Food and Agriculture Organization of the United Nations

Global guidelines for the restoration of degraded forests and landscapes in drylands

Building resilience and benefiting livelihoods

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Cover photo: Soil preparation for planting in Tera, Great Green Wall, the Niger (©Moctar Sacande)

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Building resilience and benefiting livelihoods

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Contents

Boxes

Foreword

Drylands cover 41 percent of the earth's land surface and are home to 2 billion people. They are facing extraordinary challenges, including those posed by desertification, biodiversity loss, poverty, food insecurity and climate change.

Trees and forests are vital for tackling such challenges. Among other things, trees and forests can help avert desertification, which threatens vast areas of dryland worldwide. Managed well, they can also increase the resilience of ecosystems, landscapes and human communities in the face of global change.

In many regions, however, dryland forests and landscapes are under unprecedented pressure, brought about by changing and competing land uses and practices, wasteful and unsustainable water use, inappropriate cultivation and grazing practices, and overharvesting. Up to 20 percent of the world's drylands are degraded, and people living there are often locked in a vicious circle of poverty, destructive practices and environmental degradation. It is clear that urgent efforts are needed to arrest dryland degradation and restore degraded lands.

At the same time, macro-level worry about the degrading natural resource base has overlooked the many micro-level gains that have been made in sustainable management and restoration practices and efforts led by governments, local communities, non-governmental organizations and other stakeholders. These gains and successes, if identified and analysed, can inspire others and lead to their scaling up – nationally, regionally and worldwide. Look closely almost anywhere and you will find valuable management and restoration practices being implemented right now by national and local institutions and by thousands of farmers and their families. Such practices have generally had positive impacts in reducing climatic risks, raising yields and lowering yield variability, protecting soils, strengthening natural buffers against disasters, recharging aquifers, protecting biodiversity, reducing sedimentation, storing carbon and generating benefits, livelihoods and employment opportunities for the rural poor.

In 2011 and 2012, FAO member countries requested FAO to conduct a comprehensive analysis, evaluation and documentation of afforestation, reforestation and restoration projects, programmes and initiatives in drylands. In response, FAO launched the FAO Drylands Restoration Initiative with the aim of capturing, evaluating and sharing knowledge on dryland restoration.

This publication, *Global guidelines for the restoration of degraded forests and landscapes in drylands*, is an output of this initiative, drawing lessons from the many experiences in dryland restoration worldwide. It is targeted at policymakers and other decision-makers, and dryland restoration practitioners, because both groups have the power to bring about positive change. Well-informed policymakers and decision-makers can be enablers of effective restoration efforts by providing appropriate policies, governance mechanisms and financial and other incentives. Practitioners are the vital link between high-level policies and rural and peri-urban

communities, who ultimately will perform much of the work in ground-level restoration initiatives.

The development of these guidelines was a highly collaborative process led by FAO and the Ministry of Forestry and Water Affairs, Turkey, and the Turkish Cooperation and Coordination Agency. We thank all the many individuals involved in the process, led by Nora Berrahmouni and her team at FAO Forestry, and the many institutional partners and donors.

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Senegal workshop

Hassan Abdelgader Hilal, Maman Adda, Daniel Andre, Ali Oumar Mohamed Asal, Ibrahim Atalay, Hanifi Avci, Mahmoud M. El Bagouri, Ismail Belen, Abdelkader Benkheira, Nora Berrahmouni, Ansoumana Bodian, Slami Boukhnifer, Michele Bozzano, Paolo Ceci, Mhusaya Moses Khwashin Chindaba, Matar Cissé, Haoua Coulibaly, Kouloutan Coulibaly, Eddy De Laethauwer, Mamadou Diallo,

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Preface

Many countries and communities worldwide are battling to overcome the challenges posed by poverty, food insecurity, drought, natural disasters and war. Dryland regions have been highly vulnerable to such challenges for centuries. Many struggle to produce sufficient food for their growing populations and face daunting physical and demographic challenges: high rates of poverty and unemployment, rapid urbanization, severe water scarcity, and land degradation. Such problems and constraints are expected to worsen as a result of climate change.

Turkey has always been ready to mobilize its resources with sincerity and courage to contribute wherever needed to the development efforts of other countries. Through the Turkish Cooperation and Coordination Agency (TIKA, see box next page), Turkey is sharing its knowledge and experience in fields as diverse as education, health, land restoration, forestry and agricultural development, finance, tourism and industry with more than 100 countries, ranging from the Pacific to Central Asia, from the Middle East and Africa to the Balkans, and from the Caucasus to South America.

In cooperation with relevant departments of the Ministry of Forestry and Water Affairs, in particular the General Directorate of Combating Desertification and Erosion, TIKA has been a major partner of FAO, with which it is working closely on several forestry activities, including forest and watershed management. TIKA is also an enthusiastic supporter of activities undertaken by the FAO Committee on Mediterranean Forestry Questions–*Silva Mediterranea*, including its Working Group on Desertification and Restoration of Degraded Forest Ecosystems in Arid Zones. In the formulation of these guidelines, TIKA made significant contributions to the funding of two international workshops: one in Konya, Turkey, in May 2012, and another in Dakar, Senegal, in February 2013.

The *Global guidelines for the restoration of degraded forests and landscapes in drylands* examine the major issues, challenges and opportunities for dryland restoration and provide guidance for a wide range of users. TIKA will continue to support dryland restoration initiatives and to work closely with FAO towards this end.

Serdar Cam
President of TIKA

The TIKA–FAO partnership

The Turkish Cooperation and Coordination Agency (TIKA) has been operating since 1992, providing support to projects in 110 countries on five continents.

FAO is one of TIKA's most important partners, with the FAO Subregional Office for Central Asia opening in Ankara, Turkey, in 2006. Under the Host Country Agreement, TIKA is one of the Subregional Office's main collaborating agencies, together with the Ministry of Forestry and Water Affairs.

TIKA has worked with FAO on many forestry-related projects and initiatives, both nationally and internationally. TIKA and FAO signed a cooperation agreement in May 2013 and continue to work closely to further their mutual aims.

Acronyms and abbreviations

ACP	African, Caribbean and Pacific Group of States
AI	aridity index
ANIA	Asociación para la Niñez y su Ambiente (Peru)
ANR	assisted natural regeneration
APEFE	Association pour la Promotion de l'Education et de la Formation à l'Etranger (Belgium)
BCP	biocultural community protocol
BIWMP	Bagmati Integrated Watershed Management Programme (Nepal)
CBD	Convention on Biological Diversity
COFO	FAO Committee on Forestry
CSIF-SLM	Strategic Investment Framework for Sustainable Land Management (Mali)
EIF	Enhanced Integrated Framework (Mali)
FAO	Food and Agriculture Organization of the United Nations
FLR	forest and landscape restoration
FMNR	farmer-managed natural regeneration
FPO	forest producer organization
GM-UNCCD	Global Mechanism of the UNCCD
GPFLR	Global Partnership on Forest and Landscape Restoration
ha	hectare(s)
HRMS	hill resource management society (India)
HSL	Horqin Sandy Land (China)
ICARDA	International Centre for Agricultural Research in the Dry Areas
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JFM	joint forest management (India)
K	potassium
kg	kilogram(s)
m^3	cubic metre(s)
MA&D	Market Analysis and Development
MEA	Millennium Ecosystem Assessment
MLA	Meat and Livestock Australia
MSBP	Millennium Seed Bank Partnership (Royal Botanic Gardens, Kew)
N	nitrogen
NGO	non-governmental organization
NWFP	non-wood forest product
P	phosphorous
PES	payments for environmental services

REDD+	reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
ROAM	Restoration Opportunities Assessment Methodology
SLM	sustainable land management
SWC	soil and water conservation
TERI	The Energy and Resources Institute (India)
TIKA	Turkish Cooperation and Coordination Agency
US$	United States dollar(s)
UFRSI	Uzbek Forestry Research and Scientific Institution
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICA	Universidad Nacional San Luis Gonzaga de Ica (Peru)
ZAR	South African rand(s)

Executive summary

Drylands, which cover 41 percent of the earth's land surface and are home to 2 billion people, are widely affected by desertification, biodiversity loss, poverty and food insecurity.

Trees and forests are essential for tackling the challenges that confront drylands, and they are also a source and factor of resilience in the face of global change. Large areas of dryland forests and other wooded lands are being degraded, however, and there is an urgent need for action. Restoration actions range from on-the-ground activities such as habitat protection, assisted natural regeneration, sand-dune stabilization and tree-planting to policy improvements, the provision of financial incentives, capacity development, and continuous monitoring and learning. To be effective and sustainable, dryland restoration should be approached at the landscape scale.

At the request of member countries and in collaboration with a wide range of partners, FAO launched the Drylands Restoration Initiative with the aim of capturing, evaluating and sharing knowledge on dryland restoration gained in dryland restoration initiatives worldwide. This publication, *Global guidelines for the restoration of degraded forests and landscapes in drylands*, is an output of that initiative.

