptation and that funding is driven by just a handful of major donors. Moreover, less than 2% of all public international climate finance goes toward NbS for adaptation, missing a critical opportunity to harness the power of nature to make communities more resilient to climate impacts. As for corporate financial flows, an estimated US$5tn impact nature negatively every year, and only US$35bn of annual investment goes to NbS[2].

Thus, both public and private sector finance will need to triple to close this finance gap and increasing investments from the private sector are viewed as essential because public funds are dwindling as a result of competing demands from inflation, political instability, wars, post-Covid adjustments and associated energy and food shortages.

Currently there is increasing attention on public-private-philanthropic partnerships for transformative changes in the use of nature where over 50 models have merged (McKinsey & Company, 2023). More on these aspects are expected in the forthcoming IPBES report on the methodological assessment of the impact and dependence of business on biodiversity and nature's contribution to people.

Both national and international public funds have been mobilised to shift drought-prone economies out of unsustainable patterns and to scale up proactive partnership approaches amongst public and/or private sector actors (UNCCD, 2022). This tends to involve high transaction costs, but relatively higher rates of economic growth and new markets in previously depressed areas are of significant reward for successful investments (King-Okumu, 2015a; Pek and Salman, 2023; Cuevas et al., 2024). Not all investments generate the expected results (UNCCD, 1994, 2022; UNEP/WEF/ELD 2023), and there are failures and instances of underperformance as well as some successes. More learning and investment is still needed (UNCCD, 2023) especially to identify where self-sustaining returns on investments and co-benefits justify increases in the use of public or private finance (King-Okumu, 2022; UNCCD, 2022).

The GEF has published Strategies for taking on more risks across its portfolio (not only to reach the Least Developed and more fragile countries). It has also published a Strategy for Engaging the Private Sector.

(GEF, 2020, 2021). Similarly, the GCF also invests in stimulating the private sectors, including the financial sector. For several decades since the 1980s, increasing attention has been paid to policies for creating public-private-philanthropic partnerships. A helpful compilation of the different sources of finance dedicated to supporting NbS is available (Piiponen-Doyle, 2023). However, this is not focused only on NbS to droughts.

The types of financial instruments available for investments in NbS and drought risk management and SLM options are shown in Box 10 and include both public, private and philanthropic sources. Blended finance is considered as part of the required new institutional arrangements consisting of different counterparties and investment models that include guarantees. Given the heterogeneity of contexts the financing of NbS will probably be a mixture of different products and several investors, particularly if the trend continues towards the use of blended finances (the reader is referred to Miller and Jones, 2010; EIB, 2023; Pek and Salman 2023; UNEP, 2024, WEF, 2024 for more details of these financial mechanisms and their categorization). Listing of funding agencies for NbS can be found at (Swann et al., 2021; UNCCD 2022; Cuevas et al., 2024).

Box 10: Examples of Instruments for financing public and private investment in nature-based solutions (see also UNCCD 2022)

Public	Private sources	Financial services provided by finance industry
• Grants, subsidies, tax incentives, direct payments, microcredits from public sources • Multilateral climate funds, e.g., the adaptation fund, the global environment facility, green climate fund • Repurposing nature-negative subsidies and reallocation to sustainable practices • Land tenure conditions and incentives • Tax conditions and incentives • Regulatory measures such as standards & safeguards	• Payments for environmental services (directly & along a value chain) • Impact investing for land restoration, carbon sequestration or REDD+ • Creation of markets and banking schemes for carbon and water • Philanthropic sources • Corporate Social Responsibility • Systems for nature-related financial disclosure	• Venture capital, private equity, impact investors, retail investors, crowd funding, commercial banks, concessional loans • Loans micro-credit to land-users • Green bonds, nature bonds, sustainability-linked bonds, impact bonds • Agricultural value chain finance • Insurances

1.3.1 Investment opportunities

Grants dominate the funding for land restoration activities including drought mitigation measures and are generally of the order of US$1-10 million and are most useful at the inception of land transformation activities. To scale up and sustain interventions funding needs to be substantially greater and such amounts are unlikely to be provided from public or philanthropic sources (UNEP/WEF/ELD, 2023). The process of scaling up and sustaining action therefore needs a variety of financing means and different investors as the amounts required rise with scale. Better targeting investors from the private sector would include, for example, bank and other repayable loans, private equity and debt and equity capital markets as depicted in Figure 7.

There are usually 3 phases in land transformation starting with an inception and pilot study leading to replication and scaling up and thirdly, sustained growth over time. The characteristics of companies most associated with the 3 phases of Figure 7 are, for inception and piloting; small companies that are developing their business model linked to their products or services, have variable rates of growth and high risk of failure. For the replication and scaling up phase companies are those that are growing rapidly and have business models that match specific client's needs with varying levels of risk and they interact with investors as needs arise. For the sustained growth phase, companies generally have dedicated staff for specific functions, have well defined business models and processes, are perhaps slowing in growth but have low risk of failure and have personnel dedicated to investor relations (adapted from (Faruqi & Landsberg, 2017). Careful monitoring by an independent agency of the type of private sector investments will be necessary to ensure that nature-negative effects of their business activities are avoided or minimised.

Enabling, piloting and catalysing investments in value chains remains an important way to strengthen economic growth in drought-prone areas, for example, in pastoral communities (Miller & Jones, 2010; King-Okumu, 2015a; Nkurunziza et al., 2022). Not to be forgotten are remittances from family members who have migrated out for work or study that are a significant source of private finance. These funds enable investment in land and drought risk management. These types of finance are invested to generate private returns that are not necessarily financial – e.g. to strengthen family ties, take care of elderly and younger family members, secure property, influence local political developments, settle disputes, or others.

Recent work published in support of a new Global Biodiversity Framework and Fund has pushed the debate on private financing for nature and built national capacities to explore how policy-makers can work more effectively with the private sector using economic instruments to regulate unintended environmental impacts and reward good practices (UNEP, 2023b). This work focuses on the needs for donors to mainstream nature into national adaptation and development-related policies, budgets, and investment plans and build a pipeline of NbS investments at the country level (Swann et al., 2021).

Private sector funds that support investments in NbS and SLM to reverse drought risks include water funds established by utility companies and drinks distributors. For example, AB InBev, provides funds to support The Nature Conservancy in land restoration and tracks results in terms of volumetric increase in available clean water reserves (Lahud, 2023; Vigerstol et al., 2023). Recently some 100 investors have signed up to the Valuing Water Finance Initiative with potential access to US$17.6 trillion worth of assets (VWFI, 2024). Similarly, a Dutch-based pension fund has earmarked €1 billion for biodiversity indicating the increased interest in NbS (Carbon Plus, 2024). For the private sector, corporate social responsibility frameworks and standards are important. These include systems for Financial Disclosures in relation to water, climate and nature (Linsley et al., 2023; Taskforce on Nature Markets, 2022; TNFD, 2023). Policy-makers can work with the private sector to increase their uptake, engagement and compliance with these systems. They can also progressively review, restructure and strengthen these systems for public disclosure.

Payments for Environmental Services (PES) provide ways to reward land managers where there are markets and consumers who are willing to pay for the services that their management practices generate. These can include services that are needed to buffer drought risks (e.g. groundwater recharge, storage, treatment, etc.). In many marginal and drought-prone areas, private individuals and companies already pay very high prices for access to water, food and other services. Furthermore, socially responsible consumers elsewhere may be willing to pay a premium for products that are sourced sustainably and reduce vulnerability to drought risks. Product labelling, certification systems, brand recognition and traceability are key factors in securing premiums of this type – e.g. for alcoholic beverages, textiles or other consumer goods. These can be produced using ecologically sustainable production methods in dry and drought-prone areas.

As green businesses grow, they will generate taxes, boost public revenues *and* build resilience to droughts –whereas other businesses may instead deplete water reserves (King-Okumu, 2015). In Kenya, some of the fastest economic growth is taking place in the Arid and Semi-Arid Counties because greater attention is being given to these areas that have been economically marginalised for so long. Similarly, economic growth rates have been very high in other parts of the Horn of Africa where economies have been affected by droughts.

1.3.2 Shift from traditional investments into those that consider environmental, social and governance factors (ESG)

Different approaches can be considered for investments in sustainability that are also applicable to drought risk management (Figure 7 and Figure 8). At one end of a spectrum is traditional investing that is driven solely by the desire for maximum financial returns while those that consider impact first over finance first are willing to excpect lower than market returns but have greater environmental and social impacts and will contribute more to solutions to the main global challenges (water shortages, droughts, other aspects of climate change, biodiversity loss and land degradation). Impact investments are those made by companies, organisations and businesses that aim to generate beneficial social and/or environmental impacts together with a financial return (Entenmann, 2021). At the extreme end of the spectrum are philanthropists who may not wish for any return on their capital. Current investors feature mainly in the finance first approach paying some attention to mitigating risks and harm to ESG factors but contributing less to solutions.

It is in this middle ground of the spectrum that more efforts are needed and indeed there is evidence that companies that balance finance first with impact first (Figure 8) and that include the interests of all stakeholders (shared value) are out performing companies that remain at the left side of the spectrum (Carney, 2021; Impact Investing Institutel, 2017). High transactions costs particularly for remote areas and a lack of mutual understanding are major obstacles that need addressing for more impact investing (Entenmann, 2021). As more evidence emerges, stimulated by public funding support, the risks to investors will be reduced, confidence will be gained leading to greater investments.

Box 11: **Drought resilience for pisco cultivation in Chile**

Pisco is a spirit produced in Chile by distilling the fermented juice of the pisco grape. It is a culturally significant product with Designation of Origin since 1931. Chile cultivates 10,000 hectares of pisca grapes annually, producing 36 million liters of pisco and generating 3,500 permanent jobs 85 and 40,000 indirect jobs. The Elqui River basin in northern Chile is currently facing one of the most severe water crises in its history, characterised by extreme drought and accelerated aridification. The river flow reduced by 32% during 2023 and reservoirs operated at only 18% of their capacity. This dramatically impacted the production of pisca grapes in the CAPEL Cooperative from 200,000 tons in 2000 to barely 50,000 tons in 2024.

Producers have responded to drought in two ways: through irrigation, which was adopted by 70% of cooperative members, and through implementation of agroecological systems (Nature-based solutions). Economic analysis reveals that the agroecological system complemented with irrigation has a net present value 36.5% higher than the purely technical irrigation solution. The agroecological system also displays greater adaptive capacity, due to its lower dependence on external inputs (5% of total costs versus 27% in the conventional system), lower operating costs in the long-term, greater income diversification, and better adaptability to climate change.

Agroecological systems also generate important additional benefits that, although not monetised in traditional economic analysis, are fundamental for ecosystem sustainability. These benefits include increased biodiversity, improved water retention in the soil, natural pest control, preservation of traditional knowledge and strengthening of territorial identity. These ecosystem services contribute significantly to the overall resilience of the production system.

The CAPEL Cooperative (Cooperativa Agrícola Pisquera Elqui Limitada) has been instrumental in adapting to the effects of climate and drought in the valley. CAPEL has played a crucial role in short-, medium- and long-term strategic planning and coordinating work between cooperative members. Pisco grape producers require new public resources, targeted institutional solutions, innovations and research and development from companies and universities, within the framework of a plan that includes the entire value chain of the pisciculture industry.

The study underscores the urgent need to move towards resilient and sustainable agricultural practices that not only improve productivity, but also conserve ecosystems and mitigate the effects of climate change. This requires supporting public policy, with: incentives for combining NbS with irrigation; investment in agroecological systems, training, and preserving traditional practices by the production sector, and; establishment of ecosystem monitoring systems, biodiversity conservation programs, and water management.

Further information on this case study is provided in a separate appendix to this report, downloadable via unccd.int.

1.3.3 Role of Artificial Intelligence (AI) and digital technologies

The complexities of collating information involving large amounts of data, spatial scales, multiple institutional and stakeholder challenges will require harnessing the capacities of both analytical and generative artificial intelligence (AI). AI can help analyse large amounts of data, can aid environmental monitoring through satellite and drone imagery, risk assessment, predict likely outcomes of land transformational changes and be used to develop decision support systems (e.g., Marwala and Hurwtiz, 2017; Moloi and Marwala, 2020). For agriculture, the possibilities range from alerts for droughts, pests and diseases, soil and crop health monitoring and nutrient management to market information (McKinsey & Company, 2024). Research on identifying useful genomic traits such as drought resilience will be enhanced by AI and can add value to produce by analysing value chains and changing market conditions. The resulting personalised agronomic and marketing information will aid land users, policy makers, researchers, and actors along value chains from producer to consumers. Harvesting and analyses of agricultural production information can aid traceability of produce, improve the efficiencies of value chains, help with access to loans, and offer alternatives to traditional insurances such as index insurance for drought.

