Food and Agriculture Organization of the United Nations

Building climate-resilient dryland forests and agrosilvopastoral production systems

An approach for context-dependent economic, social and environmentally sustainable transformations

FORESTRY WORKING PAPER

22

ISSN 2664-1062

Building climate-resilient dryland forests and agrosilvopastoral production systems

An approach for context-dependent economic, social and environmentally sustainable transformations

By
Fidaa F. Haddad
Clara Ariza
Anders Malmer

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2021

Recommended citation:
Haddad, F.F., Ariza, C. & Malmer, A. 2021. *Building climate-resilient dryland forests and agrosilvopastoral production systems: An approach for context-dependent economic, social and environmentally sustainable transformations*. Forestry Working Paper No. 22. Rome, FAO. https://doi.org/10.4060/cb3803en

ISBN 978-92-5-134119-3
ISSN 2664-1062 [Print]
ISSN 2664-1070 [Online]

Cover: Digital composition Marco Perri

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Foreword

Drylands contain 1.1 billion hectares of forest, or approximately 27 percent of the world's forest area. Dryland forests offer food, medicines, energy, fodder and fibre to local communities. Non-wood forest products enhance food diversity, contribute to nutrition and improve food security, particularly during periods of drought and other food crises. In Africa alone, dryland forests and other wooded lands are estimated to meet a large part of the needs of 320 million people. Future land use depends, in part, on the desired climate outcomes and the portfolio of response options available. As such, modelled pathways that limit warming to 1.5 °C or well below 2 °C require land-based mitigation and land use change, with most including different combinations of reforestation, afforestation, reduced deforestation and avoided degradation.

A business-as-usual approach is no longer an option for a food-secure future under climate change. Ensuring sustainable dryland food production systems and associated livelihoods while alleviating poverty and reducing the risk of conflict and disasters requires a transformation in land and natural resource management.

This transformation can take place through effective actions, at various scales and initiated by different stakeholders. It depends on the identification, implementation and scaling up of traditional and innovative best practices, sharing knowledge, building capacities and involving communities and other key stakeholders at each relevant level. The transformation further requires strengthening institutions and creating enabling policies and regulatory frameworks, so that context-specific solutions to current and future challenges can be rapidly adopted. There is also the need to rapidly establish baselines, assess and start monitoring progress on the transformation to sustainable dryland food production systems emerging as a result of the action taken.

The FAO Committee on Forestry (COFO) Working Group on Dryland Forests and Agrosilvopastoral Systems convened a consultation process with dryland experts to provide a simple approach for the context-dependent economic, social and environmentally sustainable dryland forests transformations to take place under the climate change context.

The approach developed focuses on the sustainability of production systems and livelihoods in drylands. Under each of the three sustainability pillars, it provides three expected transformations agreed during consultations with dryland experts and practitioners. While gender and indigenous peoples' rights and knowledge are included as cross-cutting issues, each expected transformation is described and complemented with relevant sources of information about best practices and approaches that can contribute to the transformation.

FAO Forestry Division

Acknowledgements

This working paper benefited from the contribution of members from different regions of the COFO Working Group on Dryland Forests and Agrosilvopastoral Systems. Special thanks to Chadi Mohana, Dominique Louppe, Ezekiel Mwakalukwa, and Moukrim Said for their input and review.

The authors would like to thank the dryland experts and practitioners who contributed with case studies and technical inputs to categorize the suggested nine expected transformations. They are: Grace Alazer, Heba Al-hariry, Abdelkader Bensada, August Emmett Boyer, Guillermo Fernández Centeno, Savino Di Lernia, Niels Dreber, Hussein El-Atfy, Amgad Elmahdi, Amer Abd Elmajeed, Mina Estegamat, Luuk Fleskens, Ayman Frija, Nashwa Hassan, Mounier Louaichi, Alisher Mirzabaev, Claire Ogali, Cate Owren, Stanislav Shmelev, and Shahira Wahbi.

Many thanks are given to the technical officers across FAO who provided reviews, case studies and valuable contributions. Special thanks to: Guido Agostinucci, Fady Asmar, Christophe Besacier, Simone Borelli, Kakoli Ghosh, Thomas Hammond, Amir Mafi, Nicolas Picard, Moctar Sacande, Kenichi Shono, Elaine Springgay and Feras Ziadat.

Internal reviewers of the paper include: Edmundo Barrios, Mauro Bottaro, Tiina Vahanen, Peter Moore, Pieter VanLierop and Gregorio VelascoGil.

External peer reviewers of the paper include: Purabi Bose (dryland researcher), Jonathan Davies (IUCN), Wadid Erian (League of Arab States), Lindsay Stringer (University of Leeds), Richard Thomas (United Nations University Institute for Water, Environment and Health (UNU-INWEH)) and Seta Tutundjiian (International Center for Biosaline Agriculture (ICBA)).

We acknowledge the technical editing and expertise of Alex Chepstow-Lusty in preparing the policy brief.

Lynette Hunt edited the paper and Marco Perri provided layout and design.

The Government of Spain has kindly agreed to fund the translation of this publication into Spanish.

The paper is also available in Arabic and French.

Acronyms

AFR100	African Forest Landscape Restoration Initiative
ASAL	arid and semi-arid lands
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
COFO	FAO Committee on Forestry
ECA	Europe and Central Asia
FAO	Food and Agriculture Organization of the United Nations
FFF	Forest and Farm Facility
FFPO	forest and farm producer organization
FLR	forest and landscape restoration
FMNR	farmer managed natural regeneration
FRA	Global Forest Resources Assessment
GDP	gross domestic product
GGW	Great Green Wall
GHG	greenhouse gas
ICARDA	International Center for Agricultural Research in the Dry Areas
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IBLI	Index-Based Livestock Insurance Project
IPC	integrated food security phase classification
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IUFRO	International Union of Forest Research Organizations
JOD	Jordanian dinar
LDN	land degradation neutrality
MENA	Middle East and North Africa
NAD	Namibian dollar
NAMS	national agricultural monitoring system
NGO	non-governmental organization
NWFP	non-wood forest products
NUS	neglected and underutilized species
ODI	Overseas Development Institute
PWES	payment for watershed ecosystem services
REDD+	reducing emissions from deforestation and forest degradation in developing countries, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
SAI	sustainable agricultural intensification
SDG	Sustainable Development Goal

SFN school and food nutrition
SLM sustainable land management
SOM soil organic matter
TOF trees outside forests
UN United Nations
UNCCD United Nations Convention to Combat Desertification
VGGT Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security

Executive summary

The way we produce our food matters and dietary choices can help reduce greenhouse gas emissions and pressure on land (IPCC, 2019). Hence, a business-as-usual approach is no longer an option for a food-secure future under climate change. Healthy and productive landscapes are the basic building blocks for attaining better livelihoods, healthier diets and resilient economies, and this applies equally to those living in the drylands of the world.

Dryland systems contain 44 percent of the world's agricultural land (58.4 percent of which is in Africa alone) and supply about 60 percent of the world's food production. Moreover, globally over 30 percent of urban areas and 34 percent of urban populations are found in dryland regions.

The 1.5°C warming scenario should alert the world to the vulnerability of dryland systems to climate change and land degradation. Climate warming in drylands is currently twice the global average and compounded crises are on the rise in these regions, as demonstrated by the ongoing impacts of the COVID-19 pandemic in areas where droughts, floods, locust swarms, conflicts and other factors have recently devastated livelihoods.

To achieve the necessary transformational change in the management of drylands and their associated agrosilvopastoral systems. We need to ensure that they continue to provide critical goods and services to dryland communities, ensuring food security and healthy livelihoods. At the same time, by protecting and restoring biodiversity, soil fertility will be enhanced and carbon storage increased in soils and biomass.

To achieve necessary the transformational change, local stakeholders – both women and men – should play a crucial role, combined with lessons learnt from traditional knowledge, especially in contributing to equity for the most vulnerable people.

An approach to sustainability in drylands and their agrosilvopastoral systems

FAO's common vision for sustainable food and agriculture goes hand in hand with global efforts such as the UN Decade on Ecosystem Restoration (2021–2030), which aims "to prevent, halt and reverse degradation of ecosystems worldwide" in order to "help end poverty, combat climate change and prevent a mass extinction."

Moreover, many of the conclusions of the 165th session of FAO's Council (December 2020) reinforce these aims, such as the request for "FAO to showcase and promote existing and complementary practices between agriculture activities and the conservation, restoration and sustainable use of forests, avoiding deforestation and maintaining ecosystem services, as agriculture and forestry can synergistically support sustainable development."

This paper focuses on the sustainability of dryland production systems and respective livelihoods. Under each of the three interconnected social, economic and environmental sustainability pillars, there are three expected transformations (i.e. nine in total). The proposed approach aims to pave the way for transformational change in the management of drylands and their associated agrosilvopastoral systems, as set out below:

i. Drylands encompass areas with wide-ranging environmental and socio-economic differences. Governance structure, political stability and therefore sustainability choices may greatly vary across regions and countries. Consequently, actions to produce the desired changes within reasonable timeframes will need to be context-dependent.
ii. The approach contributes to the interactions of multiple Sustainable Development Goals (SDGs). Transitioning towards systems capable of delivering nutritious food, while minimizing environmental impacts and meeting the needs of future generations sustainably and equitably, could contribute to achieving zero hunger (SDG 2), addressing water scarcity (SDG 6), reducing climate impacts (SDG 13), and protecting life in water and on land (SDGs 14 and 15).
iii. It helps to shift the way decisions are made, from decisions based on trade-offs (where immediate benefits are traded for later costs and thus jeopardizing sustainability), to decisions based on synergies.
iv. The approach calls for national and subnational governments, programmes, projects, individual practitioners and experts in conjunction with local people to jointly define the indicators they will use for measuring the progress of interventions towards the expected transformations.
v. At its heart, the approach integrates gender and indigenous people's rights, equity and traditional knowledge.
vi. The approach is founded on successful examples and initiatives on the ground to achieve the proposed transformations.

The way forward

The expected transformations, when combined, can reinforce the connections between the economic, social and environmental pillars of sustainability. Potential benefits and trade-offs should be assessed, weighed up and managed accordingly, while taking account of traditional knowledge and gender equity. Nevertheless, the perception of benefits and trade-offs may be different for different stakeholder groups. The nine key expected transformations are as follows:

Expected transformation 1 INVESTMENT: *Increased investment in sustainable dryland production systems and associated livelihoods through the collaboration of government, the private sector and others.*

Expected transformation 2 SCALABLE VALUE CHAINS: *Scaled up sustainable dryland product value chains*

Expected transformation 3 CLIMATE RISK INSURANCE: *Guaranteed equal and inclusive access to climate risk insurance mechanisms for dryland agrosilvopastoral system-dependent populations.*

Expected transformation 4 EQUITY: *Improved social well-being and equity for dryland forest and agrosilvopastoral system-dependent livelihoods.*

Expected transformation 5 DISASTER RISK MANAGEMENT: *Protecting the lives and livelihoods of dryland agrosilvopastoral system-dependent populations against climate shocks, disasters and conflicts.*

Expected transformation 6 INCLUSION, PARTICIPATION AND EMPOWERMENT: *Participation and empowerment of dryland agrosilvopastoral system-dependent populations in all adaptation and mitigation decision-making and implementation processes.*

Expected transformation 7 NATURAL RESOURCE USE EFFICIENCY: Efficient *use of dryland natural resources to ensure the long-term provision of ecosystem services under climate change.*

Expected transformation 8 RESTORATION: *Restored degraded ecosystems and halted deforestation to reduce the impacts of climate change on land degradation processes.*

Expected transformation 9 ECOSYSTEM CONSERVATION AND PROTECTION: *Conserved and protected dryland ecosystems and biodiversity to maintain ecosystem services and the subsequent sustainable and equitable provision of ecosystem goods and services under climate change.*

Last but not least, champions are needed to advocate and promote the transformational changes in the management of dryland agrosilvopastoral systems. Champions can facilitate the creation of a shared vision and help make sustainable innovations known. In this process, women and youth in particular should be empowered to be able to make a significant contribution and to benefit accordingly.

Malawi

1. Introduction

1.1 THE APPROACH, METHODOLOGY AND AUDIENCE

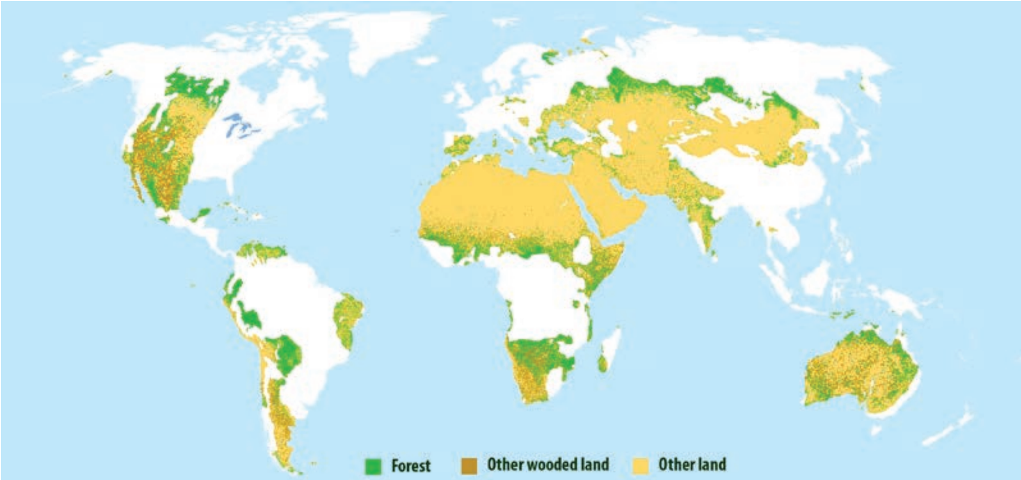
This working paper is the result of a process stemming from the Food and Agriculture Organization of the United Nations (FAO) Committee on Forestry (COFO) Working Group on Dryland Forests and Agrosilvopastoral Systems (Working Group). It brings together current trends, examples and experiences of changes in the management of dryland production systems that have, in different contexts and countries, contributed to meeting major environmental, social and economic challenges faced by dryland forests and agrosilvopastoral systems. The document outlines an approach to guide policymakers and practitioners in accelerating the necessary action for these systems to continue providing goods and services to local populations and humankind in a sustainable and resilient manner, in the coming decades and under climate change.

After a comprehensive literature review, a call for case studies was disseminated among different organizations working in the field of dryland forests and agrosilvopastoral systems. Extensive consultations with Working Group members and other national and sectoral experts began in October 2019 with the identification of the main challenges in dryland production systems, the key sustainability outcomes (transformations) to be achieved through actions at the policy, governance and practice levels and past evidence of the effectiveness of the identified actions. This information is the basis of the approach presented in this working paper, which underwent a peer-review process between June and July 2020 and was finalized in August 2020. It is expected that the approach developed here will support a broad audience of developers, policymakers, stakeholders and interest groups in their efforts to advance the drylands sustainability discourse and to progress in the implementation of actions to meet needed multifunctional transitions for diverse contexts.

1.2 DRYLANDS ARE KEY FOR DEVELOPMENT BUT FACE SEVERE CHALLENGES

Drylands constitute 41 percent of the global land area and are significant parts of all continents (apart from Antarctica) (Figure 1). They are the home and lifeline to more than 38 percent of the total global population – an estimated 2.7 billion people (Koutroulis, 2019; van der Esch, 2017), and estimated to reach 4 billion by 2050, most of whom are in low-income countries. Drylands support more than half of the world's livestock and host 27 percent of the world's forests and woodlands (FAO, 2019a; FAO, 2020) (Box 1).

Figure 1. Global map of drylands by continent, showing the different land uses



Source: UN, 2019

Box 1. Key facts on dryland ecosystem services

- Often considered as barren, remote and unproductive, drylands produce about 60 percent of the world's food in 44 percent of the world's agricultural land, mainly concentrated in Africa and Asia.
- Drylands support over 50 percent of the world's livestock, which is the main source of income for about 25 million pastoralists and 240 million agropastoralists (Neely *et al.*, 2009).
- Drylands play a vital role in global climate regulation as they store approximately 46 percent of global carbon reserves (MEA, 2005).

In addition, a significant number of trees are found in croplands and other areas outside forests (Box 2). Thus, dryland forests and agrosilvopastoral systems play a significant role in the provision of desired products for future bio-based economies (food, fodder, fibre and fuel) as well as in the achievement of social and environmental goals of the 2030 Agenda for Sustainable Development.

Box 2. Trees outside forests

Trees outside forests (TOF) refers to single trees, clumps of trees and trees of sparse canopy cover that do not meet the definition for forests in terms of degree of canopy cover, spatial extent and forest as major land-use. Especially in drylands, TOF fulfil many key functions for food, fodder, shade, water and soil fertility regulation, wind break, energy and construction material, etc. in pastoral, silvopastoral, agroforestry and open agricultural systems. It can be argued that TOF are more important in the driest areas, but the bulk of TOF occur in the more humid parts of drylands. Thus, less than 10 percent of drylands in Northern Africa and Asia have TOF, while in the rest of African dryland regions 33–45 percent of total drylands have TOF.

Source: (FAO Forestry Paper 184, 2019a)

Drylands are characterized by a scarcity of water, which makes both natural and managed ecosystems more vulnerable than elsewhere to climate fluctuation and unsustainable land use. For centuries, dryland communities have utilized a mix of traditional and autonomous adaptation strategies, shaped by limiting water scarcity, guarding soil productivity and annual subsistence from natural variation of dry spells.


Tunisia, Ksar Hallouf

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These communities are often marginalized from national development planning and policies due to the historical perception of drylands as wastelands. They are often further away from developing urban and peri-urban regions and therefore have less investment, infrastructure and fewer services and risk mitigation options available to them (Ludi *et al.*, 2018). Over recent time, drivers such as population growth and land development, without local community involvement, have resulted in increasing land pressure and in soil degradation. In many countries, dryland communities have lost their traditional tenure rights due to land tenure policies that ignore essential features of local governance, such as communal property, mobility and adaptation capacity (Forsythe *et al.*, 2015). Thus, dryland communities often have lower and declining incomes, increased malnutrition, and poor health culminating in higher mortality rates and famine (Pedrick, 2012; Cervigni *et al.*, 2016). With limited livelihood opportunities, migration from rural to urban areas, and trans-frontier regions often follows (McLeman, 2017). The vicious cycle of exacerbating poverty, competition for land, and degradation of natural resources can result in social, ethnic, and political strife, which then reinforces the levels of poverty and limited access to resources such as water (FAO, 2018a). The recent 2020 Global Report on Food Crisis (WFP, 2020) indicated almost 3.1 million people in arid and semi-arid lands (ASALs) were facing crises and categorized as IPC[1] phase 3 or above.