The aim of the guidelines is to enhance restoration efforts in the world's drylands. They provide specific guidance for policymakers and other decision-makers, and for practitioners.

Policymakers and other decision-makers

Well-informed policymakers and other higher-level decision-makers can be enablers in the design and implementation of effective restoration efforts by providing appropriate policies, governance mechanisms and financial and other incentives. Among other things, policymakers and other decision-makers should:

- *Enable and invest in assessment and monitoring* – various tools are available to assist in assessing the need for dryland restoration, identifying priority areas for such assessment and restoration, and estimating the required level of investment.
- *Address drivers of land degradation by engaging in cross-sectoral dialogue and planning at the landscape level* – a lack of intersectoral coordination often means that different institutions treat various components of land management and restoration separately, limiting their capacity to address the drivers of degradation associated with competing land uses. Multisectoral platforms can be used to raise awareness of the extent and negative impacts of dryland degradation, encourage intersectoral approaches for addressing dryland degradation, and demonstrate restoration benefits and returns on investment.
- *Enable and invest in capacity assessment and development* – in many countries with drylands there is an urgent need for more qualified practitioners who

can deliver restoration competently and effectively, and also a need to develop networks of communicators and opinion leaders to influence policymakers. Ensuring the required capacities should be part of the initial planning of restoration initiatives, and the first step is capacity assessment. FAO capacity development tools can be adapted and used for such assessments.

- *Improve the supply of, and access to, plant reproductive material for restoration* – national and regional seed centres and programmes should be developed and strengthened to ensure the availability of genetically appropriate seeds in the quantities and of the quality needed for restoration.
- *Improve the governance and policy framework* – an enabling holistic policy framework needs to be in place to encourage restoration and avoid perverse policies that drive degradation. Secure land tenure is particularly important for achieving sustainable land management and boosting livelihoods. Local and national-level institutions should support local-level processes by providing technical and financial assistance and adequate governance structures and policies and by encouraging the equitable participation of stakeholders.
- *Create the right conditions for investment and resource mobilization for restoration* – sufficient funds are required to initiate and sustain restoration activities. Equitable and productive company–community partnerships can have important strategic value for investors. Small-scale, locally driven tree and forest product enterprises can broaden local income opportunities through restoration; it may be necessary to improve access to credit for such enterprises if they are to invest in restoration initiatives.
- *Encourage knowledge, research, learning and experimenting* – collaborative and adaptive learning and experimenting processes based on traditional knowledge and innovative research, and promoting the sharing of knowledge among land users, are keys for successful restoration.

Practitioners

Practitioners are the doers of restoration, and guidance is provided for them on the actions they should consider in any restoration initiative. Before taking action on the ground, practitioners should support facilitated processes to formulate restoration goals and interventions that address the needs of all stakeholders. Among other things, practitioners should:

- *Plan and choose the most cost-effective restoration strategies* – involving communities in the planning of restoration strategies can be effective in formulating restoration interventions and sustainable goals that address the needs of all stakeholders. Non-degraded areas can be used as reference sites for defining restoration goals and assessing the progress and impacts of restoration activities. Landscape-scale planning takes into account the mosaic of land uses and the diversity of needs of all stakeholders. Diverse restoration strategies should be promoted.

- *Protect and manage* – improvements in protection and management are potentially more cost-effective than planting in restoration initiatives. A good starting point for initiatives is protecting soils against erosion, using cost-efficient water-harvesting techniques, and mainstreaming the use of integrated management plans to address threats such as excessive wood collection, unplanned grazing and damaging fire.
- *Promote natural regeneration* – assisted natural regeneration and, on farms, farmer-managed natural regeneration are simple and effective restoration measures that require little investment. They also have the potential to be scaled up quickly in areas where tree and shrub species have the ability to re-sprout after harvest and where rights to resource use are appropriate.
- *Plant where and when necessary* – if a planting strategy is needed, the choice of species should take technical criteria and local preferences into account. Special attention should be given to ensuring the quality of genetic material, and native species should be favoured. The number of species, and their genetic diversity, should be maximized as a way of enhancing resilience. Adequate nursery techniques should be employed, and planting times and densities should be chosen carefully to ensure optimal use of limited water resources.

Monitoring and evaluation

Effective monitoring is an essential element of adaptive management because it provides feedback on restoration activities, results and management. By measuring progress over time, monitoring and evaluation provide the evidence base on which strategies can be built and adapted, thereby helping build resilience. Policymakers and practitioners should integrate monitoring and evaluation in restoration initiatives, including by:

- developing the monitoring plan or programme in the planning phase;
- promoting the participation of all stakeholders in the design and implementation of monitoring; and
- consistently monitoring and evaluating restoration initiatives and sharing the lessons learned for the benefit of ongoing and future initiatives.

The Monitoring and Reporting Tool for Forest and Landscape Restoration, developed by FAO in collaboration with a wide range of experts, aims to: support the reporting of forest and landscape restoration initiatives in countries and worldwide; monitor the impacts of such initiatives; capture the lessons learned; and design restoration initiatives by acting as a checklist of the required elements that need to be considered in designing such initiatives. The tool will be made available online.

Case studies

Twenty-seven case studies are presented to demonstrate the breadth of experiences in dryland restoration, and they also illustrate the actions recommended in these guidelines.

The way forward

The urgent restoration of degraded forests and landscapes in drylands is essential if the global community is to meet the challenges posed by desertification, food insecurity, climate change and biodiversity loss, among other negative trends. The many efforts that have already been made – with more or less success – provide lessons that underpin these guidelines.

These guidelines are intended to be global in scope, and they should be tailored to suit regional and local contexts. They present the essential components for the design, implementation and sustainability of restoration initiatives that help build ecological and social resilience and generate benefits for local people.

The guidelines will be promoted, disseminated and translated into other languages as required to make them available to local actors while encouraging their use and adaptation to local, national and regional contexts. Capacity-development workshops and information events will be organized to support the dissemination and use of the guidelines. Nurturing and broadening the informal network of professionals established in the course of developing these guidelines is essential for widening and facilitating the community of restoration enablers.

These guidelines show that restoration needs to be considered across the entire market value chain, from seed to end-product. Regional collaboration in establishing a network of regional seed-supply centres is essential for developing value chains for native species suitable for building resilient forests and landscapes in drylands.

A major effort is needed to strengthen local governance and develop local leaders and restoration champions, such as by strengthening community-based organizations, local administrations, forest producer organizations and small and medium-sized enterprises. Financing opportunities emerging from the various funding instruments need to be further explored and used to advance restoration and the implementation of these guidelines.

Many national, regional and global research networks are active in dryland regions. It is essential to create linkages between such networks, restoration practitioners and communities as a way of applying research results on the ground and combining new learning with traditional practices.

The Rome Promise, which was adopted in early 2015, is a call to action to improve the monitoring and assessment of drylands for their sustainable management and restoration. The first global assessment of drylands, now underway, is a first step in the implementation of the Rome Promise and will build a robust baseline to support restoration monitoring efforts and the further development of these guidelines over time.

1 Introduction

1.1 WHY GUIDELINES?

Drylands cover 41 percent of the earth's land surface and are home to 2 billion people. They are characterized by drastic water deficits, hot temperatures, and dry and poor soils. Drylands are widely affected by desertification, biodiversity loss, poverty and food insecurity. Such problems are exacerbated by climate change.

Trees and forests play key roles in tackling the challenges that confront drylands, and they are also a source of resilience in the face of global change. Nevertheless, satellite data indicate that at least 3 percent of the world's dryland forests were lost between 2000 and 2012 (R. D'Annunzio, personal communication, 2014). In many dryland regions, too, trees and forests are suffering from degradation because of unsustainable practices and poor management. The importance of drylands for the provision of goods and environmental services is generally undervalued, which restricts the policy attention they receive, the funds available for their restoration and management, and the extent of scientific research. The management of drylands often requires differing approaches to those suited to humid forests. There is a clear and urgent need for more policy support for dryland management, conservation and restoration.

A number of restoration initiatives have been implemented in the world's drylands, with variable success, and these are an important source of knowledge that could be used to improve restoration efforts. Accordingly, member countries of FAO[1] requested FAO to conduct, with their collaboration and that of local and international partner organizations, a comprehensive analysis, evaluation and documentation of relevant afforestation, reforestation and restoration projects, programmes and initiatives in drylands.

In response to the request, FAO launched the Drylands Restoration Initiative[2] with the aim of capturing, evaluating and sharing knowledge on dryland restoration, based on the extensive experience accumulated in dryland restoration initiatives worldwide. This publication, *Global guidelines for the restoration of degraded forests and landscapes in drylands*, is an output of the Initiative, and its aim is to support restoration efforts carried out in the world's drylands.

1 This request was made at sessions of the FAO Near East Regional Forestry and Range Commission in 2011 and 2012 and at the 21st session of the FAO Committee on Forestry in 2012.