Proponents of public and private blockchain technologies believe that the harnessing of agricultural production information can reduce time for traceability of produce, improve the efficiencies of value chains, help with access to loans, offer alternatives to traditional insurances such as index insurance for drought. It is estimated that blockchain technologies could facilitate global savings of up to US$6 billion per year in business transactions (ICT, 2018).

Such innovations are estimated to be able to add US$100-250 billion value globally to agriculture (McKinsey & Company, 2024). Thus, one can expect the private sector to develop and invest in these possibilities. However, AI remains incipient in developing countries as they depend on mobile smart phones, large amounts of computing power and energy. Successful applications of AI will require better organisation, harmonisation and more standardisation of data with significant costs.

FIGURE 7 Examples of types of financing for stages of scaling up land transformations

FIGURE 8 **Characteristics of different types of investments** (Carney, 2021; Entenmann, 2021; III, 2017)

Approach	Traditional	Responsible	Sustainable	Impact driven			Philanthropy	
				Finance first	⟷	Impact first		
Financial goals		Accept competitive risk-adjusted financial returns				Accept below market financial returns	Partial capital preservation	Complete capital loss
Impact goals		Avoid harm and mitigate ESG risks						
			Benefit stakeholders – generate positive outcomes for people					
				Contribute to solutions				
					Catalytic capital , close funding gaps and facilitate additional investments			
Description	Limited or no regard to EGS or social impact	Mitigate ESG practices	Adopt progressive ESG practices	Address societal challenges with competitive financial returns	Address societal challenges but returns are unknown	Address societal challenges with below market returns	Address societal challenges with non-commercially viable returns	Address societal challenges with donations or full capital loss

Footnote: ESG = environment, social and governance

1.3.4 Overcoming barriers to investments

Barriers to the adoption of NbS include the complexities of scale ranging from the individual land user on farms and forest lots, to watersheds, regions, nations and global, time, financial and market barriers, knowledge skills, land tenure and gender issues and behavioural limitations (Ding et al., 2017, Pek and Salman 2023; UNEP, 2024; Cuveas et al., 2024).

Financial barriers

Many ecosystem services (ES) that are affected by drought do not have a price and will not function in competitive markets and hence the private sector (PS) has shown little interest to date. This suggests there should be a move towards part grant part repayable capital in drought mitigation interventions, i.e., sharing the costs and benefits.

Risks to investments are associated with long pay back periods, a lack of a track record of successful NbS and uncertain scopes of scalability and the wide variety of contextual conditions that ascertain viable options. The piecemeal approach to projects that focus on one or a few determining aspects is also hindering replication and scaling up of promising innovations. This requires a collation of evidence and meta-analyses of successful projects/programs. Evidence suggest that the documentation of success stories will act as a stimulus to further investments,

Engagement with the private sector in the development of transformation plans would help build financial capacities amongst those attempting to implement proactive drought mitigation schemes.

More effort is required to monetise co-benefits and valuations of NbS in order to compare with grey infrastructure such as, dams, seawalls, roads, water treatment plants as the latter often become the default option. Available assessments indicate that NbS are less expensive than grey infrastructure projects but more evidence of positive business cases is required.

Market barriers

Decision makers and investors have difficulty in identifying and collating relevant data and information on suitable nature-based solutions for drought preparedness and mitigation. There is a lack of processes and means to aggregate small scale projects so that they can attract private sector funding. A better targeting of options is required that matches the interventions to the specific contextual biophysical, social and economic conditions. Various geo-informatic tools are currently being developed that will aid decision makers for better land use planning (e.g., GEO, 2023; Zucca et al., 2023; FAO, 2024).

A Nature Data Public Facility has been proposed to collate data involving public and private enterprises to address better accessibility, quality, comparability, verifiability and assurability (TNFD, 2024) This initiative aims to improve reporting, target setting and transitioning to *inter alia* better land management.

Natural capital is a public good that is non-excludable and non-rivalrous and as such acts as a disincentive for private sector investments. Usually only some of the benefits will accrue to the private with the majority of benefits going to the public. Increasing the spatial and financial scales of projects will help overcome this barrier.

As the time horizons for land transformations are usually in the range of 5-10 years, stimuli to cover these initial costs should come from public sources and guarantees. This is particularly important for farmers who are reluctant to change their production systems and are tied to seasonal timeframes.

A lack of standardised metrics for transformation innovations, e.g., the price of 1 t C or 1 l of water restricts more definitive studies. This lack of standardisation is one reason for the lack of data, monitoring, reporting and verification processes that also hinder assessments of progress towards better drought preparedness. Efforts such as those by WOCAT, the Natural Capital Coalition, TMG, the World Bank and others are beginning to address standardised metrics (WOCAT/ELD/UNCCD, 2022; TMG, 2022; EIB 2023; Capitals Coalition 2024).

Knowledge and skill gaps

Knowledge and skill gaps amongst practitioners and policy makers are frequently cited as barriers to the upscaling of successful drought mitigation interventions (UNCCD 2022). This requires a strengthening of extension services and personnel who work on the ground with practitioners. Concerted efforts are needed to build national trans-disciplinary teams that can develop linkages to both public and private financial mechanism and increase the understanding of the economies of scale, co-benefits and synergies amongst the goals of the UN conventions.

The public needs to be more engaged in fora and debates on what kind of environment they wish to see. To overcome difficulties in organising the necessary multiple public and private agencies with different responsibilities to implement interventions, intermediary agencies, or brokers are required that can organise, distribute and oversee different of types of finance.

Behavioral and common language barriers

Land users are generally reluctant to change their management systems for cultural and social reasons even when positive financial returns are likely. Similarly government ministries with differing responsibilities for land use and planning often operate in silos of approaches and actions.

In developed economies in the EU for example, marginal land farmers rely heavily on subsidies from governments and they proudly focus on food production and not on delivering public goods or environmental protection and risk management. More efforts are needed to switch incentives to include the production of public goods such as carbon storage, flood prevention, water quantity and quality show promise. Building and accelerating trust amongst among land owners/users and other agencies such as government departments, extension services, civil society organisations and private sector is needed to change behaviours.

Private companies have tended to ignore the trends towards greater attention to environmental, social and governance factors that can affect their supply chains, profits and reputations in the mid- to long-term. However attitudes are changing rapidly as the private sector moves towards more impact investing and shared value (Porter, & Kramer, 2011).

1.4 Transformative change towards sustainability

The measures to achieve more proactive approaches proposed in this report include a significant increase in using nature-based solutions and sustainable land management practices and mobilising finance for these measures in particular and ecosystem restoration in general, as well as supportive policies and governance arrangements. The following figure uses the framework from Wittmer et al. (2021) to outline the potential of the transition from reactive approaches to more proactive approaches of drought management that contribute to transforming society towards sustainability (as also depicted in the right spiral in Figure 1 of this report).

The framework includes the X-curve concept (Loorbach et al., 2017, Hebinck et al., 2022) that depicts the dynamics of a sustainability transition, highlighting the need for both phasing-in new sustainable elements as well as phasing-out key elements of the unsustainable system. The X-curve allows locating different policies or governance options that enable phasing-in (in blue) and phasing-out (in red) processes. The framework highlights the need for additional building blocks of a sustainability transformation identified in Wittmer et al (2021): a transformative vision (in brown), transformative knowledge (in amber), and the empowerment of local actors ("emancipatory agency" – in green).

Transformative knowledge (in amber) is the knowledge needed to change the system. This includes identifying and understanding the root causes of droughts as well as their impacts. Analysis of anthropogenic causes and how they interact with other causes includes the role of land use and management changes and excessive water demands, as outlined in the report, but should also identify the root causes, such as increasing resource and where this demand is generated. The broader impacts of droughts include, for instance, the health effects of too little water.

Besides the causes, steps and pathways to change need to be identified as well as how and where resistance is to be expected and how it might be overcome. Further knowledge needs arise as institutionalisation and phasing out stages of the X-curve are reached. Along the entire evolution, reflexive monitoring enables decision makers to adequately react to the changing system.

Regarding a **transformative vision**, the report proposes to reduce impacts of droughts to build trust in institutions to then be able to transform societies. This is reflected as "resilient communities", as this is of central interest and mobilises more people than only "resilient ecosystems". To motivate people to start changes, new **narratives** can outline what will be achieved by proactive drought management, what it takes and how the respective society can make it happen, both to make the new approach imaginable and to motivate and mobilise people for action. While reducing drought impacts might initially be sufficient to capture people's interest, increasing the ambition will help to maintain it over time.

The **sustainability conditions or ambitions** (in brown, in the center of the x-curve) indicate clear directions and summarise the conditions that any transformative policy approach should follow: if it substantially improves at least one of these conditions without making the others worse, it has the potential to contribute to transformative change.

If improvements achieved by a policy are marginal, the measure might rather be part of optimisation (top left of the red curve). Policies that try to tackle fundamental issues with a slightly better version of the current approach, i.e. with a positive but marginal improvement, seem to address the problem but may prevent more fundamental and potentially more effective measures from being presented.

A more fundamental **phasing-out** (red curve) of unsustainable management approaches and root causes of droughts is likely to require destabilisation of the status quo, meaning current strategies that promote unsustainable practices are abandoned. This destabilisation can come as evidence of the hidden costs of unsustainable approaches comes to light and as the value of more sustainable options is better understood.

Initial steps outlined in the report are to demonstrate the considerable externalisation of social and environmental costs, where an important aspect here is to understand who bears these costs: either society as a whole, "the public" or certain groups or individuals. This also includes that the insurance industry and central banks acknowledge and integrate the financial risks of unsustainably land management and the degradation of ecosystems. Other measures that will disrupt the status quo may include regulations to internalise true costs of unsustainable land management and measures to support divestment of practices that further exacerbate droughts or are unsustainable in other ways, and this will require some compensation for stranded assets.

The blue curve contains the measures to support **phasing-in** of a pro-active and nature-based drought management, from experimentation to institutionalisation. It includes all kinds of measures to pilot and then up-scale sustainable agricultural practices and other sustainable land management for drought prevention and resilience, including action and management plans, capacitation and technical support as well as funding. As mentioned in the report, this requires collaboration and partnerships between the public and the private sector, and to systematically integrate NbS in investment decisions. In order to institutionalise and stabilise the new system, the policy framework would have to be fundamentally aligned with the objective of pro-active and nature-based drought prevention, and to include conditions and support schemes such as early warning systems and insurance schemes as well as strong transnational measures for dealing with water scarcity.

Finally, the elements in green illustrate potentials to create or increase **agency** and to empower (local) actors to contribute to the transformation. For instance, establishing rights (to land – but also to water or to a healthy environment) are among the most powerful measures for supporting agency and emancipation. Involving large groups of the affected population can help to harness creativity and ensure local fit by adapting measures or inventing similar ones, that work in local contexts.