It is estimated that globally, 10–21 percent of drylands are degraded (MEA, 2005; Pulla *et al.*, 2015) and their ecosystems' ability to provide essential goods and services are in continuous decline, which makes survival from the land even more difficult (Mortimore *et al.*, 2009).

Furthermore, this poverty trap of marginalization and declining subsistence economies and livelihoods will mean dryland communities' production and environmental stability is unable to adapt to the additional intensity and incidence of climate hazard impacts under climate change without external support (IPCC, 2019).

Climate change has already affected food security due to warming, changing precipitation patterns, and a higher frequency of extreme weather events such as droughts (FAO, 2019). There is also robust evidence that with climate change, secondary effects like agricultural pests and diseases are likely to have more significant impacts. For example, Striga hermonthica, a devastating weed responsible for substantial losses in the drylands of Africa, persists in degraded soils with lower nitrogen levels and is expected to continue to wreak havoc on local livelihoods under changing climate conditions (Mandumbu *et al.*, 2017). In all drylands, climate change and land degradation are projected to cause reductions in crop and livestock productivity, modify the plant species mix, and reduce biodiversity.

1.3 OPPORTUNITIES TO MEET THE DRYLAND CHALLENGES

In its Special Report on Land and Climate Change, the IPCC (2019) highlights that better land management, including many options available to drylands, can be effective for climate change adaptation, with mitigation co-benefits. Additional benefits include reducing biodiversity loss and contributing to overall socio-economic development. This is well in line with efforts to combine multiple Sustainable Development Goals (SDGs) in the 2030 Agenda. The UNCCD (2019) advocated that the reduction and reversing of land degradation can enhance soil fertility and increase carbon storage in soils and biomass while benefiting agricultural productivity and food security. Consequently, in the last decade, increasing efforts have been aligned to restoring the ecological resilience and productivity of land through interventions under the banner of sustainable agricultural intensification (SAI) (Pretty and Bharucha, 2014) and forest and landscape restoration (FLR) (Chazdon *et al.*, 2016) in agricultural systems (Box 3) and in mixed land use landscapes (including dryland forests and agrosilvopastoral systems).

1 The Integrated Food Security Phase Classification (IPC) is a set of standardized tools that aims at providing a "common currency" for classifying the severity and magnitude of food insecurity. The IPC is a multi-agency initiative globally led by ten partners, including FAO, DG DEVCO and DG ECHO. http://www.fao.org/europeanunion/eu-projects/ipc/en/

Box 3. SAI and FLR for drylands management

Sustainable Agricultural Intensification (SAI) in drylands: As drylands are characterized by complex and geographically heterogeneous patterns of vulnerability (Füssel, 2010), the concept of sustainable intensification to produce more food is critical. It is important to consider not only the agro-climatic conditions of drylands but also the viable economic, social and environmental conditions to avoid increasing production vulnerability. Moreover, improvement and innovation in agricultural machinery and technologies are critical, including increasingly applying monitoring systems to water stress and the existing pests and diseases and their reaction to alternate crops (Robinson *et al.*, 2015). Dryland farming adheres to the principles and practices of good agricultural practices in dryland landscape with critical attention to water management and scarcity.

Forest and Landscape Restoration (FLR) in drylands emphasizes the importance of environmental restoration as an approach to land use. It includes activities that enhance the conservation, recovery, and sustainable management of forest and other ecosystems, which in turn would help to reduce poverty and food and water insecurity. In 2015, dryland experts endorsed the Rome Promise on Monitoring and Assessment of Drylands for Sustainable Management and Restoration (FAO, 2015b) and produced the First Global Dryland Assessment: Trees, Forest and Land use in Drylands to value and communicate the importance of FLR for dryland restoration and monitoring initiatives (FAO, 2019a). For example, in March 2017, ten Mediterranean countries ratified their commitment towards the effective implementation of FLR by endorsing the Agadir Commitment which seeks to create a Regional Mediterranean Initiative to restore at least eight million hectares by 2030. The Agadir Commitment focuses on the improvement of current national efforts and regional cooperation on FLR, land degradation neutrality (LDN) and biodiversity conservation, as well as on the elaboration of a financing strategy and a voluntary monitoring and evaluation and notification system for FLR and LDN in the region.

Source: FAO–Silva Mediterranea Committee (2017)

The level of expected negative societal impacts from climate change is directly correlated to development levels, with significant implications on extreme poverty by 2030, affecting communities already coping with livelihood limitations and inequalities (IPCC, 2019), as is the case for many dryland communities in developing countries. There is therefore an urgent need to accelerate the implementation of effective and efficient approaches to build resilience to expected climate impacts. In drylands, this includes transformation in the management of forest and agrosilvopastoral systems that ensure the long-term sustainability of production and livelihoods. This working paper aims to gather current experiences relevant to various dryland contexts and to present an approach for the transformations needed to combine, social, economic and environmental change in ways that can upscale positive development.

Harvesting ground nuts, Central Java, Indonesia

2. Trends in transformation of dryland forests and agrosilvopastoral systems

Transformation efforts of dryland forests and agrosilvopastoral systems are most often centred on the different technical aspects of system management. They typically target aspects like grazing management, restoring or adding trees and managing organic matter, water and soil fertility. Primary anticipated impacts and secondary effects may vary with dryland context and with the purpose and intention of the intervening actors. However, intended impacts of transformation often target broad aspects spanning food security and poverty reduction and improved ecosystem management, which also support the achievement of the SDGs.

Timescales are important to consider in such interventions. Some actions may have short-term impact, like grazing management, some cultivation management and changing fuel for cooking. Other actions including using trees for restoring land productivity, integrated water management and climate mitigation may take up to decades to deliver measurable results. Furthermore, expected effects in social change may also be slow, a major constraint for project interventions seldom exceeding three to five years (project life period).

2.1 DRYLAND FORESTS AND TREE PRODUCTION SYSTEMS

There is increased awareness on the role of forests and trees in the protection of soil, water and biodiversity. Dryland forests have played a critical role in coping with climate variability, in particular in terms of food security and nutrition for local communities. However, embarking on large-scale forest interventions, as an adaptation and mitigation response to climate change, requires effectively addressing these at different scales, such as the issue of competition for land and associated trade-offs at the local level. With climate change and the increasing demands on land, forests and trees create new challenges, but also opportunities.

Trees are efficient in supplying organic matter to maintain or improve physical and chemical soil properties. Efforts to maintain dry forests and woodlands and planting of trees to maintain and restore degraded soil fertility and water availability have been practised for a long time. There has been increasing awareness of the role of trees in a multitude of ecosystem services spanning from food production, water regulation to biodiversity and carbon storage for climate mitigation (Kuya *et al.*, 2016). However, interventions with multiple benefits require effectively addressing contexts and challenges at different scales and sectors (social, economic and environmental). Most interventions will create both opportunities for multiple co-benefits, as well as challenges from trade-offs.

Apart from the benefits for various ecosystem services, many countries have a need for restoring forests, including relevant dryland forests, for the sustainable forest management (SFM) of timber. Demand for raw wood material is expected to grow considerably at the global level, e.g. for housing. There is a need to build 96 000 new housing units per day globally to reach adequate housing by 2030 (replacing inadequate and new urban houses) (UN-Habitat, 2011). The current expansion of cities, housing needs and increasing household incomes boosts the demand for carpentry such as furniture, flooring, doors, etc. However, the big transformation in the ongoing technology shift: laminated wood (being cheaper, lighter and climate neutral) has the potential to replace steel and concrete (Manninen, 2014). This new and fast development in high-income countries is a driver for bio-based economies, as it will be in current low- and middle-income countries also, where much of the housing expansion will occur.

Creating new opportunities from sustainable forest management may interfere with traditional forest uses like grazing, fodder collection and firewood harvest. Larger scale and industrial interventions may spark even more serious competition for land. Thus, an integrated landscape approach is needed to ensure transformative interventions in pastoral, crop agriculture and forest management do not increase competition or generate environmental deficits. International and national commitments for FLR include hundreds of millions of hectares for both large-scale and small-scale interventions. Some countries are committed to set their national targets for land degradation neutrality (LDN) and most have aligned their targets with forest restoration and land management initiatives, such as the African Forest Landscape Restoration initiative (AFR100) and Bonn Challenge (UNCCD, 2016). IUCN and UNCCD conducted a policy analysis in 2019 for 13 out of 63 selected countries that had consolidated linkages to the Bonn Challenge and LDN, which highlighted that regardless of the name of the approach, both FLR and LDN are complementary and interchangeable approaches to support ecosystem services (IUCN, 2019).

Moreover, IUFRO conducted a large-scale analysis of FLR implementation in seventeen landscapes in nine countries and on three continents (Stanturf *et al.*, 2020). Overarching lessons for the limited success for FLR so far span social, economic and environmental aspects. Several aspects relate to possibilities to understand, discuss, negotiate and unite between stakeholders on how future landscapes and livelihoods will look and function in scales of time and space. Considering the frequently resource-poor and vulnerable communities and individuals in drylands, this is certainly a major challenge.

BOX 4. Ten lessons learnt on FLR

International Union of Forest Research Organizations (IUFRO) assessed FLR interventions in seventeen landscapes in nine countries to understand the economic, social and ecological challenges for progress towards the Bonn Challenge goals. Five of the landscapes were in arid areas and another three were in dry sub-humid zones. The report concludes with ten overarching lessons:

- Align expectations in project design;
- address threats;
- strengthen collaboration and participation;
- incorporate incentives and reduce disincentives;
- consider spatial and time scales;
- utilise appropriate knowledge and methods;
- focus on capacity building and technical assistance;
- include monitoring;
- improve communication;
- strengthen political support.

Source: IUFRO Occasional paper # 33, Stanturf *et al*, 2020

A classical issue of co-benefits or trade-offs is whether forests and trees locally use more water than what they can contribute to by regulating groundwater in drylands (Malmer *et al.*, 2010). More recently, research findings suggest forest distribution effects on water regulation are on both a local and a global scale (Ellison *et al.*, 2017), underpinning the value of trees but making valuation less straightforward. However, at the local scale, evidence indicates that the role of trees in water regulation in drylands depends on the number of trees and the structure of their distribution in a landscape may have a context-dependent (aridity) optimum (Ilstedt *et al.*, 2016).

Traditionally, dryland forests and trees in pastoral landscapes have played a critical role in coping with climate variability, particularly in terms of food security and nutrition for local communities (Bose and van Dijk, 2016). However, traditional and formal tenure rights for trees in agricultural landscapes or the use of nearby forests may vary to a high degree. Tenure may include traditional collection of various fruits and other non-wood forest products (NWFPs), but more seldom include the use of timber or even the selling of charcoal. The latter hinders efforts to transform land use systems to give local communities rights and power to manage their natural resources.

An interesting example comes from Niger of bringing back trees into agricultural landscapes where farmer-managed, agro-environmental transformation has occurred over the past three decades, enabling both land rehabilitation and agricultural intensification to support a dense and growing population. This transformation has been based on the farmer-managed process of natural regeneration (FMNR), using improved local agroforestry practices.

The landscape-wide transformation has been largely possible, among other factors, because of a policy change concerning farmers' tenure rights to trees on their agriculturetenured land. During the 1990s, interest in FMNR was stimulated when the success of several pilot projects was shared with government policymakers. This led to less restrictive forestry regulation, which had previously strongly limited farmer management of their trees, and it also addressed historical policy shifts that saw uncertainty in farmer tenure systems. Previous governance systems led to strong disincentives to farmer ownership and management of trees. When these factors were addressed, FMNR landscapes began to spread rapidly (Reij and Hecht, 2014). In 2004, the Government of Niger formally recognized the trend by issuing a Forest Code that eliminated the restrictions on the freedom of farmers to manage the trees that they regenerated on their land. Tree density and tree cover in Niger have increased dramatically in recent decades.

Between 2003 to 2008 alone, in the Maradi and Zinder regions of Niger, about 4.8 million hectares of farmland were regenerated through FMNR. An estimated 1.2 million households engaged in managing these systems through their independent efforts, and many villages now have 10–20 times more trees than 20 years ago. The agricultural landscapes of southern Niger have over 200 million more trees than they did 30 years ago (IFPRI, 2009). Some studies (Garrity and Bayala, 2019) estimate that this transformation has resulted in an average of at least 500 000 tonnes of additional food produced per year, meeting the needs of 2.5 million people. Beyond food security and water, FMNR in Niger has also brought farmers better incomes through improved crop yields, the sale of tree products, including building timber, firewood, food, medicines, tool handles and other furniture and through improved livestock production. Social benefits have included the ownership of trees and their benefits, the creation of networks and partnerships between varied actors in the region, and the increased role and influence of women, who play key roles in the implementation and keeping of FMNR.

The experience from Niger demonstrates that sustainability of forests and trees requires governance and legal frameworks that recognize the needs and rights of vulnerable and marginalized groups, while supporting the role of forests in environmental processes.

2.2 LIVESTOCK MANAGEMENT AND PASTORALISM

The latest assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) highlighted that the most widespread driver of land degradation is the increase in and unsustainable management of croplands and grazing areas (IPBES, 2018). Livestock is the main source of income for over 200 million pastoralists in the world thus the increased use of intensive livestock production systems with high off-site impacts increases the risk of degradation in forest ecosystems.

Pastoral systems are livestock-based livelihood and food production systems, interacting with natural environments that are highly variable in seasonality and biodiversity. Pastoral systems are highly diverse, but all share a quality in improving diet for animals, welfare and products by managing their grazing itineraries at a variety of scales in time and space. However, the unplanned increase in livestock numbers to meet the growing demand for animal-sourced food has exerted substantial pressures on the vegetation cover in many areas. For example, in the Near East and North Africa region, the livestock numbers increased by 25 percent during the period 1990–2013, while the vegetation cover as a percentage of land area decreased in the same period from 3.7 percent to 2.8 percent (FAO, 2017). Moreover, the increased use of intensive livestock production systems with high off-site impacts increases the risk of degradation in forest ecosystems. For example, in sub-Saharan Africa, livestock production is the main use of around 40 percent of the dryland areas (Nyberg *et al.*, 2019).

Pastoralism contributes to the socio-economic status, food security, and nutrition of millions of dryland dwellers. It plays an essential role for local livelihoods and is estimated to be a better land use option than conversion to crop agriculture in arid and semi-arid lands (Kratli *et al.*, 2013). Studies in Niger, for example, indicate that nomadism was found to increase productivity by 27 percent compared with sedentary livestock systems and by ten percent compared with transhumant systems (Kratli *et al.*, 2013). Livestock makes a significant contribution to national economies, although often underestimated, and its value for poor farmers and pastoralists goes beyond food production and cash income. In Kenya, for example, extensive livestock production pastoralism contributed USD 4 billion, or about ten percent, to the country's GDP in 2009 (Behnke and Muthami, 2011). In Sudan, as of 2011, the value of the pastoral system was the largest subsector of national economy. In Mongolia, the livestock sector based on pastoralism accounts for 90 percent of agricultural GDP. However, pastoralism has also borne the brunt of bad policies leading to the degradation of drylands.

Livestock contribute 14.5 percent to total GHG, two thirds of which are from cattle (Grossi *et al.,* 2019). Pastoralists, like other communities, are seeking alternative sources of subsistence and income. Strategies to manage the risks they face may be opportunistic and, in many instances, maladaptive as they may jeopardize the long-term sustainability of their natural resources and become economically unviable. Examples of this are the shift towards charcoal making, or more sedentary, intensive production of livestock or irrigated crops, leading to groundwater resource depletion and other forms of environmental degradation.

Therefore, mitigation and adaptation strategies need to meet the growing demand for livestock products driven by an increase in population in dryland regions. Dryland forests and agroforestry techniques can make a major contribution to meet climate change challenges and enhance livelihood resilience by removing CO_2 from the atmosphere and storing it in biomass and soil. An application of the total economic valuation approach in Sudan shows that adopting agroforestry through the sustainable land use and livestock management in Gedaref state will lead to an additional annual ten tonnes/ha of below and above ground carbon sequestration over 25 years (Aymeric *et al.*, 2014).

On another positive note, livestock benefit forest and agrosilvopastoral ecosystem conservation by maintaining regulating services, such as seed dispersal, maintenance of natural productive soils, reservoirs of biological diversity, and ecological connectivity. With adequate grazing management, pastoral systems can also contribute to soil carbon sequestration (Assouma *et al.*, 2019). This can be achieved by purposely combining fodder plants, such as grasses and leguminous herbs, with shrubs and trees for animal nutrition and complementary uses; along with grazing management and livestock practices. Silvo-pastorals systems promotes beneficial ecological interactions such as increased yield per unit area, improved resource use efficiency and enhanced provision of environmental services such as soil carbon. The research conducted by the Centre de Coopération Internationale en Recherche Agronomique pour le Devéloppement (CIRAD) in Senegal on proper grazing management in pastoral landscape finds that one ha of pastoral ecosystem emits 0 .71 tonnes of carbon equivalent, sequesters 0.75 tonnes, and emissions from animals are offset by carbon sequestration in soils and plants (Assouma *et al.*, 2019).

The economic rationality and ecological sustainability of pastoral systems are well documented (Homewood, 2008) and are attracting renewed attention in relation to resilience and adaptation (ODI, 2018; Kratli *et al.*, 2013). Despite being marginalized in many contexts, pastoralists have been adapting through knowledge-intensive systems – including traditional knowledge and digital technology. This has included the use of mobile technologies for finance, market access, exploring innovative insurance approaches, and embracing new approaches to water and dryland management (ODI, 2018). Lessons from such knowledge-intensive adaptation responses bring new insights to linking local, national, and regional contexts while embracing markets and innovative cross-sectoral partnerships to support climate change adaptation and mitigation locally.

2.3 INTEGRATED SUSTAINABLE FOREST AND LAND MANAGEMENT

From the two previous sections it is evident that transformation of both forest and tree management as well as transformation in pastoral livestock production is desirable. Although integrated land and forest management on a landscape scale is desirable, and is indeed sometimes included in transformative interventions, it should be noted that these multi-sector transformations come with several structural challenges. One very basic challenge is that pastoralists or dryland farmers seldom have the tradition or even tenure to tend trees or forests. This makes acceptance and understanding of a broad vision for diversified outcomes hard to achieve and local buy-in from already vulnerable actors may fail.

Initiatives and resources to support interventions often start with a specific objective, which frequently does not resonate with local communities, even if co-benefits for livelihoods and local climate adaptation are expected. Climate compensation, REDD+[2], payment for ecosystem services and biodiversity conservation draw resources for interventions but may marginalize the role of poverty alleviation locally. Remaining poverty within and around efforts for conservation and landscape restoration may reduce or eradicate intended effects (Nambiar, 2019).