2 www.fao.org/forestry/aridzone/restoration and www.fao.org/dryland-forestry.

1.2 THE PROCESS

The process to produce the guidelines was launched in May 2012 in Konya, Turkey, at an international workshop titled "Building resilient forest landscapes to global changes in drylands" convened by the General Directorate of Combating Desertification and Erosion of the Turkish Ministry of Forestry and Water Affairs, FAO, the Turkish Cooperation and Coordination Agency (TIKA) and the German Agency for International Cooperation. The event brought together more than 90 international experts on dryland restoration from forestry departments, research institutions, the private sector, non-governmental organizations (NGOs), international development agencies and other technical and financial partners, representing 24 countries in Africa, Central Asia, the Near East and the Mediterranean region.

With the financial support of TIKA, a second international workshop was convened in Dakar, Senegal, in February 2013 by FAO, the Senegalese Ministry of Environment and Sustainable Development and its technical institutions (including the National Agency of the Great Green Wall of Senegal), the General Directorate of Combating Desertification and Erosion of the Turkish Ministry of Forestry and Water Affairs, and the African Union Commission. This workshop gathered more than 80 international experts on dryland restoration.

The guidelines have been developed based on:

- an analysis of lessons learned and experiences gained in afforestation, reforestation and restoration projects and programmes in the field;
- the application of a comprehensive monitoring and reporting tool for forest and landscape restoration (see Chapter 5) developed by FAO in collaboration with a wide range of experts;
- the results and recommendations of the Konya and Dakar workshops and other regional workshops;
- feedback on draft versions received from a network of experts through online consultation and side-events organized at the 21st session of the FAO Committee on Forestry in Rome, Italy, in September 2012 as well as at the tenth session of the United Nations Forum on Forests held in Istanbul,

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First international workshop in Konya, Turkey, May 2012

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Dakar international workshop participants testing the guidelines with local people in Mboula in the Great Green Wall area, Senegal, February 2013

Turkey, in May 2013, and the Conference of the Parties to the United Nations Convention to Combat Desertification (UNCCD) in Windhoek, Namibia, in September 2013; and

- a review of the draft by FAO technical experts across departments and decentralized offices.

1.3 THE TARGET AUDIENCE

The guidelines are designed for:

- natural-resource policymakers and other decision-makers at different levels, including the heads of departments and agencies of forestry, natural resources, land and water, and rural development at the central and decentralized levels, and managers of forest restoration programmes and initiatives in drylands; and
- restoration practitioners, officers and technicians in technical departments in countries, international and regional organizations, bilateral and multilateral development cooperation agencies, and NGOs.

1.4 THE STRUCTURE

This publication has six chapters in addition to this introduction.

- Chapter 2 sets out the need to restore drylands, highlighting the key challenges affecting drylands and the importance of forests and trees and their restoration as a means of addressing those challenges and increasing resilience in drylands.

- Chapter 3 describes guidelines for policymakers and other decision-makers, labelled as "enablers". Possible actions and recommendations are proposed for implementing and sustaining effective restoration efforts. The main focus is on policy, governance, multisectoral planning, and financial and other incentives for restoration.
- Chapter 4 presents guidelines for practitioners, considered to be on-the-ground restoration "doers", providing guidance on planning and implementing restoration, including the formulation of priorities and goals; decisions on restoration strategies; management; and planting.
- Chapter 5 describes key aspects of the monitoring and evaluation of dryland restoration initiatives. Among other things, it describes the Monitoring and Reporting Tool for Forest and Landscape Restoration developed by FAO. The tool will be available online from 2016. Note that chapters 3–5 involve activities and actions that may overlap or be implemented concurrently. For example, a monitoring and evaluation plan should be developed during the restoration planning phase and implemented throughout the life of the restoration initiative.
- Chapter 6 presents 27 case studies of successful initiatives to illustrate the actions recommended in these guidelines.
- Chapter 7, on the way forward, proposes key next steps and opportunities for promoting the implementation of these guidelines and their operationalization on the ground.
- End materials include a glossary of the key terms used in these guidelines, as well as lists of references and further reading, useful tools and other case studies, and relevant websites.

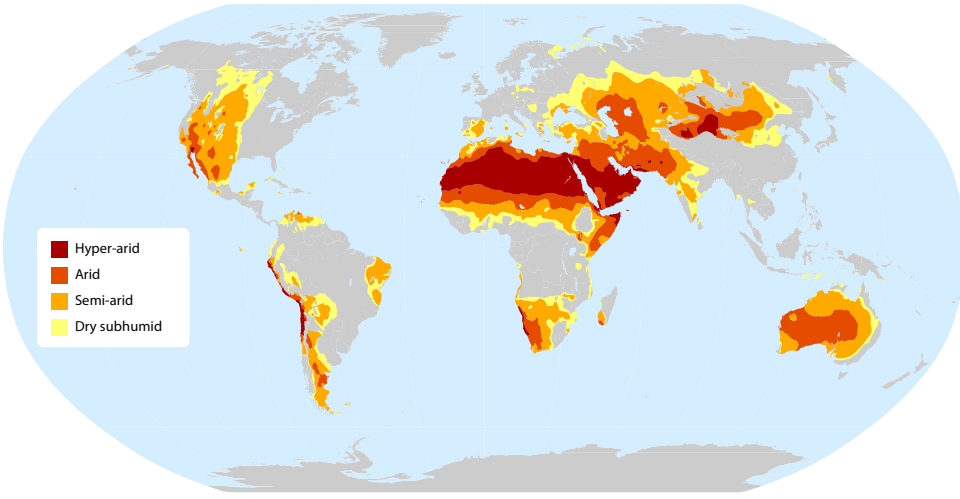
2 Drylands and the benefits of restoration

2.1 WHAT ARE DRYLANDS?

Drylands are characterized by a scarcity of water, which affects both natural and managed ecosystems and constrains the production of livestock as well as crops, wood, forage and other plants and affects the delivery of environmental services (MEA, 2005). For millennia, drylands have been shaped by a combination of low precipitation, frequent and sometimes intense and long droughts and heat waves, and human activities such as fire use, livestock grazing, the collection of wood and non-wood forest products (NWFPs), and soil cultivation. Dryland soils tend to be vulnerable to wind and water erosion, subject to intensive mineral weathering, and of low fertility (due to the low content of organic matter in the topsoil) (FAO, 1989).

The United Nations Environment Programme (UNEP) defines drylands according to an aridity index (AI), which is the ratio between average annual precipitation and potential evapotranspiration; drylands are lands with an AI of less than 0.65. UNEP's classification system subdivides drylands on the basis of AI into hyper-arid lands, arid lands, semi-arid lands and dry subhumid lands (UNEP, 1992). Drylands are found in most of the world's biomes and climatic zones and constitute 41 percent of the global land area (see map below).

Drylands and subtypes



Note: Prepared using spatial data from UNEP–WCMC (2007).

2.2 THE IMPORTANCE OF FORESTS AND TREES IN DRYLANDS

Trees and forests are essential to the lives of people and animals in drylands. They can supply many of the basic needs of human communities, such as food, medicine, wood for energy, and fodder for livestock. In drylands more than in most other biomes, however, the demands of human communities have been much higher than the capacity of ecosystems to deliver sustainably, resulting, in many places, in the rapid depletion of these resources.

Many dryland tree species are emblematic because of their key ecological and cultural functions and the important environmental services they provide. Dryland trees, forests and other wooded lands provide the following environmental services:

- **Provisioning services**. Forests and trees in drylands are essential for sustaining rural livelihoods, and they are primary sources of food for humans and livestock. In Africa, 320 million people depend on dry forests and other wooded lands to meet many of their basic needs (Chidumayo and Gumbo, 2010). It is widely acknowledged that trees, forests and other wooded lands make major contributions to food security, and this is especially true in drylands. Globally, millions of people depend on food harvested in forests and from trees outside forests to increase the nutritional quality and diversity of their diets. An estimated 2.4 billion people use woodfuel for cooking, a major contribution to food security and nutrition. Moreover, the harvesting of food in forests is an essential way in which the very poor cope with periods of food insecurity, such as during dry seasons or in the wake of natural disasters and war (FAO, 2013a). Forests and trees in drylands provide products for day-to-day subsistence and to generate income, including a large variety of non-wood forest products such as fruits, seeds, flowers, gums, resins, honey, tannins, colourants, aromatics and medicines.

A cattle herder shaking loose pods from a tree to feed the herd, the Niger

Cork, which is produced in cork oak forests in the Mediterranean region, is the sixth most important NWFP globally, with processed cork products generating an estimated US$2 billion per year (FAO, 2013c). Gum arabic is another major NWFP; it is produced in many African dryland countries (Chad, Nigeria and the Sudan are the biggest producers) and used in the food industry. Exports of gum arabic are growing and now average 50 000 tonnes per year, with good prospects for further growth (International Trade Center, 2009; FAO, 2010b).