Transformation pathway for NbS drought

Optimisation → Disruption → Breakdown → Phase-out

- Invest in technology
- End harmful subsidies
- Raise public awareness
- Promote ESG
- Integrate financial risks of unsustainable land management
- Regulations to internalise "true costs" of land management
- Divest from unsustainable land management
- Accountability for unsustainable land & water management
- Financial support for stranded assets

Experimentation → Acceleration → Institutionalisation → Stabilisation

- Scale up NbS for drought resilience
- Include NbS and SLM in national drought plans
- Shift funding & technical support to NbS
- Public-private partnerships for NbS funding
- Reshape private finance towards investments in NbS
- Set up policy framework for proactive NbS management
- Integrate with early warning systems and crop insurance
- Transnational measures for addressing water scarcity

Understand how to change the system (transformative change)

- Root causes of increasing severity of droughts
- Public costs of anthropogenic drivers of drought
- Political economy for tackling resistance to change
- Value of NbS for drought prevention and resilience
- Institutional barriers to sustainable land management
- Behavioural barriers to change
- Potential of AI for risk assessments and monitoring
- Reflexive monitoring

Build emancipatory agency

- Enhance NbS capacities of people and institutions
- Build trust and collaboration at local level
- Strengthen property and land rights for local communities
- Empower and support local actors to co-create solutions
- Visioning and imagining
- Establish rights to water and a healthy environment
- Inclusive water governance with water sharing agreements

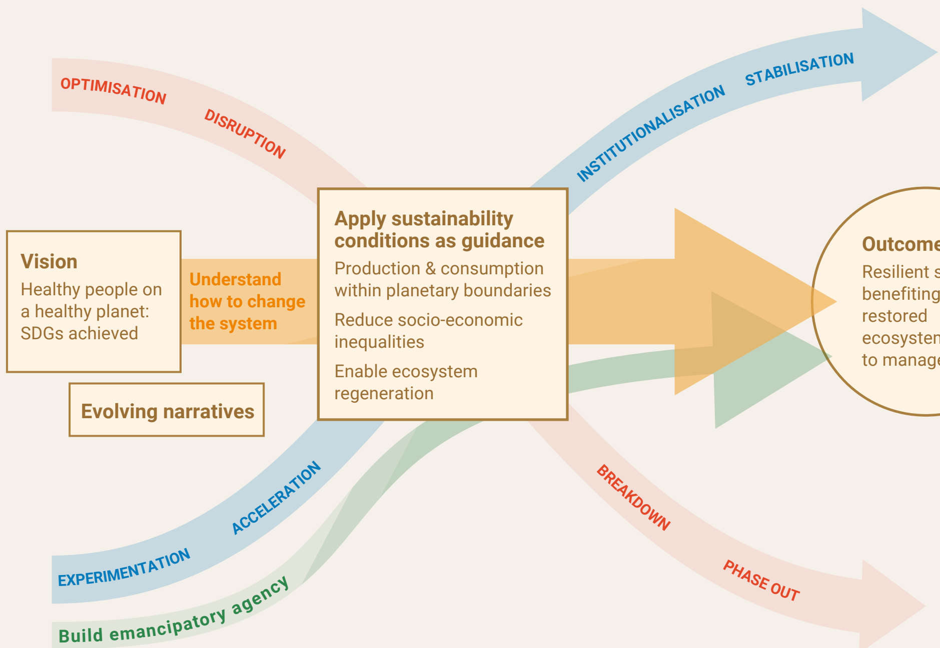


Figure adapted from Wittmer et al. 2021

Chapter 2: Making business cases for nature-based solutions in proactive drought management

This chapter synthesises available economic evidence of nature-based solutions for proactive drought management. It specifically investigates the subset of nature-based solutions that is particularly drought-relevant. These are NbS that seek to gather and retain water in the landscape's soils, aquifers and other (natural) reservoirs and increase these water storage capacities (Yimer et al., 2024). Nature-based solutions also can include management of land and water demands for drought, such as ending overgrazing and moving or selling livestock to more secure areas. The chapter makes the case for the cost-effectiveness of NbS for drought but also recognises that all NbS measures can at least indirectly contribute to drought resilience. This chapter shows that because of their large co-benefits in terms of land productivity and provision of other ecosystem services, NbS are economically viable even without considering their drought impacts. NbS are hence an important win-win solution for drought resilience and can be considered a "no-regrets" option (Reichhuber et al., 2019).

2.1 Cost-benefit analysis as decision-support tool for nature-based solutions

Quantification of the benefits and costs nature-based solutions, and their systematic summary evaluation have long been used informally in household, institutional and public comparisons of management alternatives (Roman times ~52 CE, (Leveau, 1993, Lund, 2021). In modern times, since the 1930s formalisation of such comparative analyses has become called cost-benefit analysis. This has long taken on a formal role in government decision-making in many countries, including the US and many other developed countries (Arnold, 1988). Similar to financial evaluations in the private and banking sectors, such analyses provide an organised framework for evaluating, discussing, and comparing the merits of proposed projects and investments. Quantification and estimation of benefits and costs is always something of a fraught exercise (Flyvbjerg & Bester, 2021). However, cost-benefit analyses have improved the success and transparency of organisations and projects which employ such analysis.

The fundamental steps of cost-benefit analysis are summarised in Box 6, below and have been applied to efforts on land degradation neutrality with limited reference to drought (Quillerou and Thomas, 2012; ELD, 2015).

Box 6: **Overview of conducting cost-benefit analysis (Howe, 1971; ELD 2015)**

Purpose: To assess the economic, financial and risk management desirability of a project. Evaluation is always relative to some competing design or alternative. Financial evaluation considers only cash flows to land users, private sector firms, etc. whereas economic evaluation usually includes benefits to the total economy.

Steps in undertaking a cost-benefit analysis:

1. Choose and define an *accounting perspective*. Benefits and costs are to be estimated relative to what? The accounting perspective can be that of a region, agency, group, or individual.
2. Identify risks, benefits and costs over the lifetime and influence-life of the project.
3. Estimate the magnitudes of these benefits and costs in monetary units for each future time period.
4. Choose the evaluation criterion: Net present value, cost-benefit ratio, internal rate of return, return on investment, etc.
5. If necessary, select a discount rate appropriate for the purpose and accounting perspective of the evaluation.
6. Calculate the summary statistic for each design alternative.
7. Perform sensitivity and error analysis with respect to important uncertain parameters.
8. Compare and interpret results.
9. Later, compare realised benefits and costs of project against pre-project estimates to improve benefit and cost estimation methods and decision-making.

Many types of benefits and costs can be counted in evaluating nature-based solutions for drought resilience and other elements of drought management portfolios. These could entail direct and indirect costs, as well as transaction costs and non-market/intangible costs. Typologies of drought costs and benefits are detailed in Figure 9. Cost-benefit analyses are based on an accounting perspective which defines who is important for the analysis. Individual, group, local, regional, national, and global perspectives on a project can differ, which would be reflected in the inventory of benefits and costs for an action or portfolio and the valuation of each impact. The occurrence of these economic effects over time is also important. Some common benefits and costs are summarised in Table 4.

FIGURE 9 **Typology of drought costs and benefits** (Cuevas et al., 2024)

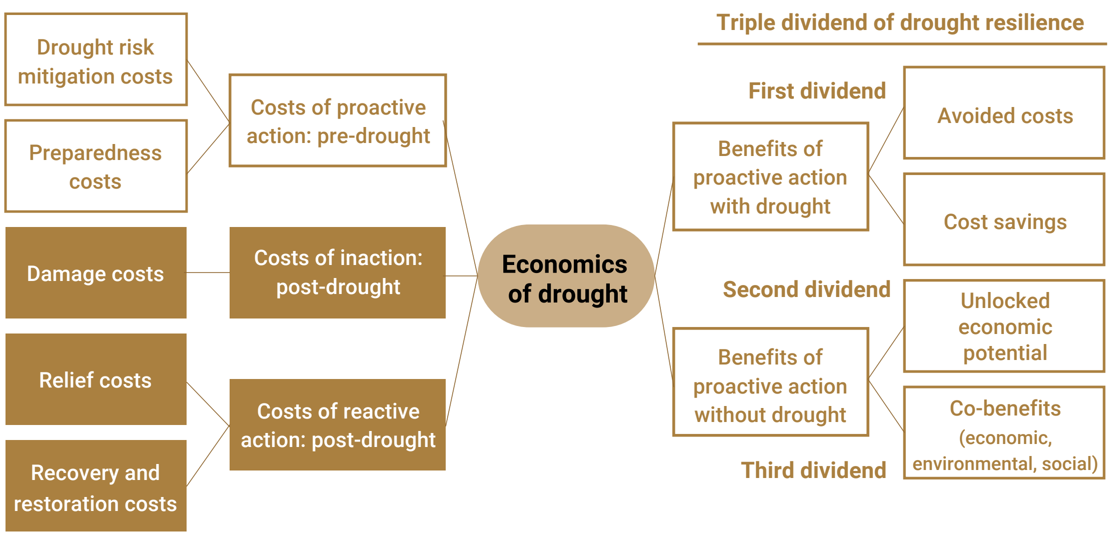


TABLE 4 Common examples of benefits and costs associated with farm-based nature-based solutions

Benefits	Costs
Household impacts	
Health, safety, and food security Water supply reliability Wages Crop yields and prices Sales of goods and services Property values Other external payments Reduced stress migration	Fees and taxes Time to manage (e.g., time to fetch water) Capital costs Labor investments, initial and ongoing Consumable production inputs
Community impacts	
Public health Social, environmental, and justice Property values (private and public) Jobs Water supply reliability	Capital investments Ongoing costs Labor investments, initial and ongoing Social mobilisation and capacity building
Regional impacts	
Public health Social, environmental, and justice Ecological health and biodiversity Reduced erosion and sedimentation Trade Jobs Water supply reliability Food security	Investments Material resource inputs (e.g., water) Water supply reliability
National impacts	
Public health Economic prosperity Social environment and justice Ecological health and biodiversity	Capital costs of water treatment and conveyance
Global impacts	
Public health Carbon sequestration Economic prosperity Ecological health and biodiversity Social, environmental, and justice	Greenhouse gas emissions

Discounted net benefits, cost-benefit ratios, and internal rates of return are the most common summary evaluation statistics for comparing alternative land management solutions. Benefit/cost ratios are a common and intuitively appealing dimensionless summary measure of economic performance but are subject to instabilities from the definition and aggregation of benefits and costs (Lund, 1992). Internal rates of return are also nicely dimensionless, but sometimes suffer from having several numerical solution values.

Box 7: **Challenges and stumbling blocks in the practical application of cost-benefit analyses**

The mathematics of cost-benefit analysis allows a wide range and immense numbers of benefits and costs, at different places and times, to be consolidated into a single evaluation statistic. While the math provides an organisation of the many impacts for evaluation, challenges remain in identifying the range of impacts and their quantification.

Challenges in the application of cost-benefit analyses often include:

- Unclear or mis-specified accounting perspectives, where benefits and costs are poorly identified for the area, people, and timeframe of a project or policy decision,
- Poor quantification of benefits and costs over the relevant area and time frame,
- Poor discount rate selection,
- Absent or poor consideration of future uncertainties or changes in conditions (such as demography, technology, or climate),
- Unsupported extrapolation of a small study (in space and time) to larger or different regional or national conditions,
- Poor comparison with relevant alternative conditions and actions (such as a no action, business-as-usual, competitive decision alternatives, or other control condition), and
- Valuation of community mobilisation, equitable sharing of benefits and management of natural resources for sustained benefits.

These problems need to be considered for the routine application of cost-benefit analysis, even in large and professionalized organisations with standards, training, and procedures for cost-benefit analyses, such as major regional and national governments and large national and international businesses and financial institutions (Flyvbjerg & Bester, 2021). Yet, these organisations still find that such formal financial and economic evaluations improve their decision-making and evaluations. Individuals, businesses, projects, NGOs, and units of government also often find that the rudiments of the cost-benefit approach structure and help improve deliberations and comparison of project and policy alternatives.

The fundamental cost-benefit approach has many institutional elaborations, standards, and manuals on methods. To enhance the comparability of project alternatives for institutions, large agencies, and countries often have detailed estimation and calibration procedures and specially trained staff and bureaucracies for cost-benefit analyses (for example, USEPA 2000). National governments often attempt to enforce standards for applying cost-benefit analyses across agencies (US OMB 2023; US OMB 2024; U.S. Water Resources Council 1993). Global agencies also have economic evaluation guidelines (Cuevas et al., 2024). However, on a global level little standardisation has been achieved so far.

Box 8: **Do economic assessments lead to better land management? Impact example - An economic valuation of a large-scale rangeland restoration project through the Hima system in Jordan**

In 2015 in Jordan, ELD carried out a study on the potential benefit of scaling-up the principle of "land rest and rotational grazing" from the Bani-Hashem community, to the whole of the Zarqa river basin. The results from the associated biomass estimates, hydrological modelling, and economic valuation were convincing. Pastoral communities stand to enjoy US$2 of benefits for every US$1 invested from enhanced biomass and health benefits to their livestock, while society would gain US$22 from every US$1 dollar of benefits, deriving mostly from reduced erosion and enhanced reservoir storage and improved groundwater infiltration. Over a 25-year time horizon, this amounts to US$207 million in benefits (in 2015 present value terms).

The study results were presented for key ministries at a high-level forum in Amman, hosted under the auspices of HRH Prince El Hassan bin Talal.

The case study informed various policy developments in Jordan:

1) **the Jordanian rangeland strategy was updated** to recognise the importance of the Hima-principle and provide the conditions for long-term land management rights for pastoral communities. Moreover, as a result of the efforts of the Agricultural Ministry to promote land rest, Jordan earned the "Future Policy Award" by the World Future Council for its planned approach to address Badia's rangelands through the "Hima" approach.
2) **Fodder subsidies that encourage overstocking of livestock**, without any connection to land carrying capacity were eliminated following the study, in alignment with the recommendations of the study.
3) **Informed Jordan's Green Growth National Action Plan, 2021 – 2025**, and associated action plan AG14. The GG NAP highlights that *"Large-scale implementation of the Hima approach, and ownership by local communities and agriculture sector stakeholders may be an excellent way to achieve green growth in Jordan, with the potential to generate net economic benefits of EUR 172-347 million to Jordanian society.* While one cannot claim that these outcomes were directly attributed to the study, it is highly likely that solid evidence from the ELD studies have helped build on existing momentum for the upscaling of the Hima approach.