Understanding and capabilities for integrated landscape management in dryland forests and agrosilvopastoral systems need to develop further. Emerging evidence demonstrates that efforts to reduce and reverse land degradation provide the double dividend of food and water security and can contribute substantially to adaptation and mitigation of climate change. This is especially important, considering the projected four billion people who will be living in drylands by 2050 (IPBES, 2018). The cost of inaction on land degradation has been shown to be at least three times that of investing in restoration initiatives in Asia and Africa, making restoration a sound investment (IPBES, 2018).

Agroforestry is a practice that can combine trees, cultivation and livestock. Many agroforestry systems rely on traditional practice, well adapted to local contexts. Indeed, there are a multitude of local and regional varieties and possibilities to use and modify systems to increase outcome diversity and connect to urban demand. As such, emerging practices and restoration actions have been demonstrated to benefit women and local communities by building on indigenous and local knowledge and collective action (IUCN, 2017).

Context is central. Delgado *et al.* (1999) describe an emerging "livestock revolution" driven by the pressure of population increase, land degradation and increasing demand for meat, resulting in shifts from nomadic to sedentary, subsistence to market inclusion and collective to private tenure. Moreover, these shifts contribute significantly to GHG.[3]

As described in the livestock section above, these transformations are ongoing, and sometimes not with the desired effects. Drylands contain vast ranges of aridity, cultural traditions and tenure systems. In some cases, systems may see small improvements in existing traditional pastoralism (drier areas, lower population pressure, etc.), while other regions may need more complex and diversifying transformations (higher population pressure, climate allowing agroforestry, closer to market, etc.). An example of the latter is transforming pastoralism to livestock in cyclic enclosures in West Pokot, Kenya (Nyberg *et al.*, 2015) where soils are restored and carbon accumulated by increased tree cover and biodiversity and livestock production have increased, while loss of collective traditions and new gender relations may present new challenges.

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[2] REDD+ reducing emissions from deforestation and forest degradation in developing countries, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks

[3] http://www.fao.org/gleam/results/en/

Lebanon

3. Expected transformational approach of dryland forests and agrosilvopastoral systems for climate-resilient and sustainable production systems

Feeding a growing world population by 2050, accommodating non-food agricultural commodities, and achieving the SDGs by 2030 will not be possible without a global transformation in food production systems. Dryland forests and agrosilvopastoral systems should spearhead these efforts as their pivotal role has enormous potential to reduce and reverse land degradation while contributing to climate change mitigation, adaptation, and sustainable livelihoods.

Learning from different experiences and initiatives, and given that time is of the essence, it becomes clear that seemingly isolated and small interventions in dryland forests and agrosilvopastoral systems can actually become part of a collective force for transformation if they target common sustainability outcomes. The approach, introduced in the following section is expected to aid in identifying, planning, implementing, monitoring, scaling up and sharing successful transformative interventions, across scales and regions. The approach allows practitioners, decision-makers and policymakers, government officers, communities, civil society organizations, the private sector and other interested and relevant stakeholders to assess the contribution of their current and planned actions in drylands and steer them towards long-term sustainability.

3.1 SUGGESTED APPROACH TO SUSTAINABILITY – THE NICHE

Numerous studies and reports describe pathways for action towards sustainable production systems, and recommendations have repeatedly been made for the sustainable development of socio-environmental systems in drylands (MEA, 2005, Reynolds *et al.*, 2007; Stringer *et al.*, 2017). Yet, the need for simple and readily actionable approaches to accelerate the context of dryland production systems is required.

The 2030 Agenda for Sustainable Development is the blueprint towards sustainable development and transformation in food and agricultural systems to end poverty and protect the planet. It emphasizes the need for cross-sectoral integrated work placing people, peace and prosperity at the centre.

FAO's common vision for sustainable food and agriculture provides a holistic framework for sustainable agriculture. It outlines five general principles (see Box 5) to guide policy and strategic action towards agricultural sustainability that are productive, economically viable and environmentally sound and contribute to equity.

BOX 5. The five principles of sustainable agriculture

1. Improving efficiency in the use of resources is crucial to sustainable agriculture.
2. Sustainability requires direct action to conserve, protect and enhance natural resources.
3. Agriculture that fails to protect and improve rural livelihoods, equity and social well-being is unsustainable.
4. Enhanced resilience of people, communities and ecosystems is key to sustainable agriculture.
5. Sustainable food and agriculture require responsible and effective governance mechanisms.

Source: FAO (2014)

The recently published ten agroecological elements (see Box 6) respond to the transformative ambitions of the 2030 Agenda. These elements, supported by scientific discipline with a set of practices and social movements that are urgently needed for the transition are outlined and aim to enhance the key functions across food systems, supporting production and multiple ecosystem services.

BOX 6. The ten elements of agroecology

1. Diversity
2. co-creation and sharing of knowledge
3. synergies
4. efficiency
5. recycling
6. resilience
7. human and social values
8. culture and food traditions
9. responsible governance
10. circular and solidarity economy

Source: Barrios *et al.*, 2020

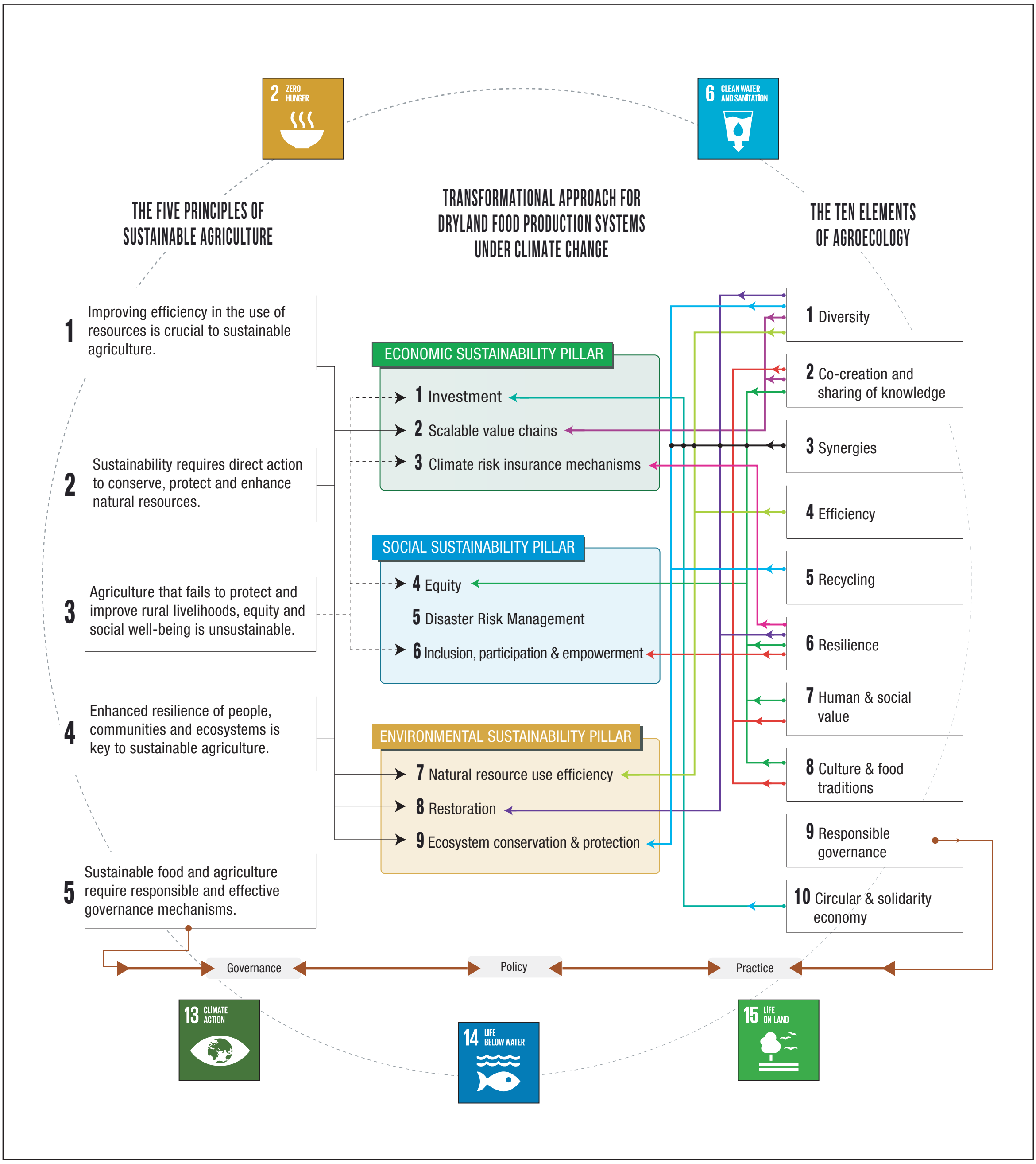
The proposed transformational approach in this paper supports FAO's common vision for sustainable food and agriculture to pave the way for transformational results in dryland forests and agrosilvopastoral production systems (see Figure 2), as detailed below:

- Drylands encompass areas with great climatic (i.e. bimodal vs. unimodal precipitation patterns), physical, environmental, and socio-economic differences (i.e. located in high-, medium- or low-income countries). Governance structure, political stability and therefore sustainability choices may greatly vary across regions and countries. Consequently, the actions to produce the desired changes within reasonable timeframes will need to be context-dependent.

- The approach contributes to the interactions of multiple Sustainable Development Goals. Transitioning towards systems capable of delivering nutritious food, while minimizing environmental impacts and meeting the needs of future generations sustainably and equitably could contribute to achieving zero hunger (SDG 2), addressing water scarcity (SDG 6), reducing climate impacts (SDG 13), and to protecting life in water and on land (SDGs 14 and 15).
- It helps to shift the way decisions are made, from decisions based on trade-offs (where immediate benefits are traded for later costs and thus jeopardizing sustainability), to decisions based on synergies. Decisions that emphasize new technological innovation systems, strategic use of economic incentives, new forms of governance, and changes in food consumption behaviour will be key to transitioning to sustainable global food systems (United Nations, 2019), and are needed to increase productivity without compromising the natural resource base (FAO, 2018b).
- It calls for national and subnational governments, programmes, projects, individual practitioners and experts to jointly define the indicators they will use for measuring the progress of their own interventions towards the expected transformations, based on the availability of data, specific national and local conditions, and the nature of their interventions.
- The approach integrates gender and indigenous people's rights, equity and traditional knowledge at the heart of its success.
- The approach is founded on successful examples and initiatives on the ground regarding the applicability of the proposed expected transformations, and the challenges of their trade-offs and synergies in the context of the most vulnerable ecosystems to climate change (IPCC, 2019).

Underpinning this approach is the need to manage drylands as sustainable multifunctional landscapes. Integrating social, economic and environmental criteria when determining spatial and temporal land use planning strategies is the best opportunity for ensuring these systems and their ecosystems continue to provide goods and services, including food production for a growing population under climate change, while maximizing social and economic benefits for dryland dwellers. Operationalization of the approach is further explained at the end of this paper; this facilitates implementation efforts and includes some relevant sources of indicators in Annex 1, along with other additional resources that support the implementation of the approach.

Figure 2. Drylands transformation approach in the context of FAO's common vision for sustainable food and agriculture and the ten elements of agroecology



3.2 THE SUSTAINABILITY APPROACH

The sustainability approach in this chapter is based on the classic sustainability theory. It integrates nine expected transformations – the most important outcomes and collective actions considered by experts as the most important and urgent to achieve the sustainability of dryland forests and agrosilvopastoral systems under climate change.

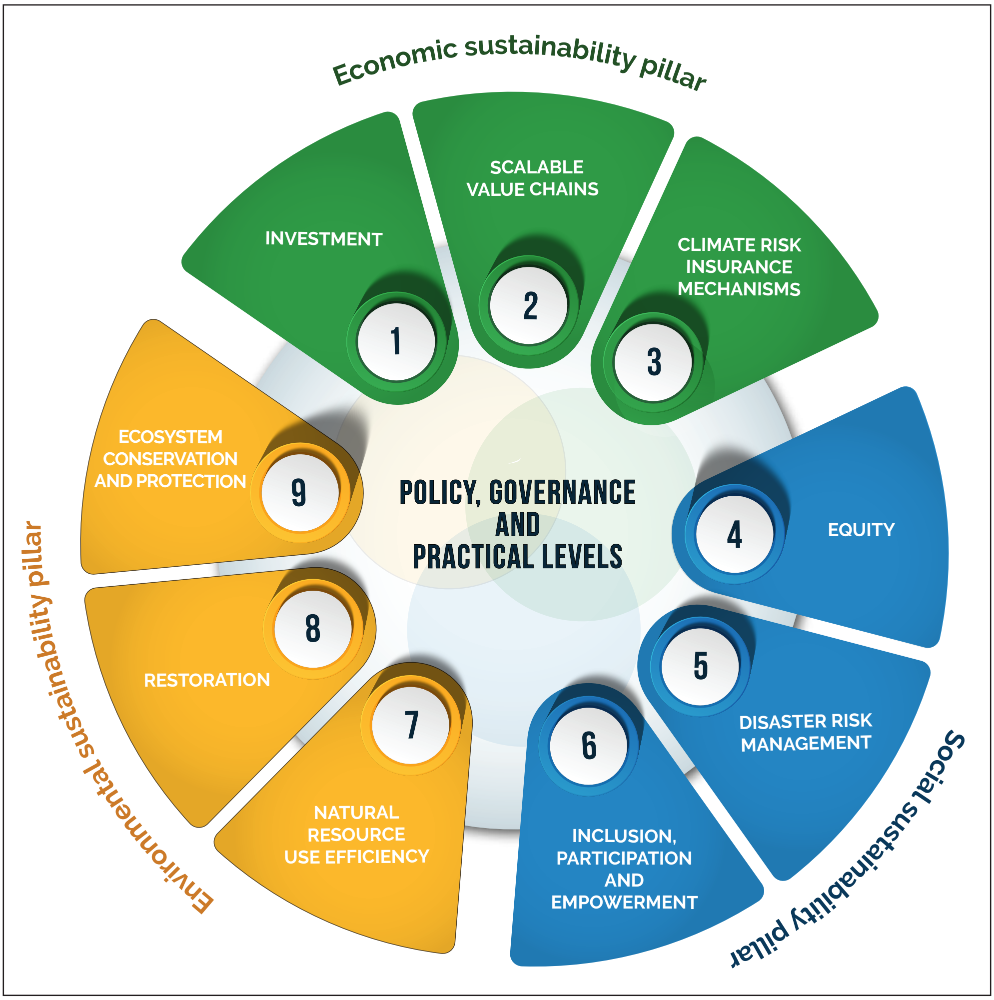
Based on the consultation process explained earlier in this paper, experts were asked to prioritize the required transformations into three expected transformations under each of the classic sustainability pillars: economic, social and environmental, to guide the planning, implementation and steering of policy, governance and practice-level actions (see Figure 3). In the context of this approach, transformation is understood as a process where one, or a series of actions/interventions, create positive change in the fundamental attributes of human and/or natural systems and the change is sustained through time. It excludes short-term, transitory gains or impact. Positive transformational results are real and sustained improvements in different production systems with a focus on dryland food production systems and dependent populations.[4]

The approach integrates gender and indigenous people's rights and traditional knowledge at the heart of its success. Implementation of the approach calls for joint efforts and integrated planning of national and subnational governments, individual practitioners and experts to define complementary and cross-cutting indicators for measuring the progress of their own interventions towards the expected transformations. This will be based on the availability of data, specific national and local conditions, and the nature of the interventions. To facilitate the efforts, some relevant sources of indicators are included in Annex 1: Additional Resources, along with other resources that support the implementation of the approach. The following sections describe the nine expected transformations included in the approach and provide examples of actions at various scales that have contributed towards their achievement. As can be inferred from the case studies, successful interventions can deliver outcomes that contribute to the achievement of other transformations.

The classic sustainability theory and this approach rely on the fact that the three sustainability pillars are interconnected. Therefore, individual and integrated policy, institutional and practical interventions on the ground can contribute positively and/or negatively and directly and/or indirectly to one or various expected transformations. For the sake of simplicity, each example presented illustrates the aspects of an intervention related to a specific expected transformation. **In general, the outcomes of successful cases contribute to the achievement of other transformations.**

[4] Adapted from UNCCD's LDN and UNDP's transformational change definitions

Figure 3. Transformational approach for dryland production systems under climate change



The approach represents policy, institutional (governance) and practical interventions implemented at the local, subnational or national scale and contribute directly to a limited set of expected transformations defined under each of the three classic sustainability pillars (see Table 1).

Table 1. Sustainability pillars

SUSTAINABILITY PILLARS	EXPECTED TRANSFORMATIONS
Economic pillar	**Expected transformation 1 (investment):** Increased investment in sustainable dryland production systems and associated livelihoods through the collaboration of government, private sector and other actors. **Expected transformation 2 (scalable value chains):** Scaled up sustainable dryland product value chains. **Expected transformation 3 (climate risk insurance mechanisms):** Guaranteed equal and inclusive access to climate risk insurance mechanisms for dryland agrosilvopastoral system-dependent populations.
Social pillar	**Expected transformation 4 (equity):** Improved social well-being and equity for forest and agrosilvopastoral systems-dependent livelihoods in drylands. **Expected transformation 5 (disaster risk management):** Lives and livelihoods of dryland forest and agrosilvopastoral systems-dependent populations protected against climate shocks, disasters, and conflict. **Expected transformation 6 (inclusion, participation and empowerment):** Participation and empowerment of dryland forest and agrosilvopastoral systems-dependent populations in all adaptation and mitigation decision-making and implementation processes.
Environmental pillar	**Expected transformation 7 (natural resource use efficiency):** Efficient use of dryland natural resources to ensure the long-term provision of ecosystem services under climate change. **Expected transformation 8 (restoration):** Restored degraded ecosystems and halted deforestation to reduce the impact of climate change on land degradation processes. **Expected transformation 9 (ecosystem conservation and protection):** Conserved and protected dryland ecosystems and biodiversity for the maintenance of ecosystem functions and the subsequent sustainable and equitable provision of ecosystem goods and services under climate change (including the carbon sequestration service).

The following sections describe the nine expected transformations included in the approach and provide examples of actions at various scales that have contributed towards their achievement.