- **Regulating services.** Dryland trees, forests and other wooded lands facilitate the infiltration of water into soil and help maintain air humidity, reduce soil erosion by wind and water (their root systems helping bind the soil together) and moderate local climates by acting as windbreaks and providing shade for soils, animals and people. Many dryland tree species have deep roots for accessing groundwater, enabling them to redistribute water upwards and thereby to improve nutrient cycling and the water balance (Davies *et al*., 2012).
- **Habitat and supporting services.** Dryland trees contribute to soil fertility by fixing nitrogen from the atmosphere; retrieving nutrients from below the rooting zones of crops; and reducing nutrient losses by preventing leaching and erosion (Buresh and Tian, 1998). Dryland trees, forests and other wooded lands generally play a crucial role in providing habitats for fauna and flora, and there is often a direct correlation between biodiversity loss and the depletion of forests and other wooded lands (Davies *et al*., 2012).
- **Cultural services.** Dryland trees, forests and other wooded lands contribute to cultural identity and diversity, cultural landscapes and heritage values, and spiritual services (Le Floc'h and Aronson, 2013). In many countries, sacred forests and sacred or totem plant species have served to protect emblemic trees such as *Adansonia digitata* (baobab), which is used traditionally in Senegal to bury the bodies of the "griots" (storytellers); and *Dracaena cinnabari* (dragon blood) in the Yemeni island of Socotra, which, according to legend, was created from the blood of a dragon defeated by an elephant.

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A sifaka (lemur) feeding on a baobab fruit in a dry forest in Madagascar

2.3 KEY CHALLENGES IN DRYLANDS

Drylands face numerous challenges linked to desertification, population pressure, climate change, and overharvesting and mismanagement. Changing land uses and practices such as the transformation of rangelands and other silvopastoral systems to cultivated croplands, wasteful and unsustainable water use, inappropriate cultivation and grazing practices, and the overharvesting of woodfuel are leading to land degradation, water shortages and major losses of environmental services. An estimated 10–20 percent of the world's drylands suffer from one or more forms of land degradation (MEA, 2005). Many people living in drylands are locked in a vicious circle of poverty, irrational practices and environmental degradation. Moreover, climate change is expected to increase the incidence of extreme weather events such as droughts and to exacerbate desertification and declines in land productivity. On the other hand, many human communities in drylands carry a wealth of ancestral knowledge, skills and other assets, and they have survived and prospered in drylands for millennia. In favourable conditions and with sufficient incentives, these communities have the capacity to achieve sustainable livelihoods, cope with natural disasters, and escape poverty (Dobie, 2003).

Water scarcity

Water scarcity may have natural or anthropogenic causes (Falkenmark *et al.*, 2007). Sedentism among formerly nomadic peoples can lead to the overstocking of grazing lands, accelerated deforestation, and intensive cultivation, which are known factors in water scarcity because they reduce vegetation cover. In periods of high or intense rainfall, runoff is much higher in areas with reduced vegetation

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Water scarcity – pastoralists and herds of livestock gathering at a water well in a dry portion of Lake Magadi, Kenya

cover, which increases soil erosion and decreases groundwater recharge. This destabilizes the hydrological balance and can lead to recurrent water shortages and sometimes flooding.

Water scarcity exacerbates the effects of desertification through direct, long-term impacts on land and soil quality, soil structure, organic matter and soil moisture. In turn, the physical effects of land degradation have negative impacts on the availability, quality and quantity of water resources by inducing the drying up of freshwater bodies; increasing the frequency of drought and of sandstorms and dust storms; intensifying floods; and inducing declines in soil nutrients and vegetation cover. Further land and water degradation can also trigger indirect effects, such as surface and groundwater pollution, siltation and the salinization and alkalization of soils.

The challenges and threats posed by water scarcity in drylands are expected to increase in the future. Climate change is leading to increased climate variability, such as more frequent droughts, and is likely to intensify water scarcity and exacerbate stresses and desertification in dryland ecosystems.

Climate change and variability

Drylands are among the most vulnerable ecosystems to extreme weather events. The main challenge posed by climate change in drylands is likely to be an increase in the frequency, magnitude and severity of such events, including prolonged droughts, intense heat waves, heavy precipitation and strong winds. Some consequences of this increase are already apparent: uncontrolled large-scale forest fires; massive forest dieback and pest attacks; major reductions in soil water storage capacity; and large-scale floods that accelerate and intensify soil degradation processes. The most recent report of the Intergovernmental Panel on Climate Change (IPCC, 2014) drew attention to a lack of capacity in socioecological systems to adapt to change and noted that "impacts from recent climate-related extremes, such as heat waves, droughts, floods and wildfires, reveal significant vulnerability and exposure of some ecosystems and human systems to current climate variability".

Climate change can magnify the effects of socioeconomic change, and vice versa, potentially triggering faster rates of degradation and landscape-scale impoverishment. There is evidence of prehistoric local and regional disappearances of forest species and ecosystems in drylands caused by combinations of climate change (e.g. an increase in temperature) and intense or rapid anthropogenic changes in land cover or management practices (e.g. the extensive use of fire for land clearance).

Desertification

According to UNCCD (1994), desertification is land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities. The Millennium Ecosystem Assessment (MEA, 2005) described drylands as "highly prone to desertification on account of their

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Sandstorm near Tongliao in the Horqin Sandy Land, Inner Mongolia, China

limited primary productivity and generally slow recovery following human disturbance" compared with other biomes.

The degradation of land resources in arid, semi-arid and dry subhumid areas results from a process or a combination of processes primarily caused by:

- vegetation degradation, fragmentation, biodiversity loss and reduced cover due to factors such as excessive wood collection, encroachment, land conversion for inappropriate agricultural practices, unplanned grazing, and the invasion of exotic species; and
- soil degradation due to erosion, compaction, nutrient mining, the loss of soil biodiversity, salinization (especially associated with irrigated lands), sand encroachment and contamination.

A high dependency on woodfuel (firewood and charcoal) coupled with its low availability and overexploitation is a particularly significant factor in land degradation in most parts of sub-Saharan Africa, where more than 90 percent of people still rely on woodfuel harvested in forests and other wooded lands for energy, especially for cooking. Overharvesting is significantly depleting forests and woodlands in the subregion (Iiyama *et al*., 2014).

Biodiversity loss

Although the absolute number of species in drylands is lower than in more humid environments, the rate of endemism is high. Drylands are also characterized by species that are highly specialized and adapted to drought, salinity and heat.

Nevertheless, the water limitations and climatic extremes in drylands render them vulnerable to disturbance and mean that recovery is slow; drylands therefore are less resistant to degradation, and have lower resilience, than many other biomes (Bainbridge, 2012).

Species and ecosystems in drylands are the result of unique evolutionary phenomena, and they have developed effective strategies for coping with environmental constraints such as water scarcity, extreme hot and cold temperatures, and unpredictable and prolonged drought periods with sporadic rainfall (FAO *et al.*, 2011). Many dryland species, therefore, potentially have great value in efforts to adapt to climate change.

A number of semi-arid and dry subhumid ecoregions are important for biodiversity, and some are considered biodiversity hotspots with exceptional concentrations of endemic species and high rates of habitat loss. Many known drivers of biodiversity loss are present in drylands, including: rapid demographic shifts and urbanization; agricultural expansion (especially intensive farming practices focusing on specific commodities); land-use change; the weakening of governance arrangements that previously regulated resource use effectively; and the introduction and spread of alien invasive species (Davies *et al.*, 2012). Habitat loss and fragmentation are expected to continue to increase, accelerating biodiversity loss.

Dryland-dwellers rely on a wide range of plant and animal products for household consumption and sale, and such products often contribute significantly to household economies. The biodiversity of drylands forms the basis of diverse livelihoods, and its conservation and sustainable use is a key to improving livelihoods. Approximately 9 percent of drylands receive formal protection, although some of the richer dryland ecosystems are under-represented in protected areas (Davies *et al.*, 2012). Many dryland areas that are protected informally by local communities (e.g. sacred sites, seasonal grazing areas and forest reserves) are not recognized officially as protected areas and may be undermined by government policies that pay insufficient attention to traditional practices. Dryland biodiversity needs to be conserved, both inside and outside protected areas, including through improved dryland management and restoration.

Poverty and food insecurity

Drylands are home to 2 billion people – about 30 percent of the global population – in over 100 countries. In general, socioeconomic conditions in drylands lag significantly behind those of other regions, and most of the world's poverty is concentrated in drylands, especially in Africa and parts of Asia and the Near East (UNDP–UNCCD, 2011). The majority of people directly affected by desertification live below the poverty line and lack adequate access to freshwater (UNCCD, 2011).