Blogs, articles, e.g. the Ecologist special report, blog posts and citations, of the study, also point to "broader uptake". All this said, despite the best of intentions, efforts to restore Jordanian rangelands, policy efforts, have been undermined by the humongous challenge associated with the influx of millions of Syrian refugees.

Further information on this case study is provided in a separate appendix to this report, downloadable via unccd.int.

Cost-benefit analyses can be useful but are only partly determinative of actual project success. Their greatest value is often in organising the many considerations involved in relatively comprehensive comparative analyses and supporting more systematic comparative discussions of project and investment alternatives.

2.2 State of knowledge: Economic assessments of nature-based solutions for drought-resilience

In the early 20th century, agriculture in the United States, Australia, and other countries suffered from excessive erosion and drought. The US Federal government sought to stabilise and expand agriculture in light of these problems and accommodate sizable immigration. This led to a series of federal and state government and academic studies since the 1930s forming the Soil Conservation Service (today, the Natural Resource Conservation Service) and other government agricultural and land use advisory and regulatory programs (Delgado et al., 2020; Wallender et al., 2020). These studies went beyond the mere technical effectiveness of a range of soil and environmental conservation practices, and often included economic performance, finance, communications, institutional, and behavioural aspects of these very successful nature-based solution programs, as they would be called today. Australian states developed similar programs in this era (Hannam, 2003). Such historical studies have supported and justified many national land and water management programs that exist today, beyond the US.

Today, the potential for using nature-based solutions for disaster risk reduction (DRR), climate change adaptation and climate change mitigation, is recognised by major national policies and international framework agreements. By the same token, the scientific evidence of their economic viability and equity impacts are increasingly surfacing in scholarly work (see Vicarrelli et al., 2024; Debele et al., 2023 and Chausson et al., 2024)

The economic case for investing in NbS is typically assessed, using cost-benefit analysis (CBA) or cost-effectiveness analysis (CEA). In simple terms, **CBA** seek to quantify all of the costs and benefits of an intervention (project or program), in monetary terms, to assess if benefits outweigh the cost of the intervention, and if so by how much? As such, CBA allows for evaluating different investment options to choose the one which maximises societal welfare.

CEA, on the other hand, compares the relative cost of two or more interventions (e.g. green versus grey infrastructure), in terms of their ability to reach a certain well-specified outcome. When the objective is precisely defined, – for example to reduce the probability of meterological drought - cost-effectiveness is often chosen as an evaluation tool. DRR benefits from protective services are often estimated, in relation to the avoided damage costs (thanks to the protection offered by the NbS), or the avoided replacement cost that would be required to substitute the NbS studied with an engineering-based solution.

Cost-effectiveness and disaster risk reduction from NbS

In a recent assessment of 529 Eco-DRR studies published between 2000 and 2021, Vicarelli et al. (2024) compare the cost-effectiveness of NbS (mangroves, forests and coastal ecosystems) and engineering-based solutions, for mitigating certain hazards. Convincingly, Vicarelli et al. (2024) showed that the majority of NbS are always more effective in attenuating hazards compared to engineering-based solutions and a quarter of NbS are partially more effective, but never less effective. Eight of these studies, consider NbS as a means to reduce droughts. The study reveals that ecosystem conservation is more efficient than restoration for eco-DRR, because protection is achieved at a lower cost.

In another comprehensive, meta-analysis of 456 NbS for hazard management, Debele et al. (2023) shows that most of the NbS are enacted in response to floods (~42 % of case studies implemented to manage fluvial floods, flash floods, urban floods, and coastal floods), followed by erosion (~21 %), droughts (~11 %) (including agricultural, hydrological, meteorological, and socio-economic droughts), heatwaves (~8 %), followed by lesser traded storm surge (~5 %), eutrophication (~4 %), and landslides (~3 %) hazards, whereas wildfire, seawater intrusion, strong wind, wildfire, snow avalanche, cold wave (in total ~4 %) being the least focussed and addressed ones.

The case for multi-purpose hazard management

Measures such as water harvesting can be developed to deliver multi-purpose flood and landslide prevention in addition to drought hazard management (Debele et al., 2023). Considering that floods and droughts are two extremes of the same hydrological cycle, the application of multi-functional NbS can offer significant potential for multi-hazard-risk reduction, specifically under future climate change conditions (Chausson et al., 2020; Ward et al., 2020). However, in reality DRR measures and strategies usually focus on either floods or droughts. Therefore, actions taken to decrease risk from one hydrological extreme (e.g. flood) may unintentionally lead to an increase in risk from another hydrological extreme (e.g. drought). To better design disaster risk reduction (DRR) measures and strategies, it is important to consider interactions between these flood and drought risk.

Besides protective services (e.g., reduction of floods, droughts, heatwaves), NbS often generate additional long-term benefits to society and co-benefits (e.g., improving vegetation cover and biodiversity, carbon storage in soil, job creation, physical and mental health) while generating limited disbenefits (e.g., increased pollen in the air, mosquitoes), thus proving cost-effective on a medium to long-term perspective (EC, 2015).

In the absence of a comprehensive cost-benefit analysis, these co-benefits are likely to be underestimated. To add to the global knowledge base, and showcase some of these co-benefits, this report also summarizes results from new and ongoing studies that apply nature-based solutions for drought management purposes in places across the globe.

TABLE 5 Overview of case studies for this report

Further information on case studies is provided in a separate appendix to this report, downloadable via uncc d.int.

Case study country	NbS practices	Other categories
Australia Mulloon Institute	Water management	Enabling environment, governance
Burkina Faso ICRAF, IUCN	Agroforestry	Enabling environment
Cape Town, South Africa TNC	Water management (watersheds), ecosystem restoration	Enabling environment
Chile National Forestry Corporation	Water management, agriculture	Enabling environment, private sector, governance
India WOTR	Water management, watershed restoration, reforestation	Enabling environment, governance
Jordan ELD, IUCN	Grasslands / pastoralism	Enabling environment, governance
Kenya NDMA, IUCN	Grasslands / pastoralism	Governance, peace building
Sao Paulo, Brazil TNC	Urban green, restoration	Governance
Spain Commonland	Holistic landscape management and restoration (incl. regenerative agriculture, reforestation, water management)	Enabling environment, governance, finance
Tunisia GIZ, ELD	Agroforestry, soil and water conservation	Enabling environment

2.3 Direct benefits of nature-based solutions for drought resilience

Nature-based solutions for drought management offer climate change mitigation, adaptation and disaster risk reduction benefits. From an economic perspective, avoided or reduced incidences of droughts, and related risks, such as fires, floods and storms, translate into lower economic costs of damage to infrastructure and crop production. Other direct benefits relate to enhanced cropland productivity, under mitigated heat-stress, and alternative income sources, from e.g. regenerated conservation areas, when other sources of income are lost or reduced due to droughts (Roe et al., 2021; Westerberg et al., 2020).

Evidence is accumulating that the introduction of NbS brings both economic benefits to drought prone areas and adds further benefits for major global challenges including climate change and carbon sequestration, loss of biodiversity (Reichhuber et al., 2019). Other co-benefits include improved water quality, human health and well-being, food and timber production and recreation (Seddon et al., 2020).

Box 9: **The economic benefits of drought resilience building in Eastern Africa**

An Eastern Africa study estimated that every US$1 invested in resilience over 15 years will result in between US$2.3 and US$3.3 in reduced humanitarian assistance and avoided losses. The study compared a range of investment and response scenarios that demonstrate early humanitarian response, safety nets and investments in resilience are far more cost effective than responding after households are engaging in negative coping strategies and prices are destabilised. The study also found that investing in a more proactive response to avert humanitarian crises could reduce the cost to international donors by 30%, whilst also protecting billions of dollars of income and assets for those most affected (Cabot-Venton, 2018).

2.3.1 Nature-based solutions for drought resilience, food and water security

Evidence shows that NbS lead to a significant reduction in drought costs. Water saving technologies reduced drought costs in Iran by US$282 million (Salami et al., 2009). A counterfactual thought experiment for Sao Paolo, Brazil, indicated that NbS would have reduced the economic cost of the 2014-2015 drought by 28% (Ciasca et al., 2023; see also Box 10). Holden et al. (2022) modelled catchment restoration via the removal of invasive trees that indicated an improvement of 3-16% in water flows (see also Box 17). In Kenya the terraces and grassed waterways increased water flows by 8% and increased shallow groundwater aquifers by 5% (Gathagu et al., 2018). Although many more case studies are required, drought risk mitigation approaches are less costly than providing drought relief after drought occurrence and that through consideration of co-benefits are 'no regret' strategies (Gerber & Mirzabaev, 2017). In Burkina Faso, the use of Zai pits secures crop yields on previously degraded land, in situations of drought, when conventionally managed land fails produce harvest (ANSD, 2023)

Box 10: **Economic cost of drought and potential benefits of investing in nature-based solutions: a case study in São Paulo, Brazil by The Nature Conservancy**

Despite its rich water resources, Brazil is increasingly facing extreme hydrologic events such as droughts and floods. The Sao Paulo Cantareira water supply system (CWSS) offers an opportunity to examine the potential economic benefits of nature-based solutions (NbS) to improve water security and reduce the economic cost of drought. The case study assesses the potential benefits under a counterfactual NbS land-use scenario compared to actual land use and the economic viability of NbS investments in the CWSS.

The economic cost of the 2014–2015 drought in Sao Paulo state for the industrial and water sectors served by the CWSS are estimated at a total of BRL1.6 billion. If NbS had been implemented, this cost could have been reduced by 28% (avoided damage cost). A cost–benefit analysis that includes only the water supply or both the water supply and carbon sequestration benefits indicates that the NbS scenario has a positive net present value of BRL144 million and BRL632 million, respectively. The results therefore make a strong case for the economic viability of the hypothetical NbS investment in mitigating extreme climatic events (Ciasca et al., 2023).

2.3.2. Nature-based solutions for integrated drought and flood resilience

By improving soil structure and moisture retention, NbS, embedded in regenerative, agroecological and sustainable land management practices, enable soils to store water, improve infiltration and availability, and reduce water losses invariably reduce vulnerabilities to drought. Such land management practices include conservation or no tillage, FMNR, crop rotations, stone barriers, terracing, mulching, and various water harvesting interventions such as keyline swales and small dams – all of which help slow down run-off and increase the water retention capacity of soils.

For example, conservation tillage which improves soils structure, was three times more profitable than that of conventional tillage in maize-legume systems in arid regions of Malawi (Ngwira et al., 2013). In central Kenya, conservation tillage also resulted in higher profits in less fertile drier fields than conventional tillage (Guto et al., 2012). In Ethiopian Nile basin Kato et al. (2011) found that stone bunds and grass strips decreased production risks from climate variability. This same NbS increased crops revenues by 17-27% in Ethiopian highlands (Pender & Gebremedhin, 2007).

Water harvesting interventions, are often integrated in headwater catchments of rural semi-arid and arid regions to reduce runoff, increase infiltration, and reduce flood risk downstream. These interventions are often used for restoration of the productivity of land with insufficient precipitation, increasing productivity of rainfed agriculture, and minimising the risk of drought and desertification (Prinz et al., 1996). The major advantages of water harvesting interventions are that they are simple, cheap, replicable, efficient and adaptable (Reij et al., 1988) However, wrongly implemented or upscaled interventions may result in increased topsoil erosion and gully formation, and therefore increased sedimentation and flood risk downstream (Ward et al., 2020). Considering that drought or flood DRR measures can have (unintended) impacts on risk of the opposite hazard, more holistic risk management approaches and economic valuation assessments, of both direct and indirect outcomes are crucial.

Box 11: **India case study**

Droughts are a recurrent phenomenon in India leading to significant hardships for affected populations. Unsustainable land use practices intensify vulnerability in semi-arid regions through soil degradation and water scarcity. The case study performed a counterfactual assessment comparing long-term NbS impacts in villages with and without NbS interventions.

The study demonstrated the effectiveness of SLM in climate-vulnerable semi-arid regions of Maharashtra. SLM measures including water budgeting, agro-metereological advisories, crop planning and watershed structures were implemented from 2010-2014. Soil erosion was reduced overall by 24.7% compared to a 2.8% increase in control villages. Through active participation local communities have effectively restored degraded resources and enhanced ecosystem services, resulting in increased water retention and a reduction in the need for water tankers. Remote sensing analyses confirmed improved land productivity and cropping intensity in project villages over a 10-year period, increasing resilience against adverse climate impacts compared to control villages. The overall cost-benefit rations of the interventions ranged from 1.15 to 1.91 of societal and financial returns for every dollar invested. Agro-metereological advisories significantly helped villagers adapt crop cycles to changing rainfall patterns, increasing yields and reducing water dependency.