Economic sustainability pillar

Drylands have long been marginalized and excluded from public investments and economic and social development policies (Mortimore *et al.*, 2009). This has resulted, particularly in Africa and Asia, in sluggish economic growth, underdevelopment, poverty and persistent shortages of food and energy. Populations depending on subsistence from dryland forests and agrosilvopastoral systems, are facing frequent and increasingly severe climatic shocks without the necessary capacity or support to cope with and recover from economic losses. In addition, drylands lose productivity (roughly 23 hectares every minute) to severe degradation. At the same time, they experience significant demographic shifts, including rapid urbanization and faster population growth than any other ecological zone (UNCCD, 2019). Drylands also have some of the highest youth unemployment rates in the world, particularly in the Middle East and North Africa (MENA) region, with a 30 percent unemployment rate in 2017 (World Bank, 2018).

Despite this, recent studies on climate resilience and economic development demonstrate that food production systems in drylands make major contributions to national and regional economies and are capable of driving economic development (ODI, 2018). For example, Behnke and Muthami (2011) revised the estimates of Kenya's dryland forests and agrosilvopastoral extensive livestock population from the 2009 census and found that the contribution of livestock to national GDP was 13 percent and accounted for 43 percent of agricultural GDP. This is a contribution of USD 4 billion versus the previous official estimates of USD 1.6 billion, demonstrating the underestimation of dryland value chains to a national economy.

Given current and future challenges, the transition towards sustainable food production systems in drylands requires investment and an enabling policy environment for interventions that: a) increase agricultural productivity while reducing the risk of environmental and economic shocks; b) create real opportunities for inclusive, climate-resilient economic development based on food production and on non-agricultural livelihoods that provide resources for land investments by dryland dwellers; and c) take into consideration the preservation and long-term sustainability of biological, social and cultural systems. Transformational results can be expected if these interventions are co-created with communities and based on the principles of accountability, equity, transparency, and the rule of law (FAO, 2014). The approach includes the following proposed three expected transformations to guide such interventions:

Expected transformation 1 (investment): Increased investment in sustainable dryland production systems and associated livelihoods through the collaboration of government, the private sector and other actors

Given climate change, the most significant opportunities to feed and supply bio-based resources for a rapidly-growing population, rely on the economic, social and environmental "sustainable intensification" of production in existing pastures, forests and croplands. In practice, this entails creating enabling conditions for the management of environmental and economic risk factors and for the adoption of the most appropriate practices and technological innovation to close yield gaps (obtain maximum possible yields). Technological innovation focusing on dryland environmental challenges, and improved land management, includes, among others, plant and livestock breeding, genetic manipulation, efficient irrigation technologies, pest control systems, agrochemicals adapted for use in agroforestry, as well as big data and IT technologies for better resource management and monitoring. The adoption and use of these technologies, adapted to dryland needs, can generate the largest gains in areas with the most substantial yield gaps. However, the sustainability of dryland farming systems that adopt these changes will depend on ensuring that technologies are not misused or compromise the natural resource base. Further, if these land use systems are to contribute to sustainability and reduce the stress on dryland forests and agrosilvopastoral systems, they should not be implemented at the expense of the food and livelihoods of the rural poor.

In all areas, and particularly where economic circumstances do not allow the adoption of technological innovation as described above, increasing productivity and reducing risks can be addressed by:

- improving rainwater harvesting techniques including the local management of runoff;
- diversification of cropping systems, agroforestry and conservation agriculture practices; and
- the planting of trees to provide year-round ground cover and livestock feed and reduce the effects of wind on farming fields.

These inexpensive interventions, often derived from traditional knowledge, can be replicated, developed with and adopted by smallholders, and have regional impacts, in terms of soil and water conservation, food security and income generation.

While the demonstrated impacts are large, and the use of some practices for the sustainable intensification of agriculture can start at the individual farmer level, enhancing the adoption and scaling up the benefits of these measures is contingent on policy and financial support. For example, in Ethiopia, spending on agricultural research has seen lentil production double between 2000 and 2014. Today, 20 percent of Ethiopian farmers benefit from growing improved lentil varieties, with almost double the yield, while using the same amount of land and smaller amounts of fertilizer (ICARDA, 2015).

In regions and countries where agricultural research for development investments has occurred, significant progress has been achieved in improving the efficiency of dryland agroforestry and agricultural production systems. The impacts have gone beyond the immediate farm level, supporting the development of value chains, agro-industries, and associated jobs, and improving livelihoods and overall stability in drylands.

Potential financial sources to promote the adoption of technologies, practices and mechanisms to increase production while reducing climate and economic risk include national budgets, donors and development agencies and more innovative sources, such as the private sector and carbon markets. Climate-smart interventions and investments could result in higher and more secure incomes for 87 million people in dryland systems, while reducing land degradation in almost 11 billion hectares (CGIAR, 2012).

Leveraging private sector investments to increase financial opportunities for a sustainable production system is crucial. In India, the Green Revolution began fifty years ago to strengthen the role of the private sector with a positive effect on agriculture and dryland farming value chains. The private sector played a major role to commercialize and diversify the farming production sector such as fruit, dairy and medicinal plants.

This shift to higher-value sectors resulted in the poverty headcount ratio declining at the national poverty line in the country from 45.3 percent in 1993 to 21.9 percent in 2011 (World Development Indicators, World Bank).

BOX 7. The Forest and Farm Facility (FFF) is a partnership between Food and Agriculture Organization of the United Nations (FAO), the International Institute for Environment and Development, the International Union for Conservation of Nature and AgriCord. It provides support to forest and farm producer organizations (FFPOs), which include women and men, smallholder families, indigenous peoples and local communities, i.e. those who have strong relationships with forests and farms in forested landscapes. The FFF seeks to strengthen their technical skills and empower FFPOs as primary change agents for climate-resilient landscapes, improved food security and livelihoods. The FFF works with governments to develop cross-sectoral mechanisms and policy processes, with the input of rural people.

Its unique mandate is to support and strengthen FFPOs that work across forests and farms in order to represent and deliver services to their members and to fulfil their role as mechanisms to deliver the Sustainable Development Goals in forest and farm landscapes.

In Bolivia (Plurinational State of), the civil defence warned that 100 000 households (500 000 people) may be affected by excess rainfall and drought in 109 municipalities. 94 organizations and 28 producer groups (including women's groups) were trained to improve their production, monitoring and marketing systems under climate change. Of these, 32 organizations managed to add value to their product market and increase the income for FFPO members.

Source: FFF website http://www.fao.org/forest-farm-facility

Expected transformation 2 (scalable value chains): Scaled up sustainable dryland product value chains

Investments in drylands can drive economic development, however, this needs a shift in perception from drylands being problem hotspots to understanding opportunities and identifying entry points for investment and action. Tapping into the economic potential of dryland forests and agrosilvopastoral systems is essential. This requires policies and investments in necessary basic infrastructure, improved access to transport, public services, storage facilities, market infrastructure, and market information. Roads, for example, improve connectivity of rural areas with urban centres and markets, reduce agricultural produce losses, open opportunities for alternative livelihoods, formal employment and income for rural populations. In Indonesia, to cite one case, empirical evidence shows that investments in roads have improved the effectiveness and efficiency of provincial economic growth to reducing poverty: every one per cent of growth in provincial GDP led to a decline in poverty incidence by 0.33 per cent in "good road" provinces and 0.09 per cent in "bad road" provinces (Gertler *et al.*, 2014).

Most dryland value chains face institutional, governance, policy and development challenges which limit their potential for higher economic benefits through market access and value addition. These are linked to water resources development and management, land tenure, extension services, technology development and transfer, rural finance and access to benefits in terminal markets.

Climate change will have significant impacts on economic activity and value chains as economic actors are increasingly forced to alter their production systems to maintain production capabilities under rapidly-changing conditions. Climate change can also lead to new possibilities for people and businesses in dryland forests and agrosilvopastoral systems, with opportunities to create new products and services, develop new markets and access new funding streams and finance mechanisms.

Dryland forests and agrosilvopastoral systems make a significant contribution to the national economies of developing countries. For example, the livestock sector and pastoralists in Kenya and Senegal reportedly contribute five to ten percent of total GDP, and 15 to 40 percent of added value in agriculture in the Sahel and Horn of Africa, respectively (ODI, 2018). In East and West Africa, livestock supports 70 percent of rural dryland populations (de Haan *et al.*, 2016). Cross-border trade of dryland products is essential for regional integration and mobility. For example, ODI (2018) estimates that between Burkina Faso and Mali, livestock trade is worth at least GBP 120 million annually and livestock trade in the Horn of Africa was worth an estimated GBP 660 million in 2010 alone (Kamuanga *et al.*, 2008; Catley, 2017). Gum arabic is a significant source of hard currency in the Sudan, which provides approximately 60 percent of global supply (Koli *et al.*, 2013). It is mostly produced by rural farmers in traditional, rain-fed farming areas, which are some of the poorest and most food-insecure regions of the country (Couteaudier, 2007). Despite this, gum arabic provides sustenance and, through employment, wide-reaching economic benefits across the value chain. The agroindustry in Afghanistan also illustrates the importance of dryland value chains, accounting for 90 percent of the nation's total manufacturing, dominated by small and medium-size enterprises and depends on raw inputs from the country's drylands (World Bank, 2014). In the Kelka Forest area in Mali, it is estimated that a one dollar investment in reforestation and agroforestry will generate a six dollar benefit to local farmers and globally a 13 dollar benefit due to carbon sequestration over a time horizon of 25 years (IUCN-ELD, 2015).

Value chains for sustainably produced building material have a large potential in national development. Substantial increases in housing construction are, in many cases, quickly increasing imports of wood and maintain illegal and unsustainable use of the last natural forests, unless scalable value chains can be formed from local rural production to urban needs. Prerequisites for this to happen include incentives for diversification in land use, as well as entrepreneurship for processing with sufficient quality of products to compete with imports.

Dryland value chains have significant socio-economic growth potential to support the transformation of drylands. The Policy Framework for Pastoralism in Africa[5] seeks to protect the lives, livelihoods and rights of pastoral peoples and to reinforce the contribution of pastoral livestock to national, regional and continent-wide economies, and lays out strategies for the development of livestock value chains. Further, the African

[5] http://www.fao.org/faolex/results/details/en/c/LEX-FAOC166944/

Union Livestock Development Strategy for Africa (LiDeSA) 2015–2035 recognizes that the livestock sector can lead to a sustained annual agricultural GDP growth of at least six percent. The sector, therefore, represents a potential for transformation in terms of employment, food security, and ecosystem services (Neely *et al.*, 2009). In Zimbabwe, since the 1980s, the agriculture sector has been dominated by smallholder farmers, tilling an average of one ha per household and producing an average of 0.4–0.6 MT of maize (LFSP, 2017), of which up to 30 percent is lost due to poor post-harvest technologies and practices. The high reliance on subsistence rain-fed agriculture, therefore, renders a large majority of the rural population vulnerable to climate-related shocks and seasonal stressors.

While dryland value chains are vulnerable and exposed to climate risk, inherent adaptive capacities can provide the basis of climate-resilient and sustainable economic development. Recent studies indicate that combinations of horizontal integration (i.e. creation of jobs in financial and animal health service industries) and vertical integration (i.e. improved quality of livestock and transformation of beef into premium cuts) offer opportunities for increasing productivity within sectors, but also diversification opportunities into related sectors. Better government incentives for non-wood forest products, such as gum arabic, can provide double dividends by contributing to reduced soil erosion, degradation, and therefore, on-farm fertility.

Greening the Charcoal Value Chain Initiative (FAO, 2017) aims to transition to a more sustainable production systems, mitigating climate change by promoting forest restoration and sustainable sourcing practices. This also includes improving carbonization practices and processes (e.g. increasing and kiln efficiency) and could benefit over 40 million people globally who are involved in commercial fuelwood and charcoal production, with a sustainable increase in income and therefore improved livelihoods. African countries could potentially reinvest USD 1.5–3.9 billion in greening the charcoal value chain from annual revenue currently lost due to lack of regulation in the sector (FAO, 2017). Interventions that contribute to the achievement of this expected transformation include those related to strengthening existing, and supporting the development of new value chains, as well as targeting current limiting factors. However, the cost of scaling up profitable production systems on the natural resource base and the lives and livelihoods of the producers needs to be taken into consideration to avoid unintended. For example, in Tajikistan a growing demand for meat products has led to a 45 percent increase in livestock production between 2011 and 2016. Livestock accounts for more than 30 percent of the total income from agricultural products and provides a direct source of income for more than four million people in rural areas. However, the livestock value chain is highly regulated with the government determining the location of herders' activities, and the number of people allowed to be herders. While the sector has the potential for short-term economic growth, its long-term sustainability is challenged by land degradation and climate change (see Case study 1).

Case study 1. Climate resilience through sustainable value chains – livestock in Tajikistan

Tajikistan is the most climate-vulnerable country in the Europe and Central Asia (ECA) region, due to its relatively weak social and economically productive structures and low adaptive capacity. The country is landlocked, covers an area of 143 000 km2 and 93 percent of its surface is mountainous. High poverty rates among rural communities in Tajikistan increase their vulnerability to climatic shocks and stresses, which is further compounded by food insecurity, high rates of labour migration, and inadequate provision of services. The cumulative effects of repeated climate-related disasters impact poverty-stricken and vulnerable populations, severely restricting their ability to improve their coping capacities. Tajikistan's economy is extremely vulnerable to natural hazards, with 20 percent of the GDP exposed (WFP, 2017). The country is affected by soil erosion, salinization, swamping, and deforestation. Land degradation, rising temperatures, and aridity have become a critical issue and a concern for the future, with water needs for irrigation of basic crops likely to increase by 20–30 percent compared to present-day conditions (WFP, 2017).

Pastoralism is strategically important and a growing industry for the country, accounting for over 32 percent of total income from agricultural products, providing food security, and being a direct source of income for more than four million people in rural areas. Increasing demand for the consumption of meat has led to a production increase of 45 percent between 2011 and 2016. Market information and integration is weak, and herders rely on informal channels of communication to support decisions of purchase and offtake. The livestock value chain is highly regulated, with the Government determining the number of herders and their activities.

While growth in the livestock sector is seen as promising, long-term sustainability issues must be considered, particularly in the context of climate change. Producers report that changes in the frequency and intensity of rainfall, characterizing recent years have affected their activities. For example, in 2017, Tajikistan received 130–140 percent of its average annual rainfall within a shorter number of days in relation to the yearly average. With five major drought periods since 2000 and fragile early warning systems, producers also see droughts, heatwaves, and insufficient water availability as significant risks.

To adapt and mitigate the adverse effects of climate change on production, farmers have identified specific issues and associated services that could be improved. For instance, they have reported the unsatisfactory state of pastures due to high levels of degradation, low hay yields, and the formation of ravines. They see access to year-round water as a significant challenge and claim for a change in the limited availability of supporting services such as veterinary support. Further, they explain high-interest rates make access to credit organizations untenable. The following recommendations favour transformation in the value chain to ensure the sustainability of Tajikistan's livestock sector under climate change:

- actions to recover and improve the state of pastures, including inventories of current grazing areas;
- initiatives for pasture restoration and regeneration, and the elaboration and implementation of management plans for the timing and use of pastures. Supporting these measures with local institutions and regulations and through government authorities is imperative;
- increasing the efficiency of the livestock sector; efficient processing and uptake of livestock would greatly increase sector profitability and reduce waste; and
- ensuring access to financial, information and climate services for adaptation. This includes early warning systems and seasonal weather forecasting to be overlaid with the pastoral and natural resource management plans.

Source: ODI (2018)

Expected transformation 3 (climate risk insurance mechanism): Guaranteed equal and inclusive access to climate risk insurance mechanisms for dryland agrosilvopastoral system-dependent populations

The livelihood strategies of dryland communities have evolved over history as adaptations to water scarcity and unpredictable weather conditions. However, the old challenges are now exacerbated by combinations of social, economic, political and environmental factors, including demographic growth, land degradation and climate change, which test the resilience of traditional livelihoods and food production systems in drylands. Strengthening the current and future ability of dryland populations, particularly the poor, to anticipate and take adequate steps to avoid or cope with and recover from shocks should be a priority.

Insurance is a crucial tool to provide the flow of capital to support communities and infrastructure to recover from disasters. Without adequate insurance, the burden of paying for losses falls mostly on individuals, governments or aid organizations, with significant impact on already strained national budgets, and economic and social hardship for those affected (Jarzabkowski *et al.*, 2019). As extreme weather events become more frequent, the role and benefits of insurance in transferring risk from disasters associated with both slow and fast onset hazards are being increasingly recognized. However, there is still a gap in the development of insurance services for low-income populations, partly because insurers cannot quantify their livelihood risks, such as agricultural risks in areas where rainfall unpredictability prevails or where climate change is expected to have substantial but uncertain long-term impacts (Jarzabkowski *et al.*, 2019).

The benefits of insurance go beyond compensation and recovery. Insurance systems can contribute to the broader understanding of climate-related risks and help promote measures that individuals and communities can use to improve their protection from climate change-driven disasters. For example, insurance expertise in risk evaluation helps to make the economic case for sound ecosystem management, stable markets, infrastructure, early warning systems, and other resilience-based interventions that can reduce the extent of disasters to nations and regions. Insurance therefore has a role in supporting livelihoods, ecosystems conservation, and rehabilitation, supporting government allocations to dryland climate-smart resilience building programmes, as well as stabilizing key value chains. Further, as an approach for risk management, insurance strengthens socio-economic resilience under a changing climate (Jarzabkowski *et al.*, 2019). This is particularly pertinent in drylands, where humanitarian interventions and emergency assistance have often arrived too late or have been inappropriate, further undermining the development of disaster-affected regions. Enhancing access to insurance, particularly index-based insurance schemes, can lead to greater inclusion and fairer distribution of benefits, addressing equity issues and the needs of the most vulnerable, including women and children (Fisher *et al.*, 2019). Nonetheless, formal insurance programmes do not replace and must not undermine traditional coping mechanisms.

In recent studies, risk transfer mechanisms in drylands such as insurance and cash transfers were found to support households to maintain their livelihood strategies, make productivity investments, and reduce negative coping strategies – all of which had a ripple effect on nutrition and health.

In Kenya for example, CARE International supported the successful pilot-testing of an index-based livestock micro-insurance scheme for migratory pastoralists. The benefits of the pilot scheme, where remote sensing techniques were used for measuring pasture availability and predicting livestock mortality, included a 36 percent reduction in the likelihood of distress livestock sales and a 25–36 percent reduction in likelihood of reducing meals as a coping strategy during drought years. During non-drought years, households with the insurance coverage increased investments in veterinary and vaccination services. This project contributed to the rolling out of a government-sponsored, large-scale insurance programme (Baumgartner and Richards, 2019).