There is a direct relationship between human well-being and the availability of provisioning environmental services (such as food, forage, water and bioenergy), which is characteristically low in most drylands. Environmental degradation

can therefore have particularly severe consequences for the poor, given their generally high economic dependence on natural resources (UNDP–UNCCD, 2011). Poverty and food insecurity, often coupled with unclear tenure rights over natural resources, drive people to overexploit remaining natural resources, which accelerates land degradation, leading to even greater poverty and malnutrition. In the Zagros region of the Islamic Republic of Iran, for example, rain-fed shifting agriculture is one of the main causes of degradation of forests and soils.

Disrupted transhumance, migration and conflict

Pastoral transhumance – the seasonal movement of people with their livestock to available pastures and watering points – is a traditional practice in drylands worldwide that enables the rational use of rangeland grazing resources (IUCN, n.d.); it is also a coping strategy that could be important for adapting to climate change. Population pressure, the weakening of traditional controls over the use of range resources, increasing land-use conflicts, the general trend towards sedentism among former transhumant communities, and environmental stresses (including those caused by climate change and increased climate variability) are affecting the sustainability of land use and in some cases causing conflicts. The migration of dryland-dwellers in response to societal and climatic changes is another critical issue. Environmental degradation, especially desertification, is a frequent cause of migration, forcing people to move away from unproductive lands. It has been estimated that up to 50 million people could be compelled to migrate in the ten years to 2020 as a result of desertification if the problem is not addressed (UNCCD, 2011).

A lack of natural resources combined with high population densities and sometimes the movement of people to other regions cause further strain on the environment, as well as social and political tensions and conflict (UNCCD, 2011). According to IPCC (2014), climate change in the twenty-first century "will have significant impacts on forms of migration that compromise human security", and it "will indirectly increase risks from violent conflict in the form of civil war, inter-group violence, and violent protests by exacerbating well-established drivers of these conflicts such as poverty and economic shocks".

Weak governance and inadequate policies

Weak governance is increasingly regarded as a root cause of the degradation and loss of natural ecosystems worldwide. A lack of understanding about the important contributions of dryland forests and trees to national development and the fragile nature of dryland ecosystems has led to their undervaluation and a general lack of effective policies, investment, institutional support and planning processes to support dryland communities and the sustainable management of their resources. Development strategies have often been limited to policies promoting agricultural intensification, especially industrial crops that lead to the degradation of dryland natural resources such as wooded lands and rangelands.

Public administrations are not always well organized, and the institutions of different sectors rarely cooperate and sometimes even act competitively or with incompatible objectives. In many countries, the lack of coherent multisectoral approaches means that different ministries address different aspects in ignorance or isolation of each other, often with the result that government policies are contradictory.

The absence of secure rights to natural resources (such as land access and management rights and the right to generate income or otherwise benefit from natural resources) is another major constraint on investment in sustainable management and restoration activities. Uncertainty about tenure, or unclear regulations, can also reduce interest in such activities among local actors, who do not wish to invest time and resources if they have no guarantee they will be allowed to use the resources when the area becomes productive.

Many dryland communities have immense local knowledge of, and experience in, dryland management, which can be reinforced with experience and scientific knowledge gained elsewhere. A major constraint, however, is the failure of governments to recognize the contributions that local actors can make to dryland management and a consequent failure to delegate sufficient power to them, reducing local support for restoration and sustainable management initiatives.

Other factors, such as a lack of institutional or organizational capacity and limited access to markets and financial capital, reduce the capacity of local communities to implement sustainable dryland restoration and management (MEA, 2005). Imperfect decentralization processes – such as the de-concentration of responsibilities without the devolution of power and resources or sufficient capacity building – has also led to the disengagement of the state and created gaps in the fulfilment of the role of public institutions.

2.4 RESTORATION IN DRYLANDS

What is restoration and why is it needed?

The Society for Ecological Restoration defines ecological restoration as the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER, 2004).

Forest and landscape restoration[3] addresses restoration at a landscape scale, often encompassing several ecosystems and land uses, as a way of enabling users to achieve trade-offs among conflicting interests and balancing social, cultural, economic and environmental benefits.

Restoration is widely acknowledged (Box 2.1) as a way of reversing degradation processes and increasing the contributions of ecosystems and landscapes to livelihoods, land productivity, environmental services and the resilience of human and natural systems. The term "restoration" covers a wide range of conservation, sustainable management and active restoration practices that increase the quality and diversity of land resources, thus enhancing ecological integrity and human well-being.

3 www.forestlandscaperestoration.org.

BOX 2.1

The international policy framework for restoration

- The **Aichi Biodiversity Targets** of the **Convention on Biological Biodiversity** (CBD) involve restoration actions. Target 15 is particularly relevant: "by 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification". At the 11th Conference of the Parties to the CBD in Hyderabad, India, in 2012, the CBD Executive Secretary made a strong call to "Parties, partners and other stakeholders to take urgent action towards achieving the Aichi Biodiversity Targets".
- The **Bonn Challenge** is a global effort launched at a ministerial conference in September 2011 to restore 150 million ha of degraded and deforested land by 2020 as a contribution to REDD+[1] and Aichi Biodiversity Target 15.
- The aim of the **United Nations Framework Convention on Climate Change** (UNFCCC) is to prevent dangerous human interference with climate systems. Parties to the UNFCCC have affirmed the need to slow, halt and reverse forest and carbon loss as important climate-change mitigation measures, and they are setting up mechanisms to provide incentives for actions under REDD+. The UNFCCC also calls for measures to adapt to climate change, including in the forest sector. The Intergovernmental Panel on Climate Change recommends forest restoration as an efficient means to considerably increase carbon stocks and reduce emissions at low cost with potential co-benefits for climate-change adaptation and sustainable development.
- The ten-year strategy (2008–2018) of the **United Nations Convention to Combat Desertification** (UNCCD) aims to forge a global partnership to reverse and prevent desertification, land degradation and drought. In the Rio+20 outcome on desertification, land degradation and drought, world leaders agreed to "strive for a land-degradation neutral world" and reaffirmed "their resolve under the UNCCD to take coordinated action nationally, regionally and internationally and to monitor, globally, land degradation and restore degraded lands in arid, semi-arid and dry subhumid areas".
- In a joint statement issued at the Rio+20 conference, the executive secretaries of the **three Rio conventions** committed to tackling sustainable development challenges by focusing on prioritized cross-cutting themes, which include landscape and ecosystem-based approaches to adaptation (e.g. ecosystem restoration), generating and sharing information on climate-change impacts and vulnerability when considering biodiversity and land use, and mainstreaming gender into activities related to the implementation of the conventions. The final outcome document of Rio+20, "The Future We Want", emphasizes ecosystem restoration and its linkages with sustainable development, including public works and climate-change responses.

- The **Global Partnership on Forest and Landscape Restoration** aims to further develop and implement landscape restoration by bringing stakeholders together to implement practices that restore an agreed optimal balance of the economic, social and ecological benefits of forests and trees within broader land-use patterns.
- At its sixth session in 2006, the **United Nations Forum on Forests** agreed on four Global Objectives on Forests. The first of these seeks to "reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation".
- The first pillar on "land and water management" of the New Partnership for Africa's Development's **Comprehensive Africa Agriculture Development Programme** aims to "extend the area under [sustainable land management] and reliable water control systems".
- The **Global Strategy for Plant Conservation** (2011–2020) includes Target 4, which is: "at least 15 percent of each ecological region or vegetation type secured through effective management and/or restoration". The vision contained in the strategy is to halt the continuing loss of plant diversity and to secure a positive, sustainable future in which human activities support the diversity of plant life (including the endurance of plant genetic diversity and survival of plant species and communities and their associated habitats and ecological associations), and where, in turn, the diversity of plants supports and improves livelihoods and well-being.
- **The FAO State of the World Forest Genetic Resources** (FAO, 2014a) and its **Global plan of action for the conservation, sustainable use and development of forest genetic resources** include Priority Area 3 and strategic priorities 12 and 13 on the use of appropriate genetic material in restoration, rehabilitation, and national plantation programmes.

[1] REDD+ = reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

Restoration actions range from on-the-ground activities such as habitat protection, assisted natural regeneration (ANR), sand-dune stabilization and tree-planting to policy improvements, the provision of financial incentives, and continuous monitoring and learning. Restoration may involve a mosaic of land uses such as agroforestry systems, parklands, agrosilvopastoral and other pastoral systems, forests, rangelands, riparian systems, barren or abandoned agricultural land, protected areas, ecological corridors, public, communal and private land, and rural, urban and peri-urban areas. Restoration offers opportunities for environmental and socioeconomic gains because it:

- helps increase the natural capital on which rural livelihoods depend;
- helps increase the resilience of landscapes, ecosystems and social systems to global change; and

- if well planned and managed, can respond to the interests and needs of a variety of stakeholders.

Restoration in dryland ecosystems can comprise a range of actions. The re-establishment of vegetation through planting or ANR is a common objective, but restoration may also consist of protection (against water and wind erosion, fire, grazing and other threats) and other management actions, such as mechanical soil management. Restoration can be practised in a variety of dryland ecosystems, such as forests, open woodlands, agroforestry systems, parklands, savannahs and grasslands.