Sustainable land and ecosystem management significantly enhanced the drought resilience of rural communities. This integrated SLM approach not only boosted production but also strengthened the adaptive capacity and resilience of local communities to climate extremes.

Further information on this case study is provided in a separate appendix to this report, downloadable via uncccd.int.

Box 12: **The Nature Conservancy: Nature-based solutions are protecting Cape Town's water supply**

In 2018, after three years of severe drought, the city of Cape Town, South Africa nearly ran out of water, requiring the city to implement severe water rationing. This event raised awareness and motivated policy makers and water managers to look for additional ways to build drought resilience for a rapidly growing population. Along with a strong tourism economy, water demand is predicted to grow at 3% per year.

Nature-based solutions (NbS) are a critical component of water management for Cape Town. The local ecosystem of its source water catchments was overrun with thirsty alien invasive species, removing an estimated 55 billion liters of drinking water from the aquifer per year. Removing these invasive species is a win-win -- native biodiversity can thrive again, jobs are created, and Cape Town residents benefit from an increased water supply at the source. In South Africa, alien invasive plants including pines, gums and wattles, are a major threat to water supply and water security. Through their excess uptake and evapotranspiration as compared with native flora, negatively Cape Town and the surrounding areas.

As of October 2023, working teams have cleared more than 46,000 hectares of invasive trees. This recovers about 15.2 billion liters of water per year (42 million liters per day) back into the water catchment and keeps the rivers flowing. This has created 722 green job opportunities, nearly half of which are held by women. About 150 of those jobs are for trained technicians. In a region grappling with severe unemployment, green jobs provide opportunities for underserved communities. The Greater Cape Town Water Fund is returning billions of liters of water to this area of South Africa (Holden et al., 2022).

2.4 Broader benefits of nature-based solutions in addition to direct drought benefits

NbS provide a large range of benefits - water provision, food security, support for ecotourism, peacebuilding, disaster risk reduction and gender equality etc. Due to the multitude of public benefits, it is crucial that policy and project appraisals, consider these plural market and non-market values, so as to stimulate policies that are inclusive and respond to human well-being beyond short-term economic objectives. For that purpose, the following section presents a further set of case-studies, where multiple public and private benefits are accounted for.

2.4.1 Overall benefits: The majority of nature-based solutions are economically viable

Nature-based solutions (NbS) generally offer higher economic returns than conventional practices both in drought-prone areas and on marginal soils as well as in non-drought prone areas. Many NbS approaches, such as conservation agriculture, agroforestry, and other SLM practices support drought resilience without sacrificing profits during wet or normal years. While these practices might show low or neutral short-term cost-benefit ratios, their long-term financial gains are substantial, with studies indicating social returns of five dollars for every dollar invested in land restoration within six years (Nkonya et al., 2016; Reichhuber et al., 2019).

Case studies implemented as part of the Economics of Land Degradation (ELD) Initiative since 2011 show a range of cost-benefit ratios for nature-based solutions between 1 and 27. Only very few NbS have shown a negative return on investment (see Table 7). BCRs reported in Table 7 are mainly based on financial increases in agricultural and agroforestry production and improved water management using a median discount rate equivalent to national bank lending rate with time periods varying from 5-30 years. Some estimates include economic benefits to society.

TABLE 7 Cost and benefit ratios of nature-based solutions

Country	Topic	Reference	Cost-benefit Ratio
44 Asian countries: 7 countries[3] 15 countries[4] 9 countries[5] 3 countries[6]	Prevention of soil erosion and nutrient on agricultural lands in	ELD, 2018	3-7 1.5-3 1-1.5 <1
Cambodia - ANG Tapeang Thmor Lake	Sediment management and watershed rehabilitation; Protected area restoration and management, forest restoration, development of riparian buffers and biodiversity safeguards; wetland restoration, reservoir zoning and water management; and development of an integrated approach to watershed, drought and flood management	ELD, 2023	3
Ethiopia	SLM technologies such as stone or soil bunds, terracing, and area closure. Period 2020-2030. increase agricultural productivity from 1.89 to 9.92 t/ha/year	ELD, 2015	4-4.6
Ghana	Farmer Managed Natural Regeneration (FMNR) with combined crop rotation for re-greening efforts in the Upper West Region of Ghana	ELD, 2019	3-3.8
India – 8 villages	Area treatment and afforestation on forest lands and private lands, drainage line treatment, capacity enhancement, institutional building, and promotion of agriculture and livelihoods.	ELD, WOTR, 2020	3-4
Jordan	Improved grazing management of rangelands BCR for land users BCR for society	ELD, 2015	2 21
Kenya – Aberdare water tower	Agroforestry, crop rotation; Rangeland management	ELD, 2020	2 1.4
Kenya – Western Kenya	Soil fertility management, manuring, intercropping, terracing, agroforestry	ELD, 2016	1-2
Rwanda	Land restoration, agroforestry, improved irrigation and fertilisation, combined agroforestry and crop production	Lal et al., 2020	1.4-1.8
Somalia – Baligubalde & Bookh rangelands	Rangeland grazing reserve management	ELD, 2021	6-10
Somalia – Puntland Somalia	Community-led grazing reserve management (CGRM) practice	ELD, 2021	27
Somalia – Puntland	Rangeland grazing reserve management	ELD, 2021	11-12
Sudan – Eastern Sudan	Agroforestry & reforestation	ELD, 2015	3-27
Thailand - Cambodia boundary – Popet and Aranyaprathet towns	Retention and infiltration of rooftop runoff, permeable surfaces, retention and infiltration of surface runoff, river channel widening and rehabilitation and river bank stabilisation and rehabilitation, urban greening	ELD, 2023	8 Poipet 1 Aranyaprathet
Thailand - Sompoi reservoir	Reforestation, riparian buffers, sedimentation barriers, irrigation	ELD, 2023	4
Tunisia	Agroecological practices for olive and cereal production including conservation agriculture, organic farming, water management and erosion control. Farmers gain 42% of the benefits, government 54% and society 4%	ELD, 2023	12-14

NbS need to be carefully catered to the site in which they are implemented. Their benefits are therefore also highly context dependent. In India, conservation tillage in rice-wheat systems became profitable within 2–3 years, with cost savings and yield increases contributing equally to profitability. In Malawi, conservation tillage proved three times more profitable than conventional tillage for maize and legumes in arid regions, while in Kenya, it was more effective on less fertile soils. Cover crops in the U.S. also enhanced ecosystem services without impacting primary crop yields, though their higher establishment costs make subsidies or higher fertilizer prices necessary for adoption (Reichhuber et al., 2019).

Box 13: **Mulloon Rehydration Initiative: Drought resilience innovation in action - costs and benefits of landscape rehydration and sustainable land management in Australia**

The *Mulloon Rehydration Initiative* (MRI) demonstrates how landscape rehydration and sustainable land management (SLM) can enhance drought resilience and deliver measurable economic benefits. Spanning 23,000 hectares in New South Wales, Australia, MRI's approach includes in-stream structures and riparian vegetation to improve water retention and soil health, supporting both agricultural productivity and environmental sustainability.

The initiative's annual costs, including $100,000 for stream rehabilitation, $25,000 for vegetation restoration, and $400,000 for monitoring, maintenance, and community engagement, total $525,000. These investments yield $650,000 in annual economic benefits, with gains from increased agricultural productivity ($300,000), water savings ($100,000), water quality improvements ($150,000), carbon credits ($50,000), and educational outreach ($50,000). This results in a net benefit of $125,000 per year, showcasing the financial viability of rehydration practices.

Scaling these practices across drought-affected areas in Australia could generate $1.3 billion annually, with a net national benefit of $575 million, after offsetting estimated annual costs of $725 million. The MRI's successes align with initiatives like Australia's Future Drought Fund, offering a replicable model to support agricultural productivity, water security and social resilience.

In summary, the MRI underscores that landscape rehydration is both economically viable and environmentally sustainable, with potential to significantly bolster Australia's resilience to drought.

Further information on this case study is provided in a separate appendix to this report, downloadable via unccd.int.

2.4.2 Economic benefits

Income and yields: NbS increase agricultural productivity and resilience and leads to better incomes for land users even in the absence of drought

The economic benefits from the implementation of NbS can be substantial depending on the scale. Controlling soil erosion and nutrient loss on croplands in Asia can yield US$4.2billion or $8,663 per hectare over 12 years (Tilahun et al., 2018). In Ghana, farmer managed natural regeneration combined with crop rotation provides an average additional income of US$104 per household/year (or 110/ha/per year) in terms of enhanced crop production and forest produce – representing a substantial addition to household incomes, in the light of an estimated food poverty line of US$137 per year/person (Westerberg et al., 2020). SLM technologies such as soil cover, mulching, conservation tillage applied to 12.8 million ha of agricultural land farmed by small holders in Ethiopia would yield a net present value of US$295 billion or 30,706 per ha over 2020-2030 (Tilahun et al., 2018).

More generally, sustainable land management and regenerative farming typically drives enhanced profitability from one or several pathways, including:

- greater yield (e.g., integrated crop-livestock farming and FMNR (Rosa-Schleich et al., 2019; Westerberg et al., 2020).
- reduced dependence on expensive inputs (BCG, 2023).
- access to premium prices in markets (BCG, 2023, Rosa-Schleich et al., 2019).
- the generation of multiple income streams, from diversified agricultural production, or carbon or nature credits, and other PES schemes (Brescia at al., 2023).
- reduced risk of economic loss, through the adoption of more drought resilient crops, or practices, such as crop rotation, intercropping, agroforestry (Rosa-Schleich et al., 2019; Reichhuber et al., 2019).

Private and public economic benefits can also arise when NbS reduce local conflicts and geopolitical instability through better management of natural resources (Chasson et al., 2024).

Pathways for higher income, revenue, or profitability fall into five overarching categories: 1) higher or new revenue generation (e.g., from the sale of goods (e.g., fish, NTFP, crops), services (e.g., offset credits), or property taxes), 2) avoided costs (e.g., energy savings from green roofs and walls, or reduced input costs for agriculture), 3) household income from employment generation, 4) labor shifts to off-farm jobs, which can be higher paid, and 5) household, business or community revenue from subsidies or payments for ecosystem services (Chausson et al., 2024).

Economic growth and employment: Large scale implementation of NbS can spur economic growth and employment.

Macro-level assessments of large-scale NbS implementation and resulting impacts on the GDP of countries and employment effects are starting to be on the menu of assessment approaches largely spurred by innovations of relevant methods and models (e.g. the integration of InVEST with GTAP or the IEEM modelling platform; e.g. Johnson et al., 2021; Banerjee et al., 2020). National-scale economic growth assessments, however, are still scarce (Chausson et al., 2024).

Available evidence points towards positive effects of NbS – and particularly those associated with higher productivity and income generation – on GDP growth and employment. Modelling from Rwanda indicates that national scale implementation of NbS measures through among others higher crop yields would lead to a GDP that in 2035 is up to US$1.1 billion to US$1.4 billion higher than the respective baseline GDP (Lal et al., 2020). Controlling and reversing just soil erosion and nutrient loss in 31 Asian countries for 13 years would cost US$1.21 billion with a resulting benefit of US$4.21 billion and additional rural employment numbers of 18-87 million jobs based on variable wage rates (Tilahun et al., 2018). The implementation of policies designed to maintain biodiversity and ecosystem services can increase global GDP by up to US$150 billion annually (Johnson et al., 2021).

Employment opportunities not only arise from direct jobs in the restoration or conservation business but to a much larger extent from opportunities in nature-based sectors and value chains. The World Economic Forum estimates that a nature-positive economy could generate up to US$10.1 trillion in annual business value and create 395 million jobs by 2030 (WEF, 2020). A more cautious estimate of ILO, UNEP and IUCN looks at an additional 20 million jobs that could be generated worldwide if investment in NbS were tripled by 2030 (ILO, UNEP and IUCN 2022).

Other evidence however also to possible financial risks that economies might face in light of conservation-related land use constraints through, for example, a significant expansion of protected areas as agreed to under the CBD Global Biodiversity Framework (Kedward and Poupard, 2024).

Large-scale implementation of NbS cannot get around sophisticated land-use planning that is sensitive to different outcome dimensions (such as productivity, climate benefits, biodiversity, other ecosystem services) and therefore identifies and balances possible trade-offs and maximises synergies. So-called "frontier" approaches aim to maximise certain outcomes but not on the expense of other aspects (Johnson et al., 2021). From a landscape finance perspective large scale integrated landscape planning is important. To build the business cases for SLM or holistic landscape management (HLM), Commonland in collaboration with The Nature Conservancy, EcoAgriculturePartners, World Resources Institute (20x20 Initiative), IUCN CEM, demonstrating the similarities and differences of financing needs for large-scale infrastructure projects versus HLM (which may include sustainable grey and green infrastructure development), see figure below (Gutierrez et al., 2023).