In Mongolia, the Index-Based Livestock Insurance Project (IBLI) prevented thousands of nomadic pastoralist households from falling into abject poverty due to the impact on their herds of extreme weather events such as dzudz.[6] This insurance scheme launched by the Government of Mongolia allows automatic payouts to insurance holders in geographic areas where conditions indicative of mortality thresholds have been met. The index-based insurance reduced transaction costs while reaching populations in remote and underpopulated areas where traditional insurance is unavailable. While IBLI addresses the climate risk reduction needs of over 15 000 herders, the success of its implementation has also revealed the challenges of insuring poor populations under increasingly uncertain climatic and environmental conditions. These include designing insurance products that respond to beneficiaries' needs and address the differences between women and men, are affordable to beneficiaries and insurance companies, and are based on solid public–private partnerships. Awareness-raising and education campaigns for creating demand have also been crucial to the success of this scheme (DeAngelis, 2013).

The use of weather index insurance helped secure the livelihoods of low-income farmers and pastoralists to face the risk of climate change (FAO, 2015a). The weather risk management facility partnership in Senegal trained 69 farmers' organizations in Kdola and Tambacounda on index insurance and risk management. As a result, 1 594 farmers were insured and received payouts due to poor rainfall in 2015 and 2016, ensuring greater impact on food security for poor smallholders and women (IFAD–WFP, 2018).

Social sustainability pillar

Living in some of the world's most variable and unpredictable environments, people in drylands have developed strategies and institutions that allowed them to cope with and harness variability to support their livelihoods, societies, and ecosystems. In recent decades, many of these age-old institutions and customary practices were negatively impacted by country borders and shifts in policies implemented by national and regional organizations that poorly captured the synergies between the local societies and the variability and limitations of drylands. For example, pastoralists in Africa have experienced processes of continuous marginalization through a history of policies that have impacted land tenure, mobility, and which have, in many instances, neglected development needs (Catley, 2017). In Niger and the Sudan, restrictive forestry policies in the past severely limited farmer management of their own trees, with implications on

[6] *Dzudz* are extreme winters in Mongolia, characterized by extremely low temperatures and snow conditions that lead to massive livestock and crop production losses.

their livelihoods and land productivity (Garrity and Bayala, 2019). The long history of mistargeted policies on pastoral and agropastoral societies has resulted in the exclusion of dryland communities from influencing policies, limiting their access to resources such as land and services, including extension services, and often resulting in poverty, conflicts, environmental degradation, and forced migration (FAO, 2018a).

Various improvements were made on dryland forest and agrosilvopastoral management, but these have not necessarily been translated into gender equality in other domains. Men and women continue to have highly unequal access to land, economic or other livelihood opportunities and civic and political participation rates. To ensure gender-equal governance, the policies and interventions should be planned based on the key environmental resources people use, how they use such resources, who the primary users are, and equitable use amongst stakeholders.

In inner Mongolia for example, pastoralists saw the cost of managing herds increase from an average USD 1 296 per year to USD 14 578 per year when forced to pen-raise their livestock due to government-established grazing bans as part of a grassland restoration policy. The significant reduction in income imposed new livelihood risks for marginalized groups; with the young and fit engaging in alternative income sources and migrating, leaving the elderly and children behind, without proper care and challenging the cultural system (Li and Gongbuzeren, 2013).

Over the past three decades, there has been a shift in policy narrative towards an increased understanding of dryland contexts. The change has focused on human and social capital, the need for increasingly integrating local knowledge, targeted development needs, informed participation, and inclusion of customary/local institutions as a means of ensuring that interventions respond to the dryland contexts. Where communities are part of the broader development discourse, positive impacts have been widely noted, with associated benefits on food, health, and nutrition.

Policies and programmes that emphasize equity are essential in addressing vulnerabilities, particularly in the context of climate change. Marginalized communities and social groups such as pastoralists, indigenous communities, women, people with disabilities, and displaced persons, often have less access to productive resources such as forests and rangelands due to shifts in land tenure, or management regimes. This leads to poverty, migration, and destitution, therefore limiting the ability of vulnerable groups to adapt to climate variability and change. Equitable policies and programmes in this context may be understood in terms of commitment to assist vulnerable groups, and include measures that increase access to assets, forests and water resources, climate information to inform their decisions, as well as addressing their immediate underlying development needs through services. In addition to this, is the commitment to protect the livelihoods base of vulnerable groups by ensuring that mitigation and adaptation policies do not jeopardize the needs of the community. This is particularly relevant where measures may compete with the immediate requirements of the community, such as access to land for cropping.

Climate change, in combination with other existing pressures, will bring challenges that will not only limit the resources available to meet the development needs at scale (Stern, 2006; IPCC, 2019), but will also require that both traditional and scientific knowledge are harnessed to support rural communities to adapt. Towards this, participation is a critical concept in achieving social sustainability as it ensures that as many groups as possible become an active part of decision-making processes. This not only ensures better targeting of policies and programmes, but also more inclusion of social groups that can be mobilized to address the scale and speed at which challenges in drylands need addressing. Such engagement can play a crucial role in ensuring that limited resources are shared equitably and that conflicts over resources are mediated. Further, by participating in governance processes, there is legitimacy and greater adoption of other sustainability actions over time, such as land tenure reforms and sustainable land management techniques.

The following three expected transformations are vital in addressing the social sustainability needs of dryland communities.

Expected transformation 4 (equity): Improved social well-being and equity for forest and agrosilvopastoral system-dependent livelihoods

The extent to which people have secure and equitable access to social services and to the natural resources they need to produce food for their consumption and nutrition and to generate income plays a critical role in land management and the sustainable development of rural areas. For many forests and agrosilvopastoral system-dependent communities in drylands, insecure tenure rights over natural resources or inadequate and inequitable access to them results in extreme poverty and hunger. This, in turn, traps them in the unsustainable use of the resources they can access, leading to land degradation and the longer-term erosion of their capacity to cope with and adapt to climatic and non-climatic impacts. However, the flipside to this is that increased equitable, secure access to natural resources is noted as contributing to improved health, nutrition, and quality of life in dryland populations. By securing access to resources and providing land tenure opportunities, farmers can make better land management investments and more sustainable rangeland management can take place, enhancing food production, food security, and better their quality of life. Further, recognizing the role local institutions and collectives have in contributing to managing dryland resources effectively goes a long way in ensuring the sustainability of food production systems in these areas.[7]

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[7] The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT) is an important step in the quest of securing tenure rights and equitable access to land, fisheries and forests as a means for eradicating hunger and poverty, supporting sustainable development and enhancing environmental conditions. The VGGT promote responsible governance of tenure of land, fisheries and forests, with respect to all forms of tenure: public, private, communal, indigenous, customary, and informal. The VGGT are expected to benefit all people in all countries, although there is an emphasis on vulnerable and marginalized people. Therefore they are particularly relevant for the World's drylands. Guidance on the implementation of the VGGT has been issued for pastoral lands (see Davies *et al.* 2016)

Different participatory models and approaches have shown positive impacts on livelihood development and well-being, food security, and good governance in dryland countries. For example, countries like Kenya and Namibia, among others, have witnessed the importance of community conservancies in forest and wildlife management. In Kenya, 89 percent of 160 conservancies are managed by communities and provide educational and health benefits to over 700 000 community households through involvement in touristic activities (African Wildlife Foundation, 2016). In Namibia, 82 community conservancies earned a total of over NAD 44 million in wages from diversified enterprises and more than NAD 2 million from tourism (NACSO, 2015).

In Jordan, for example, the revival of a traditional community governance system for agrosilvopastoral land – the Hima – has allowed the restoration and sustainable use of previously degraded pastures in areas where land tenure had been transferred to the State. The Hima governance system allows communities to implement management plans based on short-duration grazing and periods of rest to allow for the regeneration of natural pastures. The revival of the Hima system has brought substantial environmental benefits, including groundwater infiltration. Pastoralists can now access better pastures, are willing to pay for water, and respect the Hima system which is being adopted all over the country and is estimated to deliver between JOD 144 and 289 million worth of net benefits to Jordanian society (IUCN–ELD 2015).

Expected transformation 5 (disaster risk management): Lives and livelihoods of dryland forest and agrosilvopastoral system-dependent populations protected against climate shocks, disasters and conflict

Even if global warming is limited to 1.5 °C, the direct and indirect climate change impacts on drylands will test the resilience of their populations, natural resources and food production systems. Without appropriate adaptation measures in place, the capacity of rural populations to cope with and recover from the impact of climatic and non-climatic hazards will decrease with each impact, with dire socio-economic consequences that can rapidly escalate to humanitarian crises.

Crises can be nested within crises, escalating the level of disasters and hitting the dryland poor and vulnerable the hardest. Disasters can destroy years of investments and obstruct further development. For example, after two years of below average harvests, due to the worst drought in Southern Africa in 35 years, most poor households in the cereal-producing provinces of Sofala and Manica in Mozambique, were unable to conserve grain to be used as seed for the 2019 season. Then, in March 2019, these semi-arid provinces were hit by Tropical Cyclone Idai. The cyclone brought torrential rains and catastrophic flooding, which destroyed agricultural fields. The provinces saw their agricultural output sharply decline, and farming communities reported having well below average food stocks, not sufficient to last until the next full harvest in March 2020. This again, left the poorest without seeds to plant and increased their dependence on humanitarian assistance. However, for those who could still plant, the October rains did not arrive on time, as the drought continued.

In addition, fall armyworm outbreaks adversely affected crop yields, particularly maize crops. Dry weather conditions, prior to the cyclones, facilitated the spread of the pest, increasing its damage and impact on crop productivity. As a result of these various, successive climate-related events, cereal production decreased to 2.8 million tonnes in the country, about 16 percent lower than 2018. (ActionAid, 2019; FAO, 2019b; FSIN, 2020).

In another example, at the time of writing this paper, East Africa is experiencing its worst locust invasion in decades, causing massive damage to farms and pastures; with livestock-related costs and damages that in Kenya alone, could reach USD 8.5 billion by the end of 2020 (Smith and Kayama, 2020). It has been forecast that pastoralists in Ethiopia, the Sudan, and Kenya will be the worst hit in the region. While bearing the devastating losses caused by the locust swarms, dryland dwellers see tensions surge as competition for scarce resource patches arise. At the same time, the global COVID-19 pandemic spread across the world, adding yet a further burden to dryland communities. What is more, the focus of international funding for emergencies has shifted, creating shortfalls in appeals for support to those facing food shortages in the immediate term due to the locust invasion (Smith and Kayama, 2020).

Although the relationship between climate change and violent conflict is contested, the frequency and severity of crises caused by meteorological hazards – particularly drought and armed conflict are increasing (CORDAID, 2019), often leading to displacement and further diminishing people's capacity to cope with shocks, especially where government capacity to adequately address people's needs may be weak.

Given this complex dynamic context, learning from local successes that draw on indigenous and traditional knowledge and implementing other resilience-building[8] approaches and interventions in agreement and collaboration with dryland forest and agrosilvopastoral system-dependent populations will contribute to the achievement of this expected transformation.

These approaches and interventions encompass:

- economic interventions to reduce market volatility during crises;
- technology transfer interventions, such as providing access to improved, drought- and pest-resistant crop seeds and drought-resistant breeds; and
- risk management strategies such as conflict mitigation, social safety nets inclusive of cash transfers, insurance and access to credit.

Further, by increasing awareness and understanding on the linkages between short- and long-term climate trends, land degradation and resource scarcity, and by offering and expanding access to climate information and early warning systems, households are empowered to make investment decisions that enhance and protect their livelihoods and reduce their vulnerability to shocks.

[8] IPCC 2012 refers to resilience as a key factor in sustainability. It is defined as the ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, by ensuring the preservation, restoration or improvement of its essential basic structures and functions.

In the arid and semi-arid states of Bihar and Haryana in India, weather-based agro-advisory services delivered by phone to men and women have contributed to reducing the information asymmetry between genders in farming households. By increasing women's knowledge of climate-smart technologies, the services have strengthened their participation in decision-making at the farm level and have allowed families to make more efficient use of inputs during the sowing season, resulting in savings and in more sustainable land use (Venkatasubramanian *et al.*, 2014). Uncertainty of ownership and land use rights relationships is one of the main causes of land degradation, poverty and food insecurity in dryland forest regions. Considering the common property regimes such as the role of indigenous peoples, traditional knowledge, and natural resources management, institutions are critical to achieving the expected transformation for sustainable production systems. In Bolivia (Plurinational State of), the rate of deforestation in forests managed by indigenous communities is six times lower than in other areas; and 350 times lower in one part of Mexican Yucatan, in addition to the greater socio-economic benefits (Child and Cooney, 2019).

BOX 8. The role of non-governmental organizations (NGOs) as instruments for good governance

In the State of Rajasthan, India, where drought-related risk is greater than any other hazard, a project by an Indian NGO mobilized communities around inclusive participatory drought risk assessments. As a result, communities identified the most appropriate measures, created local plans and implemented them, with results that go well beyond increased productivity and reduced drought impacts. The simple process of inclusive participation in the assessments created a more collaborative environment where low-caste communities and women were heard. The chosen measures were traditional measures, based on rainwater harvesting and dryland agriculture practices (e.g. raised bunds) which were used in other parts of India and had been forgotten locally. The communities used locally-available materials, indigenous resources, and knowledge as well as local labour, which has ensured long-term sustainability. The NGO facilitated linkages and helped create a relationship between otherwise marginal communities and the Government. This empowered the communities to draw on unallocated local government resources to bring their intervention to scale.

Source: UNISDR (2009).

In another example, the National Agricultural Monitoring System (NAMS) in Australia, created through a highly participatory process, uses data provided by multiple actors, including farmers, to generate regional and national analyses and reports on production, climate, irrigation, water availability and economic productivity. Different from traditional agro-meteorological information, these reports are accessible online to producers, researchers, governments and other users, in a range of user-friendly formats.

Through the online reports, decision-makers receive immediate information on drought risk identified by NAMS and take action. One of the many benefits of NAMS is that it has expedited the delivery of targeted drought assistance support to regions before the impacts of the drought are felt as economic declines. The NAMS tool has the potential for replication in other parts of the world with fairly developed telecommunications infrastructure and high levels of Internet access for potential users, and a range of established, relevant data sets.

Expected transformation 6 (inclusion, participation and empowerment): Participation and empowerment of dryland forest and agrosilvopastoral system-dependent populations in all adaptation and mitigation decision-making and implementation processes

Historically, dryland communities have been mostly excluded from state governance processes, leading to the perception of drylands as being unproductive as well as undervaluing their contribution to national economies. In this context, decision-making on land and water management and mobility at the local level operates through a diverse array of customary systems, which often overlap. However, the authority of traditional customary governance systems over dryland resources has been affected by socio-economic and political changes, often due to state-level decisions. These decisions include those related to land tenure, migration, sedentarisation or large-scale agricultural investments, resulting at times in the fracture or demobilization of communities, hence lessening the power of dryland people to interact with and make their voice heard by government (Forsythe *et al.*, 2015). Giving a voice to marginalized dryland populations through participation and a say in all decisions that affect them, from government-level policies to the design, planning and implementation of projects on the ground has been a directive of sustainable development. Where this has happened, public investments have been more effective, the long-term integration of dryland communities into development planning has occurred and social groups have been mobilized to address major challenges, at the scale and speed required, such as in the case of reversing land degradation in Tigray (see Case study 2). Participation of dryland communities in higher-level decision-making has never been more important with the massive challenges imposed by climate change exacerbating existing structural problems threatening the sustainability of food production systems for humankind. The success of the large-scale efforts required to reverse land and water degradation, to sustain forests, trees and vegetation cover and to adapt farming and pastoral systems to the projected climate change-related transformations, depend largely on fair and transparent social agreements. Such agreements are constructed with the participation of dryland actors to guarantee the equitable sharing of limited resources and benefits derived from the actions undertaken.

Case study 2. Fostering community participation for better large-scale restoration initiatives in Tigray

Despite its abundant natural resources, Ethiopia is one of the most seriously affected countries in sub-Saharan Africa by land degradation, resulting in the decline of agricultural productivity and an increase in food insecurity. According to the 2019 integrated food security phase classification (IPC) classification, more than 8 million people in Ethiopia were in crisis (IPC Phase 3). A large-scale restoration initiative was initiated by a State programme to reverse land degradation and improve food security in Tigray – which is considered the poorest region with a 27 percent poverty rate according to the 2015/2016 Household Consumption and Expenditure Survey (Central Statistical Agency, 2018).

Effective consultation and engagement with the communities took place through the traditional mass mobilization practice that requires community members to contribute with 20 days per year of unpaid labour towards soil and water conservation. The environmental, social and economic benefits of the Tigray experience are enormous. A mosaic of restoration and other sustainable land management interventions implemented were co-created by the people and government institutions. The landscape transformation has permitted formerly famine-stricken communities to diversify their livelihoods through irrigation and improved livestock management, with some opening bank accounts to keep their savings. Over 7 000 households in Tigray graduated from chronic malnutrition and food insecurity to food self-sufficiency. The mobilization and participatory decision-making that took place in Tigray was also rolled out in other areas of Ethiopia.

As a result, Mengistu (2014) states *"millions of hectares of land have been enclosed for natural regeneration, billions of trees have been planted, million kilometres of terraces have been constructed, hundreds of thousands of hectares of land have been protected from unlimited livestock and human intervention and thousands of water harvesting and development schemes have been developed in various parts of the country."*

Increasing the involvement of community-based organizations in the implementation of sustainable land management programmes, with climate change adaptation and co-benefits allows the cost effectiveness of already limited national resources to be brought to scale, in ways that benefit smallholders and protect them from climatic and non-climatic shocks.

Source: Mengistu (2014); Neuberger-Wilkie (2017)

Environmental sustainability pillar

If climate change and land degradation remain unabated, natural dryland ecosystems may reach tipping points, beyond which they lose their ability to provide services including those that are vital for food production (Ranganathan and Hanson, 2010).

The key message highlighted by the recent Special Report on Climate Change and Land (IPCC, 2019), is to maintain the focus on the land–climate nexus and avoid duplication. The world's food production systems depend on soil fertility, pollination, clean water and multiple other services provided by natural ecosystems. In drylands, highly specialized life forms and ecosystems have evolved in response to the often-extreme abiotic conditions of these environments, particularly water scarcity. The importance of dryland natural systems to humankind is clear. Thirty percent of the plant species under cultivation today originated in drylands, and their ancestors and wild relatives still grow in these environments. The biomass of natural dryland rangelands sustains most of the livestock on the planet and can store up to 70 tonnes/ha of soil carbon (Laban *et al.*, 2018). Dryland forests account for 18 percent of the dryland area, while barren land accounts for 28 percent, grassland 25 percent and cropland 14 percent (see Figure 1) (FAO, 2019a). These lands are the source of energy, foods, medicines, fibre and income to millions of people on a regular basis and are critical for the food security of poor agro-pastoral communities during times of drought and hardship. In Africa alone, over 320 million people depend on dry forests to meet many of their basic needs (Bose and van Dijk, 2016).