The role of trees and forests in dryland restoration

Although dryland restoration at the landscape level may involve a variety of ecosystems and land uses, and restoration activities may go well beyond planting trees, forests and trees nevertheless are key components because of the often central role they play in the provision of benefits for both people and biodiversity.

For example, the canopies of trees, and the aerial parts of smaller plant species, reduce the negative impacts on the soil of:

- rain, by reducing the kinetic energy of rain droplets when they strike the soil, thereby reducing the potential of rain to loosen soil particles and cause soil erosion;
- wind, by reducing the aerial movement of soil particles; and
- the sun, by protecting against excessive evaporation and the destruction of soil microfauna.

Trees and other plants also contribute organic matter to soils, enhancing fertility and reducing soil erosion. Root systems help increase the cohesiveness of soil particles and help maintain soil porosity, thereby assisting water infiltration. Trees, forests and other wooded lands play key positive roles, therefore, in maintaining productivity in croplands and grazing lands by helping maintain soil water-holding capacity and soil fertility, and they contribute in many other ways, too, to the resilience of human populations and landscapes. They are at the centre of restoration initiatives in drylands.

In dryland mountains, forests play key roles in regulating water flows and minimizing the damage caused by floods; undisturbed forests are generally regarded as the most efficient land-cover type for maintaining the hydrological balance (FAO *et al*., 2011). In degraded dryland mountain regions with watersheds at high risk of erosion and flash floods, the restoration of tree cover can help by intercepting and storing water from rainfall and releasing it gradually while, at the same time, improving water quality.

Trees and other vegetation can be planted as part of efforts to restore sand-encroached areas. In some situations, a combination of mechanical means and the planting of trees and other perennial vegetation can be used to halt or reduce sand-dune movement by stabilizing the soil, reducing the wind-speed gradient and increasing water retention, which, in turn, allows more vegetation to establish (FAO, 2010d).

Restoration to enhance resilience

A common definition of resilience is "the capacity of a social and/or ecological system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker *et al*., 2004). In other words, resilience is the capacity of a human or natural system to maintain its integrity and functions, adapt to change, and resist being pushed past thresholds beyond which recovery may be impossible. Resilience is the antithesis of vulnerability, a term used to denote the level of risk posed to a social or ecological system by a major disruption or change (Zolli and Healy, 2013). In drylands, resilience is the capacity of socioecological systems to endure major and uncertain disturbances, such as drought, without severe, long-term consequences for livelihoods and the environment.

The development of rural societies in drylands has been both guided and limited by environmental constraints, and traditional dryland socioecological systems have been highly resilient. In many cases, such traditional systems have simultaneously shown better economic viability than "modern" land management practices while also providing conservation benefits (Davies *et al*., 2012) by being able to adapt to complex, unstable and adverse conditions and by making efficient use of limited resources and biodiversity. Such benefits highlight the importance of supporting traditional resource management strategies. However, new challenges, such as climate change, globalization, high population growth and urbanization, which are exerting strong pressure on shrinking dryland resources, suggest the need for innovative approaches alongside traditional strategies.

In drylands, healthy, productive ecosystems are generally more resilient, and there is a lower risk of ecosystem collapse (Bainbridge, 2012). Diversity is also important – in ecosystems (e.g. in terms of species and genetic diversity), socioeconomic systems (e.g. in terms of livelihood options, foods and other products), and institutions (e.g. in terms of land-use options, governance, and adaptive management). The efficient management of surface water and groundwater is another way of promoting resilience in drylands.

The re-establishment of trees and other vegetation can help restore the protective and productive functions of dryland ecosystems. For example, trees can be used as shelterbelts and windbreaks and can also play important roles in protecting against landslides and floods, stabilizing riverbanks and mitigating soil erosion while producing woodfuel, timber and NWFPs.

3 Guidelines for policymakers and other decision-makers: establishing a strong enabling environment

Well-informed policymakers and other higher-order decision-makers can be enablers in the design and implementation of effective restoration efforts by providing appropriate policies, governance mechanisms and financial and other incentives. Moreover, policymakers and other decision-makers can be key actors in the establishment of national, subnational and landscape-scale platforms for multisectoral land-use planning. Such platforms are needed for assessing opportunities and priorities in restoration and ensuring that these are captured in national development processes.

Restoration initiatives implemented in isolation and over the short term are unlikely to be sustainable. To be effective, they should be strongly embedded in larger processes that enable them to interlink with and complement other initiatives and ultimately to achieve restoration at the landscape and national scales.

This chapter describes priority actions that can be taken by policymakers at both the national/central and local decision-making levels to enable successful restoration and deliver sustainable impacts.

3.1 ENABLING AND INVESTING IN ASSESSMENT AND MONITORING

A global analysis by the Global Partnership on Forest and Landscape Restoration (GPFLR), the World Resources Institute, South Dakota State University and the International Union for Conservation of Nature (IUCN) in 2011 found that more than 2 billion ha of land worldwide could benefit from restoration.[4] What part of this is drylands? Where should the restoration efforts of the forest and other sectors be focused?

At its 22nd session in June 2014, the FAO Committee on Forestry (COFO) acknowledged that, at the global level, knowledge of the extent and value of dryland forests and agrosilvopastoral systems was limited, and that this might explain the lack of investment in their management and restoration. There was, among other things, a lack of:

- global mapping of the extent and status of dryland forests and agrosilvo pastoral systems;
- regional and global coordination and integration among existing monitoring systems for dryland forests and agrosilvopastoral systems to enable the tracking of changes and the identification of risks (e.g. those posed by deforestation, desertification and climate change);

4 www.wri.org/sites/default/files/world_of_opportunity_brochure_2011-09.pdf.

- global prioritization of investment in improving dryland forest management and restoration; and
- estimates of the required level of investment (technical and financial) for the restoration and sustainable management of dryland forests.

COFO 22 recommended that FAO work with countries and partner organizations to undertake a global assessment of dryland forests and agrosilvopastoral systems to enable the identification of priority areas for restoration and the estimation of the required level of investment. A number of tools exist that can be used in analysing the situation in dryland forests and landscapes and their restoration needs at various levels (Box 3.1).

3.2 ADDRESSING THE DRIVERS OF LAND DEGRADATION BY ENGAGING IN CROSS-SECTORAL DIALOGUE AND PLANNING AT THE

BOX 3.1

Tools for situation assessment in dryland forests and landscapes

Restoration Opportunities Assessment Methodology

The Restoration Opportunities Assessment Methodology (ROAM), a product of the International Union for Conservation of Nature (IUCN), provides a flexible and affordable framework approach by which countries can rapidly identify and analyse the potential for forest and landscape restoration (FLR) and locate specific areas of opportunity at a national or subnational level.

ROAM can support countries seeking to develop restoration programmes and landscape-level strategies. It can also enable countries to define and implement pledges to the Bonn Challenge target of restoring 150 million ha worldwide by 2020, thereby helping them meet international commitments under the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD) and the United Nations Framework Convention on Climate Change (UNFCCC). ROAM assessments can be undertaken by small core assessment teams with the collaborative engagement of other experts and stakeholders in delivering the following products:

- identified priority areas for restoration;
- a shortlist of the most relevant, technically feasible and cost-effective restoration intervention types across the assessment area;
- quantified costs and benefits of each intervention type;
- estimated values of additional carbon sequestered by these intervention types;
- analyses of the finance and investment options for restoration in the assessment area; and
- a diagnostic of "restoration readiness" and strategies for addressing major policy and institutional bottlenecks.

By implementing ROAM, decision-makers and stakeholders can expect the following types of outcome:

- better information for improved land-use decision-making;
- high-level political support for FLR;
- fundamental inputs to national strategies on FLR, REDD+, adaptation and biodiversity, among others, and mutually reinforcing convergence and coherence among such strategies;
- a basis for the better allocation of resources in restoration programmes;
- the engagement of and collaboration among key policymakers and decision-makers in different sectors and other stakeholders with interests in how landscapes are managed; and
- shared understanding of FLR opportunities and the value of multifunctional landscapes.

Source: www.forestlandscaperestoration.org. For more information, contact: gpflr@iucn.org.

Land Degradation Assessment in Drylands

In close collaboration with the World Overview of Conservation Approaches and Technologies and country partners and with funding support from the Global Environment Facility, FAO developed a methodology for assessing land degradation and sustainable land management (SLM). The Land Degradation Assessment in Drylands methodology enables stakeholders to analyse relations between the causes and drivers of change, their impacts on land resources, ecosystems and livelihoods (status and trends), and land management responses at the national to local levels. The findings obtained through the methodology can be used to inform decisions on scaling up and mainstreaming SLM and the restoration of degraded landscapes by identifying hotspots and bright spots and generating knowledge on the effectiveness of SLM measures and relevant policy measures and technical strategies and interventions.