2.4.3 Wider ecosystem service benefits

Ecosystem services

Many NbS interventions provide valuable ecosystem services beyond crop productivity, such as biodiversity conservation, soil health and climate regulation, which benefit society. Measures aimed at conservation or restoration of ecosystems from 9 biomes, including coral reefs, forests and rangelands were generally found to be beneficial in terms of economic benefit-cost ratios (De Groot et al., 2013). These estimates indicate that restoration of ecosystems through NbS can provide benefits for all major ecosystems.

Box 19: **Cost-benefit analysis of parkland agroforestry systems in Burkina Faso**

The Sahel region, including Burkina Faso is very prone to drought. In the Sahel, agriculture is often practiced amongst scattered trees and shrubs in the parkland agroforestry systems that constitute the predominant land use. The management of these parklands systems reflects the ecological knowledge of farmers in such drought-prone environments. The agroforestry parkland system in Burkina Faso can be improved through systematic integration of trees (tree planting, direct seeding or Farmer Managed Natural Regeneration) to increase tree/shrub density and species diversity. This can be combined with contour bunds for soil and water conservation. These interventions generate higher net present value compared to the business as usual where farmers typically intercrop maize, sorghum, millet, ground nuts or cotton with a few naturally occurring trees. The increase in value is attributable to the ecosystem services generated by the improved agroforestry system and contour bunds, mainly improved soil moisture and water infiltration, carbon sequestration, soil erosion control and nitrogen fixation by the management of the agroforestry trees.

The case study will be published soon.

Societal benefits

Societal benefits often exceed private gains, making subsidies vital to offset the initial adoption costs and sustain NbS practices long enough to achieve profitability. For example, the use of native plants for water conservation in California paid off after 2–3 years, demonstrating that initial costs can be justified by long-term economic and environmental gains (Reichhuber et al., 2019). The vital role of NbS for reducing vulnerability to climate change whilst increasing carbon sequestration and reducing emissions is now widely recognised (Chausson et al., 2020; Girardin et al., 2021). Often overlooked is the restoration of pride, culture and a sense of place that catalyzes greater community collaboration (Ferwerda & Gutierrez, 2021; Gutierrez et al., 2023).

Food security

Different nature-based solutions (NbS) practices can improve all aspects of food security by boosting crop yields and livestock productivity, thus enhancing food availability. These practices also raise agricultural incomes, improving access to food and helping to stabilise food consumption during droughts. Crop diversification through rotational practices further contributes to nutritional security, particularly for smallholder farms. Examples include increased food security in West Africa through rotational grazing and improved often poly-cropping cereal yields in Kenya and Morocco due to conservation tillage (Reichhuber et al., 2019).

More even, impact measurement studies on the impact of poverty reduction, pride (return of inspiration), and income at the Grain for Green Program in the Chinese Loess Plateau show that after several years a majority of stakeholders gave positive feedback (Hao Chen, 2021).

Gender-specific impacts

While drought and environmental degradation disproportionately impact women due to their limited access to resources, several studies have found that nature-based solutions can provide more equitable land holdings and social stability (Duffy et al., 2021), improved gender equity (Angom et al., 2022), or increased employment for marginalised groups (Bezner Kerr et al., 2022). In some cases, however, the labour burden disproportionately fall on women (Bezner Kerr et al., 2022).

By the same token, ELD studies have shown that sustainable land management practices are often spearheaded by women. In the cotton producing regions of Mali and Benin for example, women are typically granted a plot of land, when it is too degraded to support cotton production. This forces them to be innovative and work with nature-based solutions to regenerate soil health, they therefore tend to be the first to adopt regenerative and organic farming practices.

Nature-based solutions, can also encourage the empowerment of women, and their contribution to the formal economy, by allowing them to start new businesses (Lamptey et al, 2013). Groundswell International (Brescia et al., 2023) provides plentiful of examples from their NGO members, where women groups are empowered to generate cash income for their households through agroecological innovations and the transformation of produce harvested from the regeneration of ecosystems.

In other contexts, where civil society organisations are not as present, women may face greater challenges in adopting NbS due to restricted access to resources and advisory services.

On the basis of a large meta-analysis, Chaussons et al. (2024) found that social inequity occurs when interventions were not tailored to the needs of different groups, including consideration of vulnerabilities embedded in the sociocultural and governance context. Addressing these disparities, the UNCCD's Gender Action Plan encourages stakeholders to implement gender-responsive programs, emphasising women's role in developing innovative solutions to cope with drought impacts (Reichhuber et al., 2019).

2.5 Building business cases for nature-based solutions

2.5.1 Context dependency of business cases

Business cases for investing in nature-based solutions should depend on the business you are in. For a policymaker with global concerns, a primary business case includes all impacts (benefits and costs) to all people anywhere. For a subsistence farmer, the business case is built on food reliability, household health, reduced expenses, improved profitability of farming, and long-term viability of farmland productivity. For farmers and rural residents increasingly involved in a market economy, evaluation will be driven by financial concerns and the reliability of new cash flows. For regional and national governments, evaluation includes financial and societal accounting for benefits and costs, but purely financial evaluation also is needed. For all these perspectives, business cases for applying nature-based solutions are examined (formally or informally) in terms of cost-benefit analyses.

Within an increased understanding of how our supply chains depend on nature, another emerging driver of investments into NbS stems from corporate interest in securing supply chain resilience of key commodities and raw materials, to avoid stopped operations, damaged assets and disrupted supply chains, due to climate hazards.

NbS insetting for example involves organisations working closely with local communities to take actions to address the nature, social, and climate impacts, risks and opportunities within their supply chains and associated landscapes. e.g. changing agricultural practices to use less water, increasing resilience of supply in water or heat stressed areas.

Many **tech solutions are also emerging** which can support the financing and origination of NbS projects, by monitoring ecosystems and tracking land use and biodiversity changes, and allowing for the generation of biodiversity and carbon credits. **Monitoring, reporting, and verification (MRV)** of is essential for measuring the impacts of interventions on nature. In addition to providing transparency and accountability, MRV solutions support data-driven decision-making, which can help mitigate risk, highlight nature-positive business opportunities, and build trust in the voluntary carbon market and biodiversity markets (see for example Box 20).

Box 20: **Using MRV platforms to generate financing for nature and climate**

With the natural capital management platform 'Landler' the Landbanking Group offers AI-powered measurement, reporting, and verification (MRV) tools to track various environmental parameters like carbon, water, biodiversity, and soil health. This data is used to generate natural capital accounts, which are tools to continuously monitor the ecological health of any piece of land on the planet. Whenever an improvement is recorded on a natural capital account, for example a one tonne increase in soil carbon storage or a one litre increase in soil water holding capacity, Landler generates a "natural capital unit". Businesses can purchase natural capital units directly from land stewards. In other words, they can invest in measured, holistic nature impact. Natural capital units can be booked as green assets on balance sheets and used as building blocks to create outcome-based financing instruments.

Source: Nature4Climate 2024 (https://nature4climate.org/wp-content/uploads/2024/10/nature-tech-report.pdf)

When implemented with integrity, organisations that implement in NbS will find it easier to meet disclosure requirements and align with corporate frameworks relating to net zero and nature positive commitments, and upcoming mandatory environmental and social due diligence regulations such as the European Corporate Sustainability Reporting Directive (CSRD); and other corporate reporting standards (WBCSD 2024)

Investment in NbS insetting or offsetting could help to fill the financing gap for nature and climate. However, while corporates and their financiers have a vested interest in supporting supply chain resilience, NbS require upfront and long-term financing. To drive NbS investments at scale, all actors in the financial system will need to play a role, including banks, governments and other lenders.

Cost-benefit analysis, is once again a powerful tool to assess the financial and societal returns from NbS investments. When augmented with verifiable and auditable monitoring tools, such as eDNA, biosensors, remote sensing drones, and geographic information systems, a solid foundation can be made for tracking nature returns and performance over time.

Key to developing a business case is the costs of undertaking cost-benefit analyses which relate to the questions being asked and the level of precision required to obtain reliable analyses. Table 8 shows how the degree of precision needed in CBA related to the use of the valuation. Costs increase as precision moves from low to high.

TABLE 8 **The range of uses for CBA** (adapted from Kubiszewski et al., 2022)

Use of CBA	Appropriate values	Appropriate spatial scale	Precision needed
Raising awareness	Total values, macro aggregation	Regional to global	Low
National income & well being	Total values by sector and macro aggregation	National	Medium
Specific policy analysis	Changes to policy	Multiple	Medium to high
Urban & regional land use planning	Changes in land use scenarios	Regional	Low to medium
Payments for ecosystem services	Changes by actions	Multiple	Medium to high
Full cost accounting	Total values by business product or change in product	Regional to global depending on scale of business	Medium to high
Communal planning	Total costs to assess capital & changes to incomes & losses	Regional to global	Medium

2.5.2 A new asset class: Challenges to overcome for solid business cases of nature-based solutions

In evaluating economic net benefits from nature-based solutions and related government policies, existing studies raise several concerns and challenges:

Uncertainties in benefits

As with all cost-benefit analyses, future benefits can be murky, especially further into the future. The more experimental and non-traditional nature of many nature-based solutions makes the estimation of their benefits likely to be more uncertain. These uncertainties are especially important where they tie to the financial structure and amounts needed to implement the project and sustain it into the future, covering operation, maintenance, and upgrade costs.

Agroforestry systems are prone to uncertainties as they are complex and locally conditioned (Wainaina et al., 2020). New tree plantings can need years to decades for benefits to materialise (e.g., fruit, fodder, & timber yields from tree plantings) (Miller et al., 2021).

Farm and pasture/range based agro-ecological/agroforestry land management can suffer from leakage effects if increased costs and reduced financial returns of the new practices leads to expansion elsewhere with lower cost and/or higher productivity, but more damaging practices (UNEP, 2020)

Private and financial gains to farmers can be sensitive to many uncertainties, including speed and scale of adoption, the discount rate, the time to steady state production, and the analysis timeframe. These pose risks for innovators, particularly for the small, poor, and risk-averse. Lumley (1997) examining small farmers in the Philippines found that discount rates as high as 40–50 % more appropriately represented the cash/survival preferences of resource-constrained farmers.

Some methods to better understand these uncertainties and how they affect project evaluations include:

a) Use of biophysical modelling to better understand carbon sequestration, biodiversity, and crop yield dynamics into the future. Such modelling can be expensive and time-consuming and should not be expected for most applications, beyond establishing deeper understanding of processes and general parameters for simpler applied models.
b) Sensitivity analysis on a wider range of parameters of concern, beyond discount rates such as market prices, costs, biophysical model parameters, regional multipliers, and their reliabilities. Experimental numerical studies with these methods can help benchmark reasonable characterisations of uncertainties for simpler routine analyses.
c) Financial arrangements that provide contingencies and backstops for financial uncertainties, such as insurance and contracts. These must work for local and regional financial institutions and conditions.

Given lack of clear evidence (Miller et al., 2021; Yimer et al., 2024), localised variability, complexity, and changing returns to scale, Wainaina et al. (2020) and others argue for the importance of sensitivity analyses on cost-benefit analysis assumptions. However, systematic literature review of published cost-benefit studies for NbS for land-based restoration shows sensitivity analyses (except for the discount rate) are rare (Wainaina et al., 2020). Two cases, one varying both biophysical performance modelling inputs and economic assumptions (Lueding & Neufelt, 2012 examining re/establishment of parkland systems (~ 200 trees/ha) in appropriate eco-zones in the Sahel) and one varying CBA input assumptions about project implementation (e.g., speed & scale of adoption/roll out, yields, prices). Ideally biophysical modelling of performance would be useful, but few case studies use it (Bertel et al., 2020). No case studies used biophysical modelling to examine performance variability from uncertainties or the effects of future projected climate changes on biophysical performance. UNEP NbS thematic brief (2020) and others (Yimer et al., 2024) call for more biophysical modelling in economic assessments.

Maturation time and cost barriers of NbS

Primary ecosystems (such as forests, wetlands, mangroves and grasslands) are generally the most effective in producing benefits, e.g., water provision, biodiversity, cooling, pollution treatment, etc. Newly developed, immature and still growing, not yet at steady state, ecosystems will tend to have benefits later in time (and often with less reliability), which tends to diminish their accounted for benefits in a cost-benefit analysis.