Natural biological systems play a major role in hydrological and nutrient-cycling processes, including water infiltration and carbon storage. These processes, essential to agricultural systems and to ecosystems themselves, extend beyond vegetated areas. For example, mosses, cyanobacteria and lichens create bio-crusts that control these processes in what could be considered bare soil surfaces in many semi-arid and arid regions. Healthy dryland ecosystems are dynamic and interconnected, tested by and able to recover from erratic precipitation, fire, and other natural hazards typical to their environments. However, dryland ecosystems are also fragile and at risk from human activities and climate change.

Dryland forest environments offer enormous potential for climate change mitigation, with global benefits, if human-induced land degradation processes are controlled. Dryland forests and agrosilvopastoral ecosystems have increasingly been degraded and fragmented by deforestation, overgrazing, urban sprawl, crop encroachment into unsuitable areas, unsustainable agricultural practices, and other non-agricultural unsustainable land uses. These practices have clearly had negative consequences on their biodiversity and function, limiting their capacity to deliver essential ecosystem services and cope with the challenges of their environments. Soil erosion, loss of soil nutrients, salinization, and disruptions to the carbon, nitrogen and water cycles, caused by unsustainable land management practices already affect millions of people directly subsisting from natural resources in these regions. Unfortunately, global climate change has a significant effect on extreme environments and a profound influence on species survival. Even if global warming can be limited to a 1.5 °C increase, its impacts will further test dryland ecosystems and exacerbate land degradation processes. This is of deep concern as degraded land stores less water, aggravating water scarcity challenges to human and natural systems. Moreover, land degradation processes, such as the loss of vegetation cover, reduce the potential of drylands to sequester atmospheric carbon, and others, such as soil erosion, release carbon into the atmosphere, further contributing to global warming.

Environmental sustainability, in the context of drylands management as multifunctional landscapes, relates to ensuring food production or other actions that do not compromise the health of natural systems and their ability to deliver ecosystem services under climate change. This implies a balance in land management interventions that ensures food production, support local livelihoods and safeguard that natural resources, including water are: a) used efficiently to avoid losses, i.e. harvested no faster than they can regenerate; b) restored when degraded; and c) conserved to the extent that ensures they can rely on their biodiversity and own genetic pool to recover from disturbances. In the current context, land management strategies that restore productivity and contribute to climate change mitigation, while provisioning for the adaptation needs of local populations should be prioritized.

Three expected transformations are therefore vital in addressing the environmental sustainability in drylands, and are as follows:

Expected transformation 7 (natural resources use efficiency): Efficient use of dryland natural resources to ensure the long-term provision of ecosystem services under climate change

The efficient use of fragile ecosystems and natural resources in drylands today is key to guarantee they will be available for a growing population in a warmer world. This requires understanding and addressing efficiency issues in both the demand for and the supply of natural resources, as well as averting irreparable trade-offs. Contributing to increasing demand efficiency are interventions leading to savings in the use of natural resources to fill the same needs, through improved technologies or practices. In terms of supply, assessing the extent of the resources available, the limits to their sustainable extraction or use and their potential availability under climate change need to be assessed as some resources may inevitably be lost. The following need to be carefully assessed to avoid trade-offs:

- the level to which irrigation is possible without inducing decline in the level of water bodies or soil salinization;
- the level to which fertilizers can be used in dryland areas without compromising the quality of soils and scarce water resources; and
- the level to which it is possible to extract groundwater, wood or other forest products.

BOX 9. Collective action and traditional knowledge count for sustainable land and water management

In the central desert of the Islamic Republic of Iran, farmers have been using Qanat irrigation systems since the year 800 BCE. Qanat systems capture groundwater and through a slightly sloped underground tunnel bring it to the land surface – even kilometres away from the water source – where it is used for household use and irrigation. Qanats have sustained food and livelihood security over millennia because they are a reliable source of water for traditional family farms in dry areas where agriculture and farming would otherwise be impossible. These systems have allowed the production of high-value crops, fruit and trees and have sustained wild species. They prevent over exploitation of the tapped aquifers because the rate of water flow in a Qanat depends directly on the natural flow of groundwater. Their operation today is based on full participation of local water users who receive water according to their share of owned land. The construction and maintenance of the Qanats relies on the well-organized participation of experienced labour and full cooperation among community members. However, the relevance of Qanats has decreased in recent times due to lack of funding for their maintenance and the availability and use of high-yielding water extraction technologies, which often lead to aquifer depletion.

Beyond this knowledge, addressing the policy and institutional frameworks that govern dryland resources and action on the ground are needed. Past policy initiatives have had inadvertent effects on the rates of forest destruction, degradation of rangelands, over-extraction of water resources, and other land degradation processes in drylands.

However, as the Niger FMNR (page 9) and the Jordanian Hima examples (page 32) respectively show, when there is a better understanding of the local conditions and relevant options, appropriate policies can be enacted and governance systems put in place to improve the efficiency of natural resource use. Further, when participatory approaches are used to identify best management options, sustainable land management interventions have a greater success potential, with the additional benefit of actions on the ground being relevant to the local context and owned by users. Hence the feasibility of their widespread adoption is higher. Finding the means to build consensus among sectors and users on land and natural resource management strategies is therefore necessary, not only to reduce potential resource overexploitation but to avoid conflict. The experience of many NGOs and institutions such as the International Center for Agricultural Research in the Dry Areas (ICARDA) indicates that where inclusive, multi-stakeholder dialogue has been established (involving natural resource users and other stakeholders including scientists, economic sector representatives, policymakers and/or practitioners) to identify resource use issues, practical solutions and improved governance systems have been co-created, implemented and generated change (ICARDA, 2015). Such efforts to strengthen collective action have also provided an important space to understand the differentiated roles of men and women, pastoralists and agropastoralists in land use (Sonneveld *et al.*, 2018).

In general, actions to support this expected transformation should seek to enhance efficiency in natural resource use to avoid land degradation. At the policy level, land degradation neutrality policies should be considered as a good option because they also contribute to the other two expected transformations under the environmental sustainability. These policies promote the implementation of sustainable land management solutions to address land degradation, while supporting climate change mitigation and adaptation, with co-benefits for poverty eradication and food security. The Partnership for Action on Green Economy supported Senegal to put in place the 2015–2020 participatory national strategy to promote green jobs. As a result, 2 000 green jobs were created by 2019, with more than 40–45 percent for women and youth groups. These green jobs include recycling projects and agroforestry projects to support community entrepreneurship (Futurepolicy.org, 2019).

The implementation of such policies support farmers and communities in their effort to avoid, reduce and even reverse land degradation, thus strengthening their own adaptive capacities to better cope and recover from climate impacts. Examples of such policies include strengthening land tenure, which then drives the adoption of sustainable land management approaches, such as agroforestry and soil conservation. In addition, investment in extension services and other subnational strategies increase the local understanding of climate change and land degradation, as these can support the mobilization of communities around sustainable land management-related activities,

Case study 3. Climate change impact on dryland forests and livestock. An example from northern Mali

In northern Mali, local people have always adapted to climate variability – with more or less success – but climate change will impose an additional burden on them. A study on the vulnerability of livestock and forests in this region show that autonomous adaptation is insufficient in adapting and mitigating climate change. This is linked to the current national and subnational institutional arrangements which may fail to support local adaptive strategies. Using a participatory approach across levels and genders, scientists have analysed the vulnerability of livestock and forest-based livelihoods to climate variability and change in Lake Faguibine, northern Mali, where drastic ecological, political and social changes have occurred (CGIAR, 2012).

In this region, water stress from declining lake levels, have pushed the local community to increasingly depend on the forest ecosystem. The communities are currently using the forests for charcoal or fodder. However, these strategies will have adverse impacts on the resources, which could lead to increased vulnerability in the future, unless forests are managed sustainably. Subnational institutions have not yet realized the importance of managing these forests for enhancing local adaptive strategies. With limited rules on access and control, as well as unclear land tenure on previously irrigated lands, the potential for degradation is high. Equally, the livestock sector in this region has been severely impacted by water scarcity and reduced forage. This, coupled with the divergent views and policy instruments between national and subnational institutions, is unlikely to result in effective adaptation efforts.

Source: Sonneveld *et al* (2018)

including water-saving techniques, land restoration activities and the adoption of agroforestry practices. The UN Decade on Ecosystem Restoration 2021–2030 aims at collecting and disseminating best restoration practices, to support the work of practitioners and improve restoration results, including in drylands (Box 10).

BOX 10. UN Decade on Ecosystem Restoration 2021–2030

In an effort to mainstream ecosystem restoration into policies and plans to address current national development priorities and challenges, the United Nations (UN) Decade on Ecosystem Restoration 2021–2030 (UN Decade) is calling for the large-scale conservation and restoration of all ecosystems to ensure the SDGs will be attained. The UN Decade follows a strategy to foster a global restoration culture, through the empowerment of a global movement, political will and technical capacity for restoration. The three main goals of the strategy are:

1. Prevent, halt and reverse the degradation of ecosystems worldwide.
2. Increase understanding of the multiple benefits of ecosystem restoration.
3. Apply knowledge of ecosystem restoration in education systems and within all public and private sector decision-making.

Source: United Nations Decade on Ecosystem Restoration (2020)

Case study 4. Large-scale reforestation initiative supported by pastoral communities in Morocco

In Morocco, overgrazing has been described as the main cause of vegetation loss and land degradation and a major threat to the sustainability of the country's dryland forest ecosystems as it impedes their regeneration. In Morocco, forests are state owned, with local residents holding only limited use rights, some of which are ancient customary rights. To find long-lasting and viable solutions to reduce the heavy grazing pressure on forest ecosystems, and to support reforestation initiatives, a programme of compensation for forest areas closed to grazing was initiated with the participation of forest users.

A programme set up by uses a legal framework established in 2002, which allows the state to give financial incentives to forest users organized in grazing associations, who agree to respect the closure from grazing in reforestation sites. Through their local associations, communities have been actively involved in the choice of forested areas that will be closed to grazing. They also nominate guards to prevent herd access to those areas. The organization of users within this framework respects the perimeters closed to grazing, which results in the rehabilitation and conservation of forest resources and protection against land degradation. Such involvement of local communities and the participatory conciliation between the current needs of the local communities and the imperatives of the conservation and development of dryland forest resources has been a key success.

Since the implementation of the legal mechanism in 2005, the number of grazing associations and members involved in the programme has steadily increased. In 2019, there were more than 175 associations with approximately 101 000 hectares of dryland forests closed to grazing. The increase in number of grazing associations and in areas compensated has been linked to the improvement in reforestation success rates and the significant reduction of grazing offences. This case illustrates that forest managers and use-rights holders appreciate the mechanism and affirm that stakeholders have embraced the community involvement approach in forest resource management. Communities agree that this mechanism opened better communication and cooperation bridges between local communities and the forest administration. In summary, this has been a win-win intervention, co-created with local communities and pastoralist groups, which has resulted in better livestock management, more effective forest restoration efforts, improved land and forest management, and economic and environmental benefits for all involved.

Source: Moukrim *et al* (2019)

Expected transformation 8 (restoration): Restored degraded ecosystems and halted deforestation to reduce the impact of climate change on land degradation processes

Land restoration activities address the degradation of soils, water, vegetation and other natural resources, with the purpose of regaining ecosystem functions lost to degradation processes. Restoration activities directly support the long-term sustainability of dryland forests and agrosilvopastoral systems by contributing to securing the provision of critical ecosystem services *in situ*. They indirectly support sustainability by reducing pressure on ecosystems that have not yet been degraded by, for example, limiting the need to shift crop production from degraded areas to new and possibly less suitable areas. As drylands store approximately 46 percent of the global carbon share (MEA, 2005) with most of this carbon being stored in the soil, restoration and adaptive land management practices in these regions focused on reversing soil degradation can make a major contribution to global efforts to mitigate climate change, through the reduction of GHG emissions and the enhancement of carbon sequestration.

It is projected that populations in drylands will increase to 4 billion by 2050 (van der Esch, 2017), which will in turn intensify human impact on drylands. It is also predicted that by 2050, land degradation and climate change will reduce land productivity and thus lead to a decrease in crop yields by on average ten percent globally, and up to 50 percent in some regions (IPCC, 2014; IPBES, 2018)

Adaptive land management practices include, among others, introducing productive or enriched fallow systems, increasing fallow periods, erosion control, low stocking rates with controlled grazing and conservation tillage. In the Argentine pampas, soil quality and associated crop yields has deteriorated. This decline has been closely correlated with a reduction in soil organic matter caused by opening prairies for cultivation and adopting heavy tillage cropping systems. The declining yields prompted the need for change in existing land-management practices and led to the commencement of no-tillage experiments in the Tucuman Province, a semi-arid area in the 1960s, in an attempt to identify more sustainable agricultural systems. The results of the experiments indicate that no-tillage management practices halt the loss of soil carbon stocks. However, without additional inputs of organic matter, these practices alone will not be enough to return soils to their original condition. To reverse degradation and improve yields, the best management solution identified by the researchers was to add farmyard manure or green manure to no-tillage cultivation systems and to ensure these systems include significant periods of return to prairie grassland (FAO, 2004).

El Mollar, Tucuman, Argentina

Case study 5. Semi-arid and arid lands of Tucuman (Argentina)

In recent years, Argentina has experienced a rapid growth in the adoption of reduced and no-tillage systems, especially in dryland regions. This change has been brought about by a deterioration in soil quality and associated crop yields. Many local soils are not suited to the heavy tillage and cropping practices introduced by European settlers. The Argentine pampas now have very little natural vegetation. Xerophitic vegetation such as *Prosopis algarrobilla* and *Larrea divaricata* can still be found in the most arid areas. Agricultural practices commenced with the arrival of colonists in the sixteenth century. Ungulates were introduced to graze the grasslands, which have now been mostly re-sown. Very few trees remain except around farmsteads. Wheat was initially cultivated, and row-crop production has increased with time. In many parts, grazed pasture was dominant until the 1990s but since then there has been a marked increase in the cultivation of summer annuals, such as maize, sunflower and soybean.

The Argentine pampas have been recognized as a region with potential for increased production, if soils can be improved. Crop yields have declined in many areas. These declines have been closely correlated with a reduction in soil organic matter (SOM) content which has prompted the need for change in existing land-management practices. The negative effects of heavy tillage on SOM led to the commencement of no-tillage experiments in the 1960s, in an attempt to produce a more sustainable agricultural system. Now some 13 million ha, or about half of the agricultural area in Argentina, is under some form of reduced-tillage system. Fertilization of crops is primarily achieved through the use of inorganic fertilizers, with organic material tending to be conserved for use in horticultural farming systems.

Monte Redondo in the Tucuman Province is a semi-arid area that naturally supports xerophitic vegetation. The agricultural practices include grazed prairie lands and row cropping with the two systems often being rotated. The studied site consists of cropping for seven years followed by four years of prairie grassland. The crop sequence is wheat/ soybean, maize, soybean, wheat/ soybean, maize, soybean, wheat, and four years of prairie. Both conventional tillage and no-tillage cultivation are practiced. In the tillage system, disc and chisel plough are used for soil preparation, while the no-tillage system uses the same cropping sequence without tillage.

Using models to test the various pathways for soil carbon sequestration under tillage and zero tillage, both models register the improvement that no-tillage has on soil carbon content. However, if the decline in soil carbon content is to be reversed, additional inputs of organic matter are required – either from farmyard manure or use of green manure in the rotation. An increase in prairie in the rotation will also increase the soil carbon stock. Farm data modelling from this and other dryland provinces of Argentina shows that carbon stocks have fallen substantially since the prairies were opened up for cultivation. At all three locations, there have been sharp falls in soil carbon stocks, with losses of about 15 tonnes/ha. However, the adoption of no-tillage systems in recent years has halted these declines and, on their own, resulted in small annual increases in soil carbon in the order of 0.02 tonnes/ ha/year. Rotations with significant periods for return to prairie grassland (e.g. 4 years in 11) result in further increases in soil carbon. The highest rates of sequestration (0.1–0.25 tonnes/ha/year) occur when no-tillage systems also include cultivation of green manure and additions of farmyard manure.

Source: FAO (2004)

The way we produce our food matters and dietary choices can help reduce emissions and pressure on land (IPCC, 2019). Although more than 60 percent of the world's food production is in maize, wheat, rice, and soybeans, there is a vast number of neglected and underutilized crop species (NUS) in drylands. NUS could contribute to required crop resilient diversification, support more sustainable food systems and provide new livelihood options for small-scale men and women farmers through the integration of community knowledge with innovative technologies. For example, Bambara groundnut crop (Leguminosae family) is still a largely neglected and underutilized crop. It is a drought-tolerant crop and is very popular in sub-Saharan Africa, Malaysia, Indonesia and India with almost 160 000 tonnes/year global production (FAO, 2014). Investing in new technology and market opportunities could significantly improve food security.

Box 11. Addressing land degradation from a human food security perspective: the strong correlations between land degradation and poverty

In Africa, FAO is using the school food and nutrition (SFN) approach, which provides a comprehensive framework to assist countries in the design and implementation of SFN policies and programmes. The approach links healthy school meals to food and nutrition education, while building capacities for sustainable procurement and value chain development and enabling environments through multi-sectoral legal and policy frameworks to improve the livelihoods of local communities and create a strong nexus between agriculture, food systems and nutrition. The recent survey conducted on SFN highlighted that in 63 percent of countries, school meals are prepared using local foods, oils, fats and non-animal protein foods (beans and legumes). This approach supports the family farming system where procurement arrangements facilitate and prioritise local smallholder production.

Many examples across the world show the value of nature-based solutions to halt and reverse land degradation. Amongst the best-known examples in drylands, are those involving the planting and natural regeneration of trees, such as in the case of the Great Green Wall in Africa (see Box 12 below) and the example from Niger (Section 2). Effective interventions focusing on nature-based solutions encompass landscape governance and the assessment of synergies and trade-offs in land management for the identification of best pathways in restoring ecosystem functions lost to degradation. Land restoration activities occur on the ground to strengthen environmental sustainability. However, they are cross-cutting and should seek to provide co-benefits for economic and social well-being, including food security and the financial stability of value chains. Together, if well governed and framed by supporting policies, and by ensuring the inclusion and participation of dryland communities in decision-making, land restoration interventions can offer enormous compounded environmental, social and economic benefits that improve the sustainability of food production systems, strengthen the capacity of local communities to cope with climatic and non-climatic shocks and support global efforts to mitigate climate change.