Local assessments at representative sites involving stakeholders provide in-depth case studies of the situations faced by diverse land users and local communities. These help in identifying appropriate response measures to support a shift to SLM, overcome bottlenecks to the adoption of SLM, and control the overexploitation of resources, including by external actors.

The methodology was developed with partners in Argentina, China, Cuba, Senegal, South Africa and Tunisia with a focus on drylands, although it has also been applied successfully in humid environments.

For more information, go to www.fao.org/nr/lada.

Collect Earth

An effective and continuous monitoring system for assessing forests and their dynamics in the context of drylands should be based on a sampling methodological approach that has

a multitemporal dimension and makes full use of remote sensing data. In the context of the Great Green Wall for the Sahara and the Sahel Initiative, FAO is building a monitoring system in collaboration with its partners using a multi-phase sampling design with the aim of synergistically combining satellite remote sensing and field data. The monitoring system will be able to track land use, land-use change, and changes in forestry, trees outside forests, and permanent and ephemeral water bodies.

For the analysis of the remote sensing data and to define a sampling field strategy, the Great Green Wall for the Sahara and the Sahel Initiative monitoring system is using a free, open-source application of the Open Foris Initiative called Collect Earth. Collect Earth is a tool that enables data collection through Google Earth and allows geo-links with Bing Maps and the Google Earth Engine. Data are collected through an area or point sampling approach, and satellite data are evaluated by visual interpretation. Collect Earth allows users to simultaneously visualize very-high-resolution satellite imagery and the entire Landsat satellite data archive. The Landsat archive is visualized and analysed through the Google Earth Engine, which allows the users to go back as far as 1975 and can provide high-resolution data at a monthly frequency dating from 2001. Collect Earth includes an open-source statistical tool, Saiku, which facilitates data aggregation, analysis and visualization.

In the Great Green Wall for the Sahara and the Sahel Initiative monitoring system, historical satellite data are being used to set up a baseline starting in 2001. In the future, full land assessments will be repeated every two years, and project results will be assessed relative to the historical baseline. Field data collection will be guided by the results of the remote sensing data analysis, and its scope will be to collect detailed biophysical land information and to add information on the socioeconomic dimensions of land use.

Sources: D. Mollicone and A. Pekkarinen, personal communications, 2014; www.openforis.org.

LANDSCAPE SCALE

Dryland landscapes are made up of a diversity of natural resources (e.g. trees, wildlife and water) and land uses (e.g. rangelands, agricultural lands, forests and urban areas) that together constitute a mosaic and which should be managed holistically. Forests and trees, in particular, play essential roles in many dryland landscapes, but their health and capacity to provide goods and environmental services are influenced by many external factors. The lack of intersectoral coordination often means that different institutions treat various components of land management separately, limiting their capacity to address the cross-sectoral drivers of degradation. Trees, forests and forestry, for example, are often dealt with in relative isolation of other landscape components or development sectors (FAO, 2012a); they are also often taken for granted, despite the essential goods and environmental services they provide. A landscape approach (Box 3.2) to management that integrates trees, forests and forestry with other land uses is most likely to produce sustainable outcomes.

The restoration and management of dryland forests and landscapes should be integrated with other priorities and processes (such as poverty-reduction

BOX 3.2

The landscape approach

The term "landscape" is used to refer to relatively large areas of land containing mosaics of land uses and abiotic, biotic and human elements. Agriculture, forestry, soil protection, water supply and distribution, biodiversity conservation, pasture and other land uses are interlinked but often dealt with in relative isolation of each other; natural resources are better managed, however, when viewed from a broader perspective. A landscape approach is an integrated approach that considers and involves the perspectives, needs and interests of all stakeholders, including local communities and individual land users. Its purpose is not to replace sectors or force them into a single approach but rather to reinforce them by increasing their interactions with other sectors with a view to conserving the integrity of landscape components. Landscape approaches are increasingly seen as indispensable in developing sustainable land-use and livelihood strategies in rural areas (FAO, 2012a).

Successful restoration is likely to be based on integrated and intersectoral land-use planning. This usually means:

- community-based landscape planning and decision-making;
- effective intersectoral cooperation and coordination among government agencies at the national, subnational and local levels;
- the strengthening of local institutions to better manage conflicts over land use and tenure; and
- improved policies for integrated management (e.g. agroforestry).

Restoration efforts should be planned as an integrated part of the mosaic of land uses in a landscape with the aim of re-establishing ecological integrity and supporting human well-being. In forest landscapes, planning should "focus on restoring forest functionality: that is the goods, services and ecological processes that forests can provide at the broader landscape level as opposed to solely promoting increased tree cover at a particular location" (Maginnis and Jackson, 2005).

Participatory landscape designing and visioning processes should be undertaken to obtain – through an equitable process of negotiation and dialogue – stakeholder agreement on the landscape mosaic of habitat types and land uses that are best suited to environmental and socioeconomic conditions.

Landscape approaches are people-centred: promoting integration among institutions is always challenging, but the best "integrators" are often rural people – who instinctively adopt landscape approaches to their land management.

strategies, land-use plans, infrastructure development and subsidy schemes). Creative mechanisms to secure collaboration among disparate ministries and institutions need to be found and applied to integrate and coordinate interventions in drylands (Mansourian, 2009) and to engage land users in restoration and sustainable land management (SLM).

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A mosaic of land uses within a landscape: fynbos, karroid shrublands, vineyards, pastures and forests in the Outeniqua Mountains, South Africa

Multisectoral platforms

Multisectoral platforms (Box 3.3) involve and facilitate dialogue among sectors and stakeholders, help in recognizing and understanding the logic, interests, motivations and strategies of economically weaker sectors, and enable such sectors to defend their interests through negotiated approaches. Multisectoral platforms can be developed at several levels of governance, including the local level, so as to protect local rights and institutions and promote the equitable participation of all actors, including marginalized groups and women.

Multisectoral platforms can be used for:

- raising awareness among policymakers and managers on the extent and negative impacts of dryland degradation, encouraging intersectoral approaches for addressing dryland degradation, and demonstrating restoration benefits and returns on investment; and
- identifying, understanding and addressing the drivers of land degradation, which are often socioeconomic and political in nature, involve competing land uses and sectors, and are linked to land-tenure issues.

Increasing the challenge, land degradation drivers often operate at a large scale (e.g. national and international) and at considerable distances (in space or time) from the actual incidence of degradation. Addressing such drivers requires collaboration among the forestry, rural development and conservation communities, government institutions, public, private and communal landowners, land users, land managers, industries, researchers, communities and consumers (Berrahmouni *et al.*, 2009). Only by understanding and removing the underlying socioeconomic, political and institutional causes that drive forest and land degradation will restoration efforts be successful, sustainable and capable of being scaled up.

A cross-sectoral approach was adopted successfully in Mali, where the gum arabic sector was used as an entry point for enhancing intersectoral links. Trade-related mechanisms enabled an increase in investment in the sector, boosting the

BOX 3.3

What are multisectoral platforms?

Multisectoral platforms (also called cross-sectoral platforms – the two terms are treated synonymously here) draw together stakeholder representatives from different sectors to discuss, inform, negotiate and otherwise contribute to policy development. Multisectoral platforms are convened to harness the benefits of collaboration in policy formulation and implementation on issues that span more than one sectoral jurisdiction. They differ from other dialogue processes in the degree to which members are able to go beyond networking to make commitments, resource those commitments, and hold each other accountable in coordinated responses. Multisectoral platforms can provide an ongoing mechanism for maintaining good communication among stakeholders. The need for such platforms has become increasingly urgent for the effective management of complex decision-making across landscapes; to avoid conflicting land-use policies and programmes as pressures continue to grow for access to forests, farmland, pastures, waterways, minerals and environmental services; to explore synergies among interest groups; and to encourage investment in sustainable development outcomes.

Source: deMarsh *et al.*, 2014.

sustainable management and restoration of gum-arabic producing landscapes (**case study 1**).

Existing multisectoral platforms, such as those established as part of country commitments to implementing the provisions of the Convention on Biological Diversity (CBD), the UNCCD and the United Nations Framework Convention on Climate Change (UNFCCC), may be used for this purpose, as well as to share information and views on the status of dryland forests and landscapes and restoration needs and opportunities.

Although government institutions still dominate multisectoral platforms in most developing countries, the participation of non-governmental and community-based organizations is increasingly encouraged as part of a trend towards decentralization and the devolution of responsibilities over natural resources. The various governmental institutions intervening in a given area usually have the same target stakeholders; it is important, therefore, that mechanisms are in place for permanent dialogue and coordination among such institutions.

By enhancing multisectoral cooperation, the new policy framework adopted in 1998 in the United Republic of Tanzania has enabled the development of sectoral policies and national development strategies that support forest restoration as a component of poverty eradication, livelihood improvement and environmental conservation (**case study 2**).