Benefits from nature-based-solutions are often delayed by time needed for biological and economic maturation. Yet NbS usually have substantive initial costs and long-run maintenance costs. Recent planted trees often do not yield and many carbon storage benefits do not occur immediately but occur often slowly over time. Changes in climate, political, and economic circumstances can introduce uncertainties across time that jeopardise the viability of such projects.

Transitioning from current practices to these nature-based soil and water conservation practices often involves lower yields initially and more initial labour and other farm investment costs (Agroforestry Carbon Removal Factsheet, ICRLP American Univ., 2024). Private farm benefits will be lower and private farm costs higher than current practices until agro-ecological/agroforestry production reaches maturity. Farm cash flow will be lower and even negative compared to current practices during this transition. This can be a barrier for adoption for small farmers with few financial resources. Financial incentives are often required during a transition phase to support farmer adoption (ELD 2022; American Univ., 2024).

High initial costs often deter farmers from adopting some NbS practices, especially those requiring extensive infrastructure, such as terraces or bunds. Analysis shows the median cost of NbS practices can range from US$20 to US$20,000 per hectare, with subsidies or other financial assistance often essential to encourage uptake. Less costly NbS options, like no tilling, establishing keyline swales, soil fertility management, poly cropping, establish green cover, and/or crop selection adjustments, show greater potential for large-scale adoption (Reichhuber et al., 2019).

Monetising benefits

Monetising projected societal and global benefits often greatly increases CBAs for NbS over the business-as-usual cases, increasing the likelihood of positive discounted net benefits, depending on the assumed fungibility and reliability of these global and ecological services, and the amount and valuation of carbon removal/sequestration and other projected societal-level ecosystem services. In the Burkina Faso case study, the cost-benefit ratio for agroforestry (at 5% discount rate) is estimated at 2.3 with projected annual carbon removal benefits (at a market price of US$15/ton CO_2eq) and projected improved soil health benefits (more H_2O, more N).

Geographic and temporal extrapolations of benefits

Cost-benefit estimates for hypothetical national or regional scale projections can differ greatly from more detailed local estimates made based on geography, soils, climate, etc. of a specific habitat/geographic location (Dicks et al., 2020). These extrapolations can be less reliable than cost-benefit estimates for actual landscape situated in the context specific projects.

Financing farmers and land managers

Where an NbS cannot reliably provide additional revenues from produce and service sales locally, it may look to external service or product sales, which might initially be seen as less reliable, especially for poor farmers. If regional and global benefits are needed to justify a proposal, even very promising projects are unlikely to be implemented and sustained without 1) monetising these benefits, 2) delivering a substantial proportion of these benefits financially to farmers and landowners and 3) adopting a long-term approach that facilitates the transition of farmers towards sustainable practices

For farmers, private and financial benefits of agro-ecological and agroforestry interventions are lower than for current conditions in some case studies. So, the net present value of revenues and costs of investing in the NbS intervention over current conditions for farmers can result in a cost-benefit ratio less than 1 (e.g., Burkina case study: 0.87-0.89 for discount rates of 7%-5%).

Scaling of NbS

Economic concerns exist for scaling NbS (UNEP, 2020):

1. Benefits of climate adaptation and other ecosystem services are highly context specific. For example, water treatment benefits from constructing wetlands can be little for water treatment where there is little pollution or downstream need for treatment.
2. Both adaptation and ecosystem service benefits show (often rapidly) diminishing returns to scale, particularly if the initial studies are done at more favourable than average locations and conditions. Diminishing returns are also observed when insufficient attention is given to inclusion and the active engagement of the local community institutions. The marginal value of services can decline quickly with the geographic scale of the ecosystem. In addition, the first units of increased fish population, agricultural productivity, and other services are likely to be the easiest to obtain and most valued. While come costs have economies of scale (over some range), at great scale costs often become incrementally more expensive and has less value.

Climate benefits

So many evaluations of nature-based solutions rely on climate benefits, mostly from carbon sequestration, that it seems to merit a special section. Because carbon storage benefits of nature-based solutions are global, the value of carbon storage has some reliable economic characteristics:

1. The value of carbon storage is largely independent of where carbon is stored. This particular benefit is global and constant across scales, so global carbon storage should tend to be placed in the least expensive and most reliable locations (all else being equal).
2. Carbon storage revenues from nature-based solutions (even a lot of them) is unlikely to show rapidly diminishing returns with scale of land, given their small contributions compared to potentially huge global demand for carbon capture/storage. Carbon storage costs with nature-based solutions might show some initial positive returns to scale for nature-bases solutions. If suitable financial arrangements can be made, even modest net revenues might still be significant for farmers.
3. Finally, incremental additions to carbon storage in mature ecosystems might decline to zero as the natural system approaches its carbon-neutral steady state condition of "saturation". In this case, new, immature, and growing forests, grasslands, peat deposits, and regenerated soil might be better investments than mature forests for carbon storage.

Realising carbon benefits may require projects of sufficient scale (land area) and certainty (low enough risk) (Leudeling & Neufelt, 2012). For example, to justify establishing a payment for environmental services (PES) to off-set farmer transition costs through government revenues or carbon credits, sufficient scale and certainty in the benefits produced is needed to justify fixed transaction and on-going monitoring and measurement costs. Confidence in the likelihood of maintaining carbon storage with anticipated and potential climate, economic, and political changes would also be important and require biophysical modelling.

Luedeling & Neufelt (2012) found that farmer and carbon project viability of a potential Parklands project which paid farmers for carbon removal (without considering future climate change) required enough farms and farmers in the project (sufficient scale), of sufficient average farm size, a high enough price of carbon, and a reliable low-cost payment scheme to farmers. In many cases, the net present value of the Carbon Project was negative, including with current carbon prices. When positive for the Project, the net present value for the farmer at 12% discount rate (including carbon payments) was very small for small farms size (US$70 over 25 yrs for 2 ha farm) but was larger for large farms (NPV US$354 over 25 yrs for 10 ha) under the best payment scheme. These returns were unlikely to motivate farmers to participate. Unfortunately, carbon sequestration benefits are the most frequently monetised co-benefit, as others such as biodiversity are still harder to monetise. It is challenging to see how other non-monetised benefits would motivate farmers. Actions that improve soil health and water holding capacity are included in direct financial yield to farmers.

"Reversibility" is another concern with carbon removal and sequestration in soil, trees, other forms for biomass carbon storage. Carbon stored in biomass rather than in more permanent reservoirs is reversible; the captured carbon could be re-released to the atmosphere by wildfires, changes in land-use or land management, or climate change (American Univ., 2024). These create risks and uncertainty for projected carbon removal benefits. Luedeling & Neufeldt (2012) show unreliability of parkland trees carbon storage in the Sahel with future climate change. The same is true for any forest sequestrations.

Together, these recent case studies and the broader literature illustrate the wide range of situations and droughts for which nature-based solutions can be helpful, and sometimes economically justifiable. They also illustrate a wide variety of analytical and practical concerns for a range of business perspectives, whether the business is a local farmer or businessman, regional administrator, or a national leader.

Chapter 3: Adapting investment strategies for drought resilience: recommendations and conclusions

This report has examined the role that NbS plays in strengthening drought resilience, the opportunities for promoting NbS as part of a proactive drought management strategy, the policies needed to scale up NbS to drought, and ways of financing NbS to drought. The report makes the economic case for investing in NbS to drought and demonstrates the importance of improving evidence to support cost-benefit analysis. The report strongly supports the following messages, which are discussed further in the subsequence sections:

1. Nature-based solutions to drought include many tried-and-tested sustainable land management practices that offer no-regret options for strengthening resilience.
2. Investing in land and water management to reduce drought risk makes economic sense.
3. Building drought resilience through nature-based solutions requires investment in building capacities of people and institutions.
4. Nature-based solutions to drought may require investment to be leveraged through public-private partnerships.
5. Investments can be enabled by strengthening evidence and monitoring of the true impact of nature-based solutions.
6. Cost-benefit analysis of nature-based solutions to drought need to be further strengthened with improved methodologies and data collection.

Nature-based solutions to drought include many tried-and-tested sustainable land management practices that offer no-regret options for strengthening resilience

NbS to drought include a wide range of sustainable land and water management practices, many of which are adaptations and scale up of traditional practices that have evolved in arid and semi-arid areas. Some of these approaches have been dismissed in the past as being old-fashioned and not aligned with modern notions of land management. However, their role in safe-guarding ecosystem services—particularly those related to green water conservation—and thereby conferring drought resilience has been poorly understood.

A wide range of NbS can be used to prepare for, respond to, and recover from drought. These solutions may be context specific and need refinement and maturing in favourable conditions before becoming more widespread. In some cases, nature-based solutions may be more effective when paired with non-NbS drought portfolio elements.

In most cases, NbS-drought will be implemented by land users at a local level, although this could be carried out on a large-geographic scale by large numbers of individual land users, adding up to a significant landscape-scale impact. This presents unique challenges for long-term stakeholder convening and management, infrastructural planning, coordination, and monitoring, and presents questions over the role of public and private investments. To get local stakeholder buy in long-term trust building and convening processes are critical key success factors.

Predictability and accountability in the flows of public resources are probably more important than the overall size of public budgets required to make an effective change. Sudden injections of unprecedented funding with low accountability and short durations can be needed in crisis situations. These generally do not help to establish sustainable management processes in the long-term. A good balance between current resource availability, future planning, flexibility and accountability should enable public institutions to plan for droughts and then also to cope with other emergencies and account for outcomes.

NbS should be integral to drought management strategies because they consist of proactive drought management investments that are made ahead of time to alleviate or avert drought. NbS make sense with or without drought and include measures that are consistent with transition to sustainable and climate smart agriculture. Indeed, NbS to drought confer resilience, particularly in the agriculture sector, and should be promoted in countries regardless of whether the country has a drought management strategy.

Investing in land and water management to reduce drought risk makes economic, social and cultural sense

Nature-based solutions that reduce drought risk through investment in land and water management generate a Triple Dividend: 1) reducing drought loss and damage, 2) increasing the income of land and water users, and 3) generating broader co-benefits for climate, nature and sustainable development. Case studies from India, Jordan, Spain, Kenya and Chile all show positive returns on investments in sustainable land management and nature-based solutions. Although calculations of the benefits remain incomplete, they clearly outweigh the investment costs with or without droughts.

The co-benefits of NbS-drought and the contribution to climate adaptation are highly context specific and require locally relevant evidence. They depend on the ecosystem services supplied and the level of demand for those services. Additionally, the benefits of NbS-drought can be slow to materialise. Primary ecosystems are generally the most effective in producing benefits, such as water storage, biodiversity, cooling, and pollution treatment. Newly established, immature and developing ecosystems will tend to provide benefits later in time, and often less reliably, which diminishes their benefits in the short term.

In the absence of investment, drought losses are heavy, multiply fast, and continue to affect economic growth and development over the following 5–10-year period or longer. When the avoidance of these long-term losses is accounted for, the benefits are several orders of magnitude larger than the costs. Even when droughts do not occur, the risk and uncertainty surrounding drought negatively affects economic growth and decision-making.

The case studies highlight the greater tendency to account for the costs of drought damage than to account for the benefits of avoiding them. Important elements that have not been included in the case studies include accounting for the replacement costs of degraded and lost water purification and storage functions previously provided by nature. Rising investments in desalination technologies provide an increasingly accessible source of escalating value estimates for these replacement costs due to land degradation.

Country cases show the ways in which the unmitigated effects of a drought can spiral rapidly and create self-destructive cycles. Drought can lead to resource scarcity that can in turn exacerbate conflict. The avoidable loss of human life and other incidences of preventable violence are costly and difficult to fully account for. Situations that would have cost relatively little to avert have repeatedly spiralled out of control and threatened security as well as national economic development. Relatively small but timely investments to buffer these effects of drought can avert situations that otherwise result in the breakdown and irreversible collapse of households, livelihoods and businesses. The inspirational (cultural) and social returns are key elements of success as is described in several studies, including the Spanish case (Gutierrez et al., 2023).

Building drought resilience through nature-based solutions requires investment in building capacities of people and institutions

NbS to drought often require collaboration of large numbers of institutions and land users across landscapes. NbS are typically implemented by land users rather than hired contractors and therefore can require more local input to design and implementation. Government policies and regulatory frameworks are needed to promote cross-sectoral collaboration, landscape-scale action, and community engagement.

NbS to drought depend on the capacities of land and water managers and institutions that support them. Their agency is affected by their land tenure and water rights, their engagement in finding and implementing solutions, and their access to financial and other resources to cover the cost of transitioning to sustainable land and water management practices. These may also directly affect their access to credit, markets and decision-making. Each of these relies on the alignment of an enabling national policy framework.