Box 12. The Great Green Wall: nature-based solutions to restore degraded dryland ecosystems across African nations

The Great Green Wall (GGW) was an initiative launched by the African Union in 2007 to address the growing issue of land degradation and loss of livelihoods in the Sahel. In this region, land degradation is caused by the interaction of multiple factors, including the disruption of traditional land management practices, poor land management techniques, overexploitation and overgrazing, lack of sustainable water management strategies and wildfires. The GGW concept combines environmental protection, societal well-being and economic gain. As such, it acknowledges that only through ecosystem protection and restoration can current livelihoods be maintained.

Central to this initiative is to identify and plant trees and other species, which are well-adapted, stabilize soil, increase soil humidity, regulate wind speeds, and also contribute to local food security and livelihoods. To date, the GGW is being implemented at varied degrees across the 21 countries of the Sahel. By 2030, the ambition of the initiative is to restore 100 million hectares of currently degraded land, sequester 250 million tonnes of carbon and create ten million green jobs. This will support communities living along the wall to secure water sources, increase soil fertility, ensure food security, and start adapting to climate variability and change.

FAO is contributing through the Action Against Desertification programme, which supports large-scale restoration for small-scale farming and research into best and resilient practices that are disseminated through stakeholders, partners and countries (www.fao.org/in-action/action-against-desertification/en). To date, along with tree planting, it has devised a model that combines degraded land restoration with development of non-wood forest products to improve income and livelihoods of rural communities (Sacande and Parfondry, 2018). In five years, the programme has brought the GGW countries 53 000 hectares of degraded agrosylvopastoral land under restoration, planting 25 million trees comprising a wide range of native tree species which are commonly used by rural communities. A total of 100 tonnes of forest seeds of 110 woody and herbaceous fodder species were collected and planted in ten GGW countries, bringing huge positive economic and environmental returns. These comprehensive and integrated operations require multilayer collaboration between a wide range of actors and contributors lending their support.

In the face of unprecedented challenges such as climate change, pressures on, food, water supplies and shifting market demands from a growing human population, plant diversity is crucial for restoring degraded land and enabling sustainable production in agrosylvopastoral systems. The opportunities and benefits of restoring such vast area through the Great Green Wall programme, far overweigh investment risks and contrast with the general negative perception of drylands.

Expected transformation 9 (ecosystem conservation and protection): Conserved and protected dryland ecosystems and biodiversity to maintain ecosystem functions and the subsequent sustainable and equitable provision of ecosystem goods and services under climate change

Sustaining ecosystem services for food production in drylands goes beyond the efficient use of natural resources and the restoration of degraded land. It requires guaranteeing that species have a sufficiently large and healthy environmental range to establish, forage and reproduce, where species and genes can flow naturally between their different natural habitats and where biodiversity and genetic pools help species recover from shocks. This is even more important with climate change, as among its impacts are changes in species distribution and the loss of species, as they confront new abiotic conditions in their current ranges and try to migrate in search of the climate conditions they are adapted to. This has clear implications for the biodiversity, structure, and function of ecosystems. Under current climate change, scenarios supporting ecosystems to go through this transition, while ensuring they still provide services for people is critical. Conservation tools are the best we have to achieve this via, for example, the designation and management of protected areas within multifunctional dryland landscapes. Protected areas have been shown to favour maintenance and, where necessary, restoration of natural vegetation regimes and to enhance micro-climatic conditions, which helps to control erosion, revive aquifers, improve hydrological processes and maintain sustainable livelihoods for local communities (Dudley and Stolton, 2012).

In the context of climate change, protected areas also play an important role as carbon sinks and in enhancing the adaptive capacity of dryland populations by ensuring the provision of water, agrobiodiversity and nutrition and other services during periods of drought and other climate-related crises, which are expected to become more frequent as global warming progresses.

A full range of management approaches to protected areas are found in drylands, from ‘strict nature reserves’ to ‘protected landscapes’ where conservation is integrated with traditional lifestyles such as pastoralism, and where a certain amount of grazing is often beneficial to vegetation management. They vary from government-run national parks to ancient examples of conserved community areas, such as the Hima and Agdal of the Arabian Peninsula.

Rajasthan, India

Box 13. Payment for watershed ecosystem services (PWES) for profit in dryland agrosilvopastoral systems

An example from India of informal arrangements where protected areas are established and maintained for profit in drylands is the concept of Pay for Watershed Ecosystem Services (PWES) by pastoralists and farmers. PWES proposes local communities to pay for water security and other benefits according to their income. Farmers and pastoralists receive up to 20 percent of the investment made in conservation, from a community revolving fund fed by the "water tax" payments. This scheme has not only halted land degradation, but also slowly improved rural economies and the socio-economic status of dryland communities. Water security has allowed them to sell food, which was often not possible before, and to initiate other income-generating activities.

Economic and livelihood incentives for conservation have allowed the informal establishment of protected areas and informal payment for ecosystem services schemes, although much is still to be done to make greater conservation efforts profitable for landowners and land users. Tapping into economic benefits from carbon sequestration in protected areas is one option.

Despite having great importance for environmental, economic, and social sustainability, protected areas are under immense pressure from land use conversion, deforestation, and invasive species, among other factors. Addressing these threats is imperative and requires a suite of new conservation management and governance approaches, supporting policies, information, and the participation of users.

Box 14. The private sector's role is crucial to support conservation and livelihood resilience

Orchid habitats are very distinctive in Lebanon and have been lost due to excavation activities. Since 2014, Holcim Lebanon has been engaged in a biodiversity conservation and management project in close coordination with the IUCN, undertaking the annual biodiversity assessment to record the variety of floral species inhabiting a hillside in Kfarhazir, in one of Holcim Lebanon sites. The hill is a haven for 15 types of orchid species (out of 86 taxa), the equivalent to 17.5 percent of the national diversity of orchids, which makes this habitat a site of high significance.

The project took into account the risk of grazing by establishing a good relationship and coordination with the herders, the local community and the local municipality. The herders are continuously informed and engaged in protection activities and they assisted with the installation of signs and witnessed support by the municipality guards. They understand the collaboration on the site's protection, which is reinforced with all the management activities. The herders are reassured about the continuity of site protection and are careful to take their herds eastward to far grazing areas by using a side road.

Tigray, Ethiopia

4. The approach: synergies and trade-offs

The expected transformations linked to the three sustainability pillars are envisaged to achieve a range of co-benefits for the SDGs. As a result, the expected transformations – when combined – can reinforce the connections between the sustainability pillars, thus enhancing the co-benefits. Potential co-benefits and trade-offs should be assessed, weighed up and managed accordingly, while taking account of traditional knowledge and gender equity. Nevertheless, the perception of benefits and trade-offs may often be different for different stakeholder groups.

In dryland developing programmes, the dwellers of these landscapes (pastoralists, farmers, rural poor) are those with the least resources to embark, follow and invest in plans and incentives that may seem obvious for other actors. There may also be aspects of time and space with what is considered as synergies and trade-offs. Aspects of time can be that the current generation of practitioners may have difficulties and transitional challenges in letting go of collective traditions, changing gender relations and leaving subsistence economies. The next generation may carry other values that for example determines their decisions to stay rural or opt for urban migration. In terms of space, interventions with positive benefits in the project area may have adverse effects in other parts of landscape ecology or in socio-economic aspects in neighbouring communities.

Consequently, the transformational shift requires understanding the interconnectedness of the social, economic, and environmental pillars of sustainability to be able to assess and balance the potential implications of an action, programme or policy on the different pillars. The lessons learned from the different cases highlight that looking for solutions to contribute to achieving one or more expected transformations under one or more pillars, could potentially reduce the risk of negative effects on the achievement of other expected transformations. When a negative effect is inevitable, ways to remediate or compensate for the negative outcomes should be sought.

One clear example of a mismatch of expectations for co-benefits may be found in the intensification of livestock production. It may be highly desirable for reasons of possible resilience in diversification, in economic livelihoods and sedentarisation linking to better societal inclusion with schools, health care etc. However, lost values in collective bonds and security as well as family economies, both resulting in changed gender roles, may be overlooked.

For the sake of sustainability, single actions can forge synergies with other ongoing processes, instead of creating trade-offs. For example, ecosystem services like water availability, may have a higher value for dryland dwellers than for example biodiversity or carbon mitigation. Furthermore, irrigation or spatially extensive tree plantation in a water-scarce area may cause reduction in water availability in a downstream part of a landscape (Calder, 2005). For example, the recent assessment of forest-derived land uses in the Rejoso watershed in Indonesia showed that the infiltration-friendly agroforestry land uses minimize the loss of hydrological functions in the forest area and it varies based on the tree canopy cover on upstream, midstream and downstream of the watershed which will reflect on the production of these forests. In dryland forests and agrosilvopastoral landscapes, management decisions that balance human production and the provision of ecosystem services across time and space are key to sustainability. This is precisely the point where synergies and trade-offs need to be considered. A multifunctional landscape cannot consist exclusively of areas for ecosystem conservation, nor production. However, it needs to ensure that these ecosystems have sufficiently large territories to keep their critical functions.

Sustainable forest land management approaches can help stakeholders find synergies to implement balanced solutions, such as by enhancing biodiversity within agricultural landscapes, which offer simultaneous positive livelihood outcomes (O'Farrell and Anderson, 2010). More trees outside forests in pastoral and agrosilvopastoral landscapes may have many co-benefits, such as expectation that sustainable management of trees can add to diversification and increase of incomes for dryland dwellers. However, just planting the trees does not lead to full synergies. If tenure of trees is not clear, if there is no demand for timber or non-wood forest products, if the demand is not in reach, if remaining poverty in part of the population still drives deforestation, or if there is significant time until trees mature for utilization – the incentive will not be there for most dryland dwellers.

An example of the need for consideration of trade-offs and synergies among sustainability pillars when making decisions about land use in multifunctional dryland landscapes comes from pastoralism. Historically, mobility has conferred pastoral communities the capacity to cope with the high degree of environmental uncertainty in drylands. Despite periodic shocks, for herders, livestock represent a tradeable commodity, an insurance asset, a form of investment that earns interest through reproduction and growth, and an important source of non-cash income, e.g. milk can account for up to 50 percent of the non-cash income for many pastoral households. Livestock also play a fundamental role in marriage and other social institutions (Aklilu *et al.*, 2013).

Over centuries, intricate customary pastoral governance systems ruled resource use, both in space and time, in ways that avoided land degradation. However, a wide range of factors, including land tenure and use policies and reforms, have eroded customary institutions and, in many places, debilitated or changed traditional pastoral livelihoods. In some dryland countries, there is upfront socio-political opposition to pastoralism, in others, trade policies encourage livestock production in response to the growing demand for meat products while other policies often support maladaptive and less profitable crop expansion at the expense of livestock production (Davies *et al.*, 2010; Aklilu *et al.*, 2013).

Because each dryland landscape is different, there are no one-size-fits-all solutions. Even among various actors driving transformation, like funding bodies, local, national and global policy, interest groups etc., there may be coexisting diverging discourses on priorities for green growth (Wunder *et al.*, 2005) and the expected co-benefits may be perceived differently. Entry points of interest for dryland forest landscape restoration may be carbon sequestration from global policy, producing timber to replace increasing imports from national policy, growth of economy in the regional centre from local policy, biodiversity, climate adaptation or rural development from interest groups and civil society. Different entry points are natural, but sometimes different actors may foresee or even over-estimate trade-offs and initiate conflict rather than opting for mediation. Such examples may be between promoting restoration for biodiversity or for sustainable tree/forest management, even if starting from degraded ecosystems, a wood lot or a small plantation would benefit both aspects. Seeing the full picture and incentives in this complex picture may not be easy for dryland practitioners.

Many other options for exploiting synergies exist, for example, actions geared towards improving veterinary and extension services can enhance livestock productivity and improve the resilience of smaller herds to climate shocks and disease; demarcating grazing reserves and mobility corridors to ensure the safe passage of pastoral communities, can reduce climate and conflict risks. Single actions that enhance the direct access to markets, such as the construction of rural or tertiary roads, or that facilitate value addition to livestock products can create new economic opportunities for mobile pastoralists, sedentary pastoralists and non-pastoralists alike. Traditional and local knowledge and research can contribute to a better understanding of the linkages between environmental processes and pastoral activities and can support decisions on sustainable livestock and land management at multiple levels. Aware of these linkages, some European governments are investing in mobile pastoralism to manage and conserve biological diversity (Davies *et al.*, 2010). Furthermore, in Morocco, a successful large-scale forest restoration initiative with climate adaptation and mitigation co-benefits has been implemented with the support of local grazing associations. In summary, these and other actions, initiated from an economic, environmental or social perspective, can work to improving and better balance livestock production with other actions taking place in multifunctional dryland landscapes.

Interventions conducted in support of a specific expected transformation in one pillar can directly or indirectly co- benefit the achievement of expected transformations in other pillars. Therefore, in theory, any action can support the achievement of any expected transformation if planned under a sustainability lens, making use of synergies and reducing trade-offs, to the extent possible. Knowledge of the system, and awareness of the nine key expected transformations in this approach can help stakeholders modulate their actions to create conscious synergies, making a greater contribution towards sustainability and reducing the risk of unintended trade-offs. According to the discussion paper on financing for FLR by FAO and the Global Mechanism of the UNCCD, it is estimated that the asset value based on the mean data for market values and non-market values of dryland ecosystems is between USD 1 500 and USD 4 500 per hectare which can offer benefits beyond the dryland landscapes (FAO and UNCCD, 2015).

Working Group on Dryland Forests and Agrosilvopastoral Systems

5. Operationalizing the approach – the way forward

The approach presented in this working paper, facilitates the planning of transformative sustainability interventions in the management of dryland forests and agrosilvopastoral systems as part of multifunctional landscapes. It offers an opportunity for decision-makers, planners and practitioners to contribute, through small and large interventions, to the achievement of multiple SDGs, while working towards ensuring dryland food production systems remain productive and continue feeding communities and the world under changing climate. Multiple factors converge in operationalizing the approach in an efficient and effective manner. These include, among others, good governance, stakeholder accountability and participation, and community empowerment for example through consultation processes. Although it can be implemented by individual stakeholders, the approach promotes cooperation and partnerships between communities, government, private sector, NGOs, academia and other actors incentivized by a shared vision of the expected transformations, their benefits and an understanding of what could be lost in the process (the price to pay). Thus, when planning new or steering existing interventions in alignment with the approach, there is need for transparency, participation and indeed negotiation to agree on incentives, disincentives and to discuss the associated risks.

Given the vulnerability of drylands, the severity of the potential consequences of climate change, they are now also faced with negative impacts on food systems due to COVID-19, mainly in sub-Saharan countries, an increasing economic slowdown and further exacerbation of food insecurity and malnutrition (FAO, 2020a). Therefore, there is an urgent need to build back better that allows for a better response to gaps in improving the dryland ecosystem adaptation and create more resilient food systems (ECLAC and FAO, 2020). This can be done with an explicit approach to focus on economic insurance to address the inequality between rural and urban, poor and rich, and applying the gender lens.

Environmental economics can contribute to understand trade-offs and co-benefits of planned interventions and thus promote making informed decisions and prioritizing activities or interventions among various alternatives.

It is however necessary to consider that informed decision-making and action must take place at the right scale, from policies to ground-level interventions, to ensure equitable and sustainable production in dryland forests and agrosilvopastoral systems. Baselines need to be established and the results from the different interventions periodically monitored, using indicators commensurate to the level and context of the interventions. This will contribute to assessing progress made towards the expected and needed sustainability shifts. Also, there is the need to generate and disseminate information, at all levels, on the potential impacts of global warming on dryland forests and agrosilvopastoral systems, including ecosystems and the land management practices themselves. This will enable better decision-making for adaptation and mitigation and thus reduce uncertainty in some of the naturally most climatically-unpredictable areas of the world.

The impact of the COVID-19 pandemic does not imply a radical change in the operationalization of the proposed expected transformations. Rather, COVID-19 highlights the need for flexible adaptation approaches, as in the future, with climate change, weather-related shocks affecting dryland systems could increase in frequency and intensity, and compounded crises could become more frequent. Best practices, traditional knowledge and science can all contribute to presenting adaptation and resilience-building options.

Last but not least, champions are needed to advocate and promote the transformational change in the management of dryland food production systems. Champions can facilitate the creation of a shared vision and help make sustainable innovations known. In recent years, positive advances taking place with development tools have helped diverse groups of actors become good facilitators and champions and to more effectively create awareness among stakeholders on interlinkages between different processes. “Serious games” for social learning in sustainability transition (Speelman *et al.*, 2019; Stanitas *et al.*, 2019) are part of these tools and could be used to foster understanding on the interlinkages between sustainability pillars and expected transformations.

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7. Annex 1: Additional resources

This annex presents a collection of online resources that provide guidance to individuals, institutions and governments on the design, implementation, monitoring and evaluation of sustainability actions in drylands. It has been compiled to support policy, governance and on the ground level efforts to contribute to the expected sustainability transformations introduced in the approach.

1. **Using criteria and indicators for sustainable forest management. A way to strengthen results-based management of national forest programmes. Forestry Policy and Institutions Working Paper 37, 2017 http://www.fao.org/3/a-i6883e.pdf.** This report aims to support efforts on sustainable forest management through the use of criteria and indicators (C&I). The report supports forest policy design, planning and monitoring. It was designed based on a global consultation process and provides 30 practical examples on how to improve the use of C&I and integrating them into National Forestry Plans.
2. **IPBES. 2018. The IPBES assessment report on land degradation and restoration. Montanarella, L., Scholes, R. and Brainich, A. (Eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 744 pages. https://doi.org/10.5281/zenodo.3237392.** This document provides a critical analysis of the state of knowledge regarding the importance, drivers, status, and trends of terrestrial ecosystems (not limited to drylands). The report presents policies, governance options and management practices that can help support stakeholders at all levels to reduce the negative environmental, social and economic consequences of land degradation, as well as to rehabilitate and restore degraded land.
3. **Global guidelines for the restoration of degraded forests and landscapes in drylands: building resilience and benefiting livelihoods, by Berrahmouni, N., Regato, P. & Parfondry, M. Forestry Paper No. 175. Rome, Food and Agriculture Organization of the United Nations. http://www.fao.org/3/a-i5036e.pdf.** These guidelines, showcase global examples of, and provide specific policy and practical guidance on dryland restoration activities.
4. **Trees, forests and land use in drylands: the first global assessment – Full report. FAO Forestry Paper No. 184. Rome. http://www.fao.org/3/ca7148en/ca7148en.pdf.** This is a thematic study that complements FAO's Global Forest Resources Assessment (FRA) but differs from it in method

and scope. The assessment includes visual interpretation of satellite images. The results are reported at the global and regional levels and provide background information on the climate, importance of forests and trees for biodiversity and livelihood outcomes, as well as the trends and challenges in the drylands. It also reports on the distribution of forests, other wooded land and other land uses (such as grasslands, croplands, marshlands and wetlands, barren land, settlements and built-up areas), by aridity zone. It therefore offers a baseline from which actions can be prioritized.

5. **The land resources planning (LRP) toolbox: http://www.fao.org/3/ca5491en/ca5491en.pdf.** This toolbox is a free online resource aimed stakeholders involved in land use planning at different levels, across different sectors and in different regions. The toolbox contains a comprehensive number of tools, contains summaries and links to the tools and assists stakeholders with the selection of the most appropriate tools.
6. **A framework for priority setting in climate-smart agriculture research https://doi.org/10.1016/j.agsy.2018.09.009.** Prioritizing climate-smart agriculture (CSA) research activities is challenging primarily because it is multidimensional. The paper provides a simple six-element framework with a map to guide prioritization. It also presents case studies including dryland examples to guide a mix of different quantitative and qualitative methods. The paper spans spatial and temporal timescales to ensure CSA innovation and implementation is effective in informing practice. Many priority-setting case studies address the short- to medium-term actions and at relatively local scales.
7. **EX-Ante Carbon balance Tool (EX-ACT). http://www.fao.org/tc/exact/ex-act-home/en/.** EX-ACT is a land-based accounting system, estimating carbon stock changes (i.e. emissions or CO_2 sinks) as well as greenhouse gas emissions per unit of land, expressed in equivalent tonnes of CO2 per hectare and year. The tool supports project designers to estimate and prioritize project activities that can provide economic and environmental benefits, including climate change mitigation benefits. The tool also provides information that can be used when making the case for specific project activities.
8. **IMPACT Tool. Capturing on-farm realities https://ccafs.cgiar.org/impactlite-tool#.XlW4KWhKjIX.** The Integrated Approach Modelling Platform for Mixed Animal Crop systems (IMPACT) was initially developed to encourage data sharing through standard protocols and allowing tools to be linked to facilitate evaluations of various farming systems. The IMPACT approach has since then purposely been turned into a version that captures the diversity of farming activities and characterizes the main agricultural production systems. It has been implemented in twelve countries across East Africa, West Africa and South Asia.

9. **Life cycle assessments http://www.fao.org/in-action/micca/resources/tools/en/.** Life Cycle Assessments (LCAs) refers to the quantification of greenhouse gas (GHG) emissions arising from the entire agricultural production chain. LCAs methods are applied also to measure other environmental impacts. The methodology was primarily developed on the basis of GHG emissions arising from livestock food chains. However, this methodology can also be applied to production chains, for products such as milk, meat and eggs and the analyses help identify efficient ways to produce livestock products while reducing GHG emissions.
10. **Climate data portal http://www.ccafs-climate.org/.** The CCAFS-Climate data portal provides global and regional future high-resolution climate data sets that serve as a basis for assessing the climate change impacts and adaptation options in a variety of fields including biodiversity, agricultural and livestock production, and ecosystem services and hydrology. High-resolution climate data helps assess the impacts of climate change primarily on agriculture. These open access data sets of climate projections can help researchers/ practitioners make climate change impact assessments.
11. **Planning, implementing and evaluating climate-smart agriculture in smallholder farming systems – the experience of the Mitigation on Climate Change in Agriculture (MICCA) pilot projects http://www.fao.org/3/a-i5805e.pdf. Climate-smart agriculture (CSA)** is based on a mix of climate-resilient technologies and practices for integrated farming systems and landscape management. The evidence base and knowledge to determine the practices that work best in a given context are still emerging and require testing and implementation on the basis of a broad range of practices. This report presents the experience gained from ongoing agricultural development programmes and provides guidance on steps and considerations needed to expand CSA programmes and practices at a significantly larger scale.
12. **A gender-responsive approach to climate-smart agriculture. Evidence and guidance for practitioners https://cgspace.cgiar.org/bitstream/handle/10568/73049/CSA%20Practice%20Brief%20Gender.pdf?sequence=1&isAllowed=y.** Taking a gender-responsive approach to climate- smart agricultural (CSA) means that the particular needs, priorities, and realities of men and women are recognized and adequately addressed in the design and application of CSA so that both men and women can equally benefit. This report addresses how gender-responsive approaches can be included in projects and programmes to increase sustainability in agricultural production and incomes.
13. **Economics of land degradation initiative : Practitioner's Guide http://library.unccd.int/Details/fullCatalogue/864.** This guide supports practitioners looking to make informed economic decisions on land degradation and conservation options.

14. **A 6+1 step to economics of land degradation http://catalogue.unccd.int/863_ELD-UserGuide_07.pdf.** The 6+1 step approach is the analysis method that has been adopted by the ELD Initiative to guide users through the process of establishing scientifically sound cost-benefit analyses to inform decision-making processes for better land management. This resource includes a summary of evidence of the economic benefits of sustainable land management options. It offers assessment results to three critical target groups: the private sector, the scientific community, and policy and decision-makers.
15. **Sustainable livelihood approach for assessing community resilience to climate change https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.616.2622&rep=rep1&type=pdf.** Sustainable livelihood assessment is intended to generate an understanding of the role and impact of a project on enhancing and securing local people's livelihoods. As such, it relies on a range of data collection methods, a combination of qualitative and quantitative indicators and the application of a sustainable livelihoods approach or framework. This report describes practical steps to follow as part of the SL approach. It places special attention to the process of community engagement to better frame actions and to capture perceptions of coping/adaptive capacity during the data collection and programme design process.
16. **Tracking adaptation in agricultural sectors. Climate change adaptation indicators. Food and Agriculture Organization of the United Nations Rome, 2017 http://www.fao.org/3/a-i8145e.pdf.** This paper outlines a framework and methodology for Tracking Adaptation in Agricultural Sectors (TAAS) at the national level. The framework recognizes the complex nature of adaptation processes across agricultural subsectors. It provides a clear understanding of the interrelationships between natural resources and ecosystems, agricultural production systems including in drylands, socio-economics and institutional and policy systems that drive adaptation processes and outcomes. In addition to baseline data, it untangles complex interrelationships and supports the implementation of programmes from priority setting through to monitoring and evaluation. Many priority-setting case studies address short- to medium-term actions at relatively local scales.
17. **Climate-smart agriculture programming and indicator tool: 3 steps for increasing programming effectiveness and outcome tracking of CSA interventions. CCAFS Tool Beta version. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://ccafs.cgiar.org/csa-programming-and-indicator-tool#.X3Qgny8RoWo.** The CSA programming and indicator tool was designed to contribute to address both the need for good instruments for programming and better metrics for tracking outcomes and impact. It further allows multiple development agencies and agricultural-focused programmes to share

a common framework on how they are currently addressing CSA and how they can make their future programming process more climate-smart. The tool helps to examine the scope of a given programme or intervention through the three dimensional lenses of CSA (productivity/income, adaptation and mitigation), thereby strengthening the planning phase of interventions in order to ensure all potential CSA related outcomes are properly included in monitoring and evaluation frameworks.

18. **A complete guide to climate-smart agriculture https://csa.guide/#chapter-3**. CSA Guide provides a short and concise introduction and overview of the multifaceted aspects of climate-smart agriculture. The guide also acts as a resource library for all references, key resources, terms and questions and provides a thorough overview on the topic.
19. **Supporting agricultural extension towards climate-smart agriculture: An overview of existing tools http://www.fao.org/3/a-bl361e.pdf.** The report provides examples of more than 20 different approaches of how agricultural extension can support climate-smart agriculture. It captures inputs from across the world, not limited to drylands. It brings together experiences on the role of agricultural extension and rural advisory services in supporting CSA to rural communities.
20. **Value chain analysis for resilience in drylands (VC-ARID): identification of adaptation options in key sectors. 2018 https://www.odi.org/sites/odi.org.uk/files/resource-documents/12517.pdf.** VC-ARID is an interdisciplinary approach to value chain analysis in that it takes account of the specific characteristics of semi-arid systems. On the basis of case studies from drylands, it seeks to address value chains transformation by capturing the linkages in key value chains to markets, as well as the diversification of the value chains. Alongside the report are important case analyses providing insights to key dryland value chains in Africa and Asia.
21. **Delivering climate resilience programmes in fragile and conflict-affected contexts http://www.braced.org/resources/i/Delivering-climate-resilience-programmes-in%20fragile-contexts/.** This review explores how climate resilience programmes and projects can be designed, established and managed to be resilient in fragile and conflict-affected contexts. It combines evidence-based learning from over four years of implementation from 15 projects across 13 countries in Africa. The review offers insights for both donors and project implementers to approach fragile contexts originating in and around dryland zones flexibly – in order to ensure long-term sustainability of interventions and resilience building.
22. **Ecosystem-based adaptation: a handbook for EbA in mountain, dryland and coastal ecosystems. IIED, London. https://pubs.iied.org/pdfs/17460IIED.pdf.** This handbook provides a tool to guide the planning and implementation of ecosystem-based adaptation (EbA) in developing countries to help address the growing impacts of climate change in

drylands, mountains and coastal zones. It focuses on these systems as the populations are particularly vulnerable to climate change. For each type of ecosystem, it sets out the steps to take when planning and implementing EbA interventions, in order to increase the resilience of vulnerable people through ecosystem management and biodiversity conservation.

23. **Tools for ecosystem-based adaptation: A new navigator. https://www.iied.org/tools-for-ecosystem-based-adaptation-new-navigator-now-available.** EbA can help governments, civil society and communities manage climate change impacts. EbA is a nature-based approach that uses biodiversity and ecosystem services to help people adapt to the adverse effects of climate change. As the concept has developed, so has the number of tools and methodologies available to support the integration of EbA into adaptation strategies. This database includes a navigator that supports the search of tools and methods relevant to EbA, providing practical information about more than 240 tools, methodologies and guidance documents. The tools featured cover an array of topics, including planning and assessments, implementation and valuation, monitoring and mainstreaming. It has been designed to help users find the most appropriate tools and methods to support put them into practice.
24. **Water harvesting: Guidelines to good practice. Centre for Development and Environment (CDE), Bern; Rainwater Harvesting Implementation Network (RAIN), Amsterdam; MetaMeta, Wageningen; The International Fund for Agricultural Development (IFAD), Rome http://www.rainfoundation.org/wp-content/uploads/2017/10/rainwater-harvesting-a-guid-to-good-practices.pdf.** These guidelines provide an overview of proven good practice in rainwater harvesting from all over the world. The guidelines form a practical guide while providing technical expertise for the integration of water-harvesting technologies into the planning and design of projects. Further, the guidelines facilitate, share and upscale good practice in water harvesting given the state of current knowledge. Targeted end users are practitioners, planners at regional national and local levels.
25. **Guidelines and good practices for achieving gender equality outcomes through climate services https://gender.cgiar.org/webinar-guidelines-climate-services/.** Climate services can be a critical means of resiliency-building for smallholder farmers; however, due to gender-related factors, women and men face differing challenges and opportunities to access climate-related information. This report provides an important summary on the capacity-building needs for men and women that can support practitioners in defining pathways for inclusive climate change adaptation for women.
26. **Helping farmers understand index insurance: Guidelines for consumer education interventions. http://www.impactinsurance.org/sites/default/files/MP45_0.pdf.** Index-based insurance is an innovative financial tool that can support the resilience of farmers and pastoralist communities manage climate variability and change. However, concerns remain in the

inclusivity of index-based insurance, and the need to increase accessibility and coverage for all. Drawing from field lessons, these guidelines provide practical steps to ensure that index-based insurance is well understood and the impacts are inclusive in areas where they are implemented.

27. **Scaling up index insurance for smallholder farmers: Recent evidence and insights https://cgspace.cgiar.org/bitstream/handle/10568/53101/CCAFS_Report14.pdf.** This report explores evidence and insights from five case studies that have made significant recent progress in addressing the challenge of insuring poor smallholder farmers and pastoralists in the developing world. In India, for example, a case analysis demonstrates the role that national index insurance programmes have made in reaching over 30 million farmers through a mandatory link with agricultural credit and strong government support. The report provides insights on attributes for successful scaling up and out of index-based insurance programmes.
28. **The UNCCD drought toolbox https://knowledge.unccd.int/drought-toolbox/page/about-drought-toolbox.** The drought toolbox collates sets of tools that can support national planning towards droughts around three main aspects: drought monitoring and early warning, drought vulnerability and risk assessment, as well as drought risk mitigation measures. These represent current efforts as part of the drought initiative among UNCCD, WMO, FAO, GWP, the Joint Research Centre of the European Union, the National Drought Mitigation Center (NDMC) of the University of Nebraska, and UNEP-DHI.
29. **Adaptation at scale in the semi-arid regions (ASSAR) 2014–2018 – highlights from the ASSAR project http://www.assar.uct.ac.za/sites/default/files/image_tool/images/138/Legacy_chapters/Putting_people_%20at_the_centre_for_effective_adaptation-summary.pdf.** This report presents an analysis on the pathways towards adaptation in semi-arid regions on the basis of multi-scale, inter- and transdisciplinary research and practice work. The report looks at the barriers and enablers to effective, sustained and adaptation. The report indicates potential pathways towards resilience in drylands, as well as cross-cutting themes on stakeholder engagement, governance and capacity-building.
30. **Five practical actions towards low carbon livestock http://www.fao.org/3/ca7089en/ca7089en.pdf.** Shaping a sustainable future will depend on understanding the diversity and complexity of livestock agri-food systems including those within drylands contexts. This report delves into the five practical steps that can transform agriculture from net emission and driver of land degradation, into one of mitigation, food security and nutrition.
31. **Social protection approaches to climate risk management, including disaster risk reduction and management http://www.fao.org/3/ca6681en/CA6681EN.pdf.** This report highlights key approaches to integrate social protection into climate risk management, climate adaptation and mitigation actions. It describes the key benefits of this integration, including the

reduction of vulnerability and negative coping strategies and supporting inclusive disaster preparedness and response. As such it supports practitioners in priority setting at the local level and provides important complementarity to other risk management tools such as index-based insurance.

32. **Global Database on Sustainable Land Management (SLM) https://www.wocat.net/en/global-slm-database.** The database documents and captures SLM practices that demonstrate evidence-based decision-making with the aim of scaling up identified good practices. The database also proposes a framework and standardized tools and methods for documentation, monitoring, evaluation and dissemination of SLM knowledge, covering all steps from data collection with several questionnaires, to the Global SLM Database and to using the information for decision support.
33. **Land assessment in drylands http://www.fao.org/3/i3241e/i3241e.pdf.** LADA (Land Degradation Assessment in Drylands project) is a scientifically-based approach to assessing and mapping land degradation at different spatial scales – small to large – and at various levels – local to global. LADA also assesses the types and extent of the various SLM measures that have been implemented (on the ground responses), and their effectiveness and trends in addressing land degradation. Combining livelihood analysis and capturing the effects of land use and institutional and policy responses and investments, this tool allows local level land assessments. The tool also allows analysis on the extent to which interventions to secure land tenure and access rights are feasible.
34. **2019 state of climate services https://library.wmo.int/doc_num.php?explnum_id=10089**. The report provides a comprehensive analysis of what is needed to enhance access to climate information and services for climate-resilient development and adaptation action. It captures progress, opportunities and challenges in rolling out climate services such as seasonal forecasts, drought advisories and fire danger indices. Six major strategic areas are identified, each with recommendations: operationalizing, scaling up and supporting by adequate financing climate services with proven demonstrated benefits for adaptation in the agricultural sector; systematic observations; addressing the "last mile" barrier; enhanced climate science basis for priority climate actions; and systematic monitoring and evaluation of socio-economic benefits associated with climate services.
35. **Collecting development data with mobile phones: Key considerations from a review of the evidence https://cgspace.cgiar.org/bitstream/handle/10568/89104/InfoNote_MobileMonitoring.pdf.** Growth in mobile phone access and ownership presents a cost-effective and efficient way to collect data to support climate adaptation. This brief reviews experiences from 14 project sites in diverse countries based on practice. While such best practice guidelines are emerging which can serve as a target to achieve data quality, there are still large gaps in the evidence given the diversity of

social contexts, modes, and indicators of interest. With careful planning, field testing and innovation, mobile technologies and surveys offer a nearly unparalleled opportunity to understand people's circumstances and changes in populations for a wide range of applications and under a wide range of conditions.

36. **Towards developing scalable climate-smart village approaches: approaches and lessons learned from pilot research in West Africa http://old.worldagroforestry.org/downloads/Publications/PDFS/OP16051.pdf.** The paper presents a report from a project on "Developing community-based climate-smart agriculture through participatory action research in CCAFS benchmark sites in West Africa". After three years of implementation, the present document describes approaches used and emerging lessons learned from drylands of West Africa.
37. **Scaling up climate information services through public–private partnership business approach https://cgspace.cgiar.org/bitstream/handle/10568/101133/Info%20Note_PrivatePublicPartnershipBusinessModel.pdf.** A public–private partnership (PPP) business approach was developed in 2017 to sustain the delivery of climate information services (CIS) to farmers through mobile phone platforms. The report documents the approach with the intention of sharing a methodological approach to scaling up of climate information services through PPP. It highlights the role of government and in particular the role of governance frameworks in supporting the scaling up and out of climate-related services.
38. **Enabling private sector adaptation in sub-Saharan Africa https://prise.odi.org/research/enabling-private-sector-adaptation-to-climate-change-in-sub-saharan-africa.** The private sector is increasingly recognized as having important potential to help society adapt and become more resilient to climate change. This important article addresses the gaps by highlighting the key factors required to provide an enabling environment for the private sector in existing adaptation literature. The paper focuses on adaptation by small and medium enterprises (SMEs) in sub-Saharan Africa (SSA). In addition to this, the paper captures literature and highlights key constraints to the development and growth of SMEs. Based on case studies and secondary literature, a framework is proposed that identifies the key "building blocks" that constitute enabling conditions for private sector adaptation. Private sector in the context of drylands in Africa is defined as a single person or a group of persons engaged in selling or buying goods and services.

For more information, please contact:

Forestry Division – Natural Resources and Sustainable Production
E-mail: FO-Publications@fao.org
Web address: www.fao.org/forestry/en
Food and Agriculture Organization of the United Nations
Viale delle Terme di Caracalla
00153 Rome, Italy

ISBN 978-92-5-134119-3 ISSN 2664-1062
9 789251 341193
CB3803EN/1/03.21