Commonland developed a process of local stakeholder convening and creating landscape partnerships through focusing on three steps: 1) using a generic narrative and framework to facilitate common understanding and is place based; 2) a co-creative method (Theory U developed by MIT Presencing Institute (PI), and 3) guarantee a 20 years funding to support the landscape process.

National governments can improve the engagement of communities, businesses, and all levels of government by planning and preparing for droughts ahead of time. This may require investment in strengthening community institutions, for example for management of communal pasture or water resources. For example, India's cross-scale institutional framework connects drought-affected communities to State level, national and international institutions which would not be possible without access to local community organisations. Without the water markets in Chile, it would not be possible to organise the collective irrigation systems. Without national monitoring and early warning systems, it would not be possible to convene Kenya's county steering committees and donor coordination group.

The cases also show that additional investments in convening, governance and institution-building are needed at all levels. Establishing water user associations where previously there were none is an expensive and time-consuming business prone to false-starts and failures. On the other hand, working with existing rangeland land-user groups to establish water user associations in Kenya has been faster and easier for the county government and the water regulatory authority.

People of different genders, ages and ethnic groups sometimes have different access to local and/or customary institutions. Often, the situation may be dynamic and subject to change. The Spanish case includes in-migrating and returning populations to a previously depopulated area. Other cases involve forced refugees as well as voluntarily mobile communities including mobile pastoralists and other migrants. Areas that receive significant in-migration during dry seasons and droughts can face challenges if public funds are allocated on the basis of population census.

Empowered community institutions can not only play a role in planning and implementing NbS-drought measures and sustainable land management, but they can also provide a stronger voice for communities to articulate their needs around water and land management. For example, local irrigation collectives in Chile have succeeded in negotiating solutions with the national government that allow them to maintain their land and water rights.

Kenyan rangeland users have successfully resisted socially and environmentally unfeasible strategic plans around land and water management that would divert water from rangelands to new settlements and irrigation projects and would disrupt the flow of water to dry season grazing areas like the Lorian swamp.

Nature-based solutions to drought may require investment to be leveraged through public-private partnerships

Nature-based solutions to drought present unique challenges to investment. They require significant investment in services where private investors may lack expertise, such as developing institutions and building capacities. NbS-drought also generate returns through a wide range of co-benefits that may not align with the business models of the target investors. As a result, governments and private investors may need to develop partnerships to absorb costs and share risks.

Governments often find it easier to allocate capital funding rather than revenue: to invest in building infrastructure and equipment rather than fund salaries and processes. However, investing in social change processes is challenging and requires strong justification for the allocation of scarce public funds. The triple dividend of NbS-drought is a compelling argument.

National and global policies can put in place an enabling environment to leverage private investment in sustainable land and water management and NbS. This can be achieved through public-private partnerships with commitments from land managers, policy incentives for sustainable management, and adequate metrics and mechanisms for accountability. The case studies from Kenya, Chile and India demonstrate how governments have worked with local investors, creating new economic opportunities and growth across sustainable value chains to reinforce ecological, social and economic resilience to droughts. The case studies also show that external flows of funds from remittances and trade through local, national and international markets can also be important for local business development and investments in NbS-drought.

Frameworks for policy, planning and investment can mobilise investments that work for drought-affected communities. Chile has developed a national legal framework establishing the designation of origin of pisco and the certification system for marketing and exports, as well as the land and water rights and annual system for setting the volumetric quotas of water rights to be made available in the trading system. Governance of land and water resources in other countries remains opaque and un-monitored and may create a barrier to investment.

Further advances will depend on increasing connectivity infrastructure to take advantage of rapidly developing technologies such as short-range device-to-device connectivity, Low Power Wide Area Networks

(LPWAN), fibreoptic systems, WiFi, cloud computing, increased broadband internet such as 5G, etc. By 2050 it is estimated that advanced connectivity infrastructure will reach 80% of the world's rural areas and could unlock some US$500 billion additional agricultural value by 2030 (Goedde et al., 2024).

Promising technologies include smart crop monitoring for nutrient and water distribution, use of drones for remote sensing for crop nutrient deficiencies, drought affects, identifying pest and diseases, smart livestock monitoring for diseases, autonomous farm machinery and smart building and equipment management. Asia would benefit most from these technologies with Africa requiring the most help in establishing connectivity infrastructure to prevent furthering the North-South technological divide.

New collaborative arrangements are also needed to take advantage of increased connectivity between private sector companies. Surveys of the private sector reveals interest in valuing land beyond crop production, via land restoration and conservation and importantly including smallholder support services. It is recognised that large farms are likely to take most advantage of new technologies and increased connectivity. Encouragingly, environmental, social and governance issues related to tracking outcomes across value chains was also listed as a key concept for businesses (Brennan et al., 2024). The public sector can improve the economics of developing connectivity technologies such as broadband networks in rural areas by, for example, repurposing subsidies and providing tax breaks to telecommunication companies.

Investments can be enabled by strengthening evidence and monitoring of the true impact of nature-based solutions

Nature-based solutions can generate multiple co-benefits over several years, including positive social, economic and environmental impacts. Such outcomes can be difficult to measure, due to the challenge of identifying suitable indicators and the cost of monitoring. Furthermore, when evidence has been generated it has sometimes been rejected for being too favourable and proposing cost-benefit ratios that are perceived as unrealistic.

Most case studies struggle to make a complete accounting of all the costs and benefits of NbS-drought. Essential considerations include the negative or positive effects of the proactive approach to droughts for economic activity, Gross Domestic Product (GDP), economic growth, stability, inequality and national security (Zaveri et al., 2023).

India's national drought plan provides guidance on the establishment of monitoring systems at the state level. The India case study demonstrates the effectiveness of the devolved approach using water accounting systems at the village level to quantify the measurable effects. This enables India to calculate the economic return on the public investment in terms of avoided costs for water trucking to the affected communities.

None of the countries included in the case studies have invested in groundwater observation wells and monitoring systems, or the GIS models needed to assess the effects of different land management systems and policies on the availability of water to withstand droughts. The costs to establish, equip and maintain a network of groundwater observation wells are difficult to justify in areas where government is struggling to provide basic water supplies that communities need to survive in drought and non-drought periods. International development assistance has played a strategic role in some cases, such as USAID-funded work on groundwater monitoring in Jordan. International cooperation for groundwater recharge studies is also notable in the Chilean case, where the Dutch government has provided technical assistance.

Several case studies published previously by ELD have demonstrated means to predict and monitor the effects of NbS-drought practices on the availability of water to buffer drought risks and impacts. Case studies from Jordan and Mali, for example, evaluate the landscape-scale impacts of rangeland management, agroforestry, and soil and water conservation practices using the Soil Water Assessment Tool (SWAT). SWAT has also been used to quantify the effects of water harvesting in various watersheds in India (in combination with national hydrological monitoring systems) and the Horn of Africa (in the absence of hydrological monitoring systems).

Investments in national systems for data management remain a significant challenge in Kenya and other case study countries. The studies could not quantify the exact costs to establish and maintain the drought early warning systems that are currently available in Kenya and India, nor present specific calculations of the returns on investments in these systems. Insights into these costs can be gained by examining resource allocation for monitoring and evaluation in GCF proposals and additional information on the costs for establishment of national drought early warning is available from the World Bank. An important caveat is that these systems focus on establishing weather stations rather than monitoring land, water and socio-economic conditions with drought-affected communities.

Strengthen methodologies for cost-benefit analysis of nature-based solutions to drought

Cost-benefit analysis can be imperfect, but it does provide a more rational analytical framework for evaluation if it is applied in a disinterested way. Sensitivity analyses for a range of likely future conditions can be especially helpful for developing the business case. However, to make the economic case for global or national investments to address droughts, there are a range of established norms and expectations for CBA that make unusually high cost-benefit ratios difficult for decision-makers to accept. CBA ratios of 0-8 are generally viewed by economic decision-makers as the highest likely to be considered credible and circumspect. CBA of investments in drought-prone areas have generated ranges of desirable returns up to several orders of magnitude larger than this, posing a strategic conundrum over if and how to present analyses to sceptical decision-makers.

Understanding the relationship between land health, or ecosystem health, and soil moisture is critical to improve knowledge of suitable NbS to drought to conduct more effective, context-specific economic analysis. Examples presented in this report provide an indication of the impacts of NbS to drought to support cost-benefit analysis but provide insufficient detail to fully understand each specific context. It is recommended to examine the case studies more closely for further details, and in some cases further research may be required to validate the impacts of NbS to drought

While the dynamic catalytic effects of drought management continuously multiply and accumulate over time, major limiting factors for CBA include the timeframes and the conceptual constraints in the available models and data collection for assessment. Cases tend to focus on 5 to 10-year timeframes. Country cases show that relatively modest investments in sustainable management of watersheds and rangelands can unlock new value chains and opportunities in sectors including pastoral, meat, milk and high value rangeland plant products such as gums and resins from Kenya. Social Accounting Matrices, Environmental Accounts and Computable General Equilibrium Models all merit further consideration.

The case studies make use of established drought vulnerability and risk assessment methods, post-disaster needs assessment, and environmental accounting methods. They have included established national statistics, census data, standard social accounting matrices, and natural capital accounts, water accounting, GIS and hydrological modelling tools. The studies have combined these with market price information or other social and environmental valuation methods[7] to rapidly assess the value of land and water management achievements, alongside other contributing factors to drought resilience that are maximised through effective implementation of SLM/NbS.

Some case studies may underestimate the cost-benefit ratio as economic co-benefits from adaptation and mitigation of climate change, loss of biodiversity, human health, migration of people, avoiding conflicts over land use, direct and indirect employment opportunities are challenging to assess. Some of these are described as qualitative co-benefits. Social benefits in the form of human capacities, institutions and norms that are established over time are particularly difficult to quantify.

The case studies demonstrate that it is possible to estimate the costs of many types of investments needed to transform drought risks, as well as the benefits that they achieve, and the costs of inaction.

In some cases – such as those of Kenya, Ethiopia, Central American Dry Corridor and Jordan – detailed estimations of costs have been provided in proposals to the Green Climate Fund (GCF). In the Kenyan case, these have been followed up through annual implementation, expenditure and progress reports. These include investments by national agencies and international partners. In the absence of a dedicated funding window, less detailed cost estimates are sometimes generated by countries for the elaboration of precursors in the nationally determined Contributions (NDCs) for adaptation to climate change, and sometimes also as part of national planning processes and/or reporting to the UNCCD.

Conclusion

Holistic Landscape and Sustainable Land Management and restoration with a profound long-term stakeholder process and governance structure will be the best way to address drought issues and incorporate nature-based solutions at scale. It offers much more than simply an additional tool for drought management: they provide a significant opportunity to unlock economic growth, bring back local pride and hope, and halts social unrest and polarisation while building resilience in regions that have become locked into cycles of drought. Holistic landscape management restore nature's resilience, and the resilience of the communities who depend on natural resources, in the face of variable and unpredictable climate patterns.

Well-planned, timely investments in sustainably managing land and water have averted relatively larger losses and leveraged relatively larger gains. Collective success in planning brings its own rewards in terms of strengthened institutions and public confidence. Drought planning is a multi-sectoral and multi-stakeholder endeavour—not the preserve of drought institutions alone—and public planners need cost-benefit analyses to help make decisions within the limitations of available budgets and over realistic decision horizons. However, decisions makers should recognise the system improvements and the economic multipliers that will continue grow beyond these horizons. It should be seen as the new green infrastructural holistic landscape industry with additional financial inputs based on a firm long -term risks/return setting.

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Endnotes

1 SLM has many definitions. The World bank defined it as knowledge-based procedures that integrated land, water, biodiversity and environmental management to meet food and fiber demands while maintaining ecosystem services and livelihoods (World Bank, 2008).

2 https://archive.wbcsd.org/Imperatives/Nature-Action/Nature-based-Solutions/NbS-Business-Cases

3 Mainland China, Saudi Arabia, Uzbekistan, Iran, Myanmar, Indonesia, and Japan

4 Viet Nam, Tajikistan, Iran, Afghanistan, Yemen, Pakistan, Cambodia, Oman, Kyrgyzstan, Syria, Kuwait, Philippines, Israel, Taiwan Province of China, and Jordan

5 Lao PDR, Republic of Korea, Lebanon, Malaysia, Bangladesh, Nepal, Turkey, Iraq, and Azerbaijan

6 Hong Kong, Brunei Darussalam, Thailand

7 The valuation of ecosystem services is achieved using a variety of methods and approaches (information is available from GIZ Economics of Land Degradation (ELD Initiative, UN Food and Agriculture Organisation (FAO), Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES), Intergovernmental Panel on Climate Change (IPCC), Capitals Coalition, World Bank, European Commission (EC), Ecosystem Services Partnership (ESP), etc.

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