Communication

Communication strategies and activities are essential for raising awareness and

fostering engagement among sectors and for showing the value and benefits of forests and trees in landscapes, the costs of land degradation, and the potential returns on investments in restoration and SLM. Communicating successes and awarding champions at the local, national, regional and global levels creates a sense of pride in good works and helps incentivize and encourage those practitioners and decision-makers who are making positive changes in their environments through restoration to continue their work and to drive others to do the same in other landscapes, countries and regions.

Creating a network of champions in decision-making and practice helps draw attention to the challenges and importance of restoration. Awards already exist at the global level, such as the Collaborative Partnership on Forests' Wangari Maathai Award, launched in 2012, and the UNCCD's Land for Life Award. The latter, launched in 2011, recognizes efforts that promote the natural health and productivity of the earth's soils. Other such awards could be created in countries, districts, municipalities and villages to reward innovative and committed farmers, community groups, forest producer organizations (FPOs) and leaders.

3.3 ENABLING AND INVESTING IN CAPACITY ASSESSMENT AND DEVELOPMENT TO RESPOND TO RESTORATION NEEDS AND CHALLENGES

Capacity is "the ability of people, organizations and society as a whole to manage their affairs successfully. Capacity development is the process of unleashing, strengthening and maintaining such competency." This definition, based on the work of the Organisation for Economic Co-operation and Development (OECD), reflects the broadest possible consensus on the term within the international development community (FAO, 2010a).

The need for capacity should be assessed in terms of quality (e.g. competencies in given fields of expertise) and quantity (e.g. the critical mass of experts and other qualified actors needed, and their availability at the right moment for a given activity). In many countries, for example, there is an urgent need for more qualified practitioners who can deliver restoration competently and effectively. There is also a need for more competent staff to assist public and private organizers, farmers and other producers, communities and institutions in the design, planning, monitoring and implementation of the performance and impacts of restoration efforts. Moreover, there is a need to develop networks of communicators and opinion leaders (such as journalists, local leaders and civil-society organizations, including women's and youth groups) who can speak to policymakers and decision-makers (Clewell and Aronson, 2013).

Education in disciplines related to forestry, the environment and rural development should be reviewed and updated at the national and global levels with a view to preparing the next generation of dryland restoration professionals capable of addressing the wider context of degradation and restoration. The creation of field schools, including "green classes" (which involve field visits and special seminars for secondary school children) on dryland issues, would be beneficial; these, and the development of learning centres, are needed to ensure

that knowledge and technical assistance are available for restoration practitioners on the ground.

The required capacities should be identified – and planned for – at the outset of a restoration initiative, and the first step is capacity assessment. FAO capacity-development tools can be adapted and used for such assessments and also for planning capacity-development programmes. FAO supports countries in acquiring and using these tools in their own planning processes (Box 3.4).

3.4 SUPPORTING APPROACHES AND STRATEGIES FOR IMPROVING THE SUPPLY OF, AND ACCESS TO, PLANT REPRODUCTIVE MATERIAL FOR

BOX 3.4

Capacity development: at the core of restoration priorities

Capacity development involves three dimensions, as well as both technical and functional capacities.

The dimension of the **enabling environment** relates to political commitment and vision; policy, legal and economic frameworks; national public-sector budget allocations and processes; governance and power structures; incentives; and social norms.

The **organizational** dimension relates to public and private organizations, civil-society organizations, and networks of organizations in terms of their: strategic management functions, structures and relationships; operational capacity (processes, systems, procedures, sanctions, incentives and values); human and financial resources (policies, deployment and performance); knowledge and information resources; and infrastructure.

The **individual** dimension relates to the knowledge, skills (technical and managerial) and attitudes of the people involved in restoration. These can be addressed through facilitation, training and competency development.

Technical capacities are required in all the broad areas of restoration, from the development of tree-seed centres to ensure a sustained supply of high-quality seeds to the assessment of restoration needs and the enabling of national, subnational and local actors in carrying out the tasks required to intensify the restoration of degraded lands.

Functional capacities enable national, subnational and local institutions to plan, lead, manage and sustain improvements in restoration initiatives to ensure that technical knowhow is embodied in local systems and processes in a sustainable way. Such capacities include:

- *policy and normative* – capacities to formulate and implement policies and lead policy reform;
- *knowledge* – capacities to access, generate, manage and exchange information and knowledge, including the capacity to valorize scientific, traditional and local knowledge;
- *partnering* – capacities to engage in networks, alliances and partnerships; and
- *implementation* – management capacities to implement and deliver programmes and projects, from planning and budgeting to monitoring and evaluation.

An example of the application of FAO's tools for capacity assessment and planning

is the Great Green Wall for the Sahara and the Sahel Initiative, in which FAO has been working jointly with the African Union Commission, relevant countries and many other partners on the development and validation of a regional capacity-development strategy and action plan.[1] Related to this is the European Union–African, Caribbean and Pacific Group of States (ACP) project titled "Action against desertification", the specific objective of which is to improve the condition and productivity of agrosilvopastoral landscapes affected by desertification, land degradation and drought in ACP countries through the implementation of the Great Green Wall for the Sahara and the Sahel Initiative in six African countries. Other Caribbean and Pacific countries are using these country-assessment and planning tools to develop focused plans for enhancing the capacity of relevant governmental and non-governmental organizations and stakeholders in ACP countries to carry out effective cross-sectoral work in planning, financing, budgeting, implementation, monitoring and evaluating sustainable land and forest management and restoration efforts at the landscape scale.

[1] www.fao.org/in-action/action-against-desertification.

Sources: FAO Corporate Capacity Development Strategy and www.fao.org/capacity-development.

RESTORATION

A lack of sufficient quantities of high-quality plant reproductive material often constrains restoration programmes. Where planting is part of a restoration strategy, genetically appropriate material must be used, which means ensuring a sustainable supply. A key recommendation arising from *The state of the world's forest genetic resources* (FAO, 2014a) was the development and strengthening of national seed centres and programmes to ensure the availability of genetically appropriate seeds in the quantities and quality needed for restoration.

A first step might be to capitalize on existing regional expert networks on forest genetics by establishing regional advanced tree-seed centres. By facilitating the greater sharing of genetic materials, such centres could provide countries with considerable benefits.

Many developing countries have or are shifting towards the decentralized administration of natural resource management, with the potential to increase the equitable, direct access of local communities to plant reproductive material (FAO, 2014a). Technical structures such as farmer field schools and community-based or village tree nurseries that are close to communities and the field can facilitate the local supply and transfer of knowledge.

International certification schemes for forest reproductive material, such as those of the European Union and the OECD, have established rules for the handling of forest species that could be adapted to national and local circumstances.

3.5 IMPROVING THE GOVERNANCE AND POLICY FRAMEWORK

Developing enabling policies for restoration

To sustain restoration efforts, an adequate policy framework must be in place to encourage restoration and avoid perverse policies that drive degradation. A strong and appropriate set of policies is required that supports restoration and the equitable sharing of costs and benefits. Awareness among policymakers of the need for restoration and the policy settings required to achieve it is a prerequisite for developing an appropriate policy framework. Policies that favour unsustainable land uses (such as unsustainable agricultural practices, inappropriate water management, and land-use decisions that negatively affect forests and trees) must be replaced by regulations, incentives, institutions and planning processes that support sustainable and equitable land-use options and make drylands attractive for funding and investment, including from the private sector.

The findings of research and local knowledge on dryland values and management systems should be combined, demonstrated in the field by land users and learning networks, and, if successful, translated into policy-relevant formats. Policy formulation should be driven by a bottom-up approach informed by successful initiatives at the local level (Adeel *et al*., 2008). Local-level successes provide strong evidence for policymakers in creating enabling conditions and encourage the necessary allocations in national budgets.

In some countries, such as Kenya and Namibia, charcoal production is a main driver of forest degradation. The charcoal industry is characterized by "a complex, multilayered, and unclear regulatory framework for stakeholders". Although woodfuel production on farms can potentially be economically viable and sustainable for smallholder farmers, the lack of a framework of enabling policies is a barrier to the sustainable provision of woodfuel and charcoal (ICRAF, 2013) and leads to unsustainable forest use.

Policymakers should be aware of the following:

- the high costs of dryland degradation and the pressing need to arrest it;
- the benefits of taking timely action;
- the relevance of dryland restoration to development goals;
- the successful experiences of restoration efforts; and
- options for raising awareness on these issues (e.g. through stakeholder dialogues and greater intersectoral collaboration).

Underlying governance challenges are often overlooked in forest restoration projects and initiatives (Mansourian *et al*., 2014), yet poor governance is one of the root causes of degradation. Awareness needs to be raised among policymakers (at the local, national, regional and global levels) so that the values of dryland forests and trees are better understood, managed, promoted and integrated into relevant decision-making processes (Mansourian, 2009). Misconceptions need to be challenged; for example, senior policymakers often see drylands merely as unproductive wastelands. Attention should also be paid to the long-term costs of unsustainable land management practices.

Recognizing and protecting land tenure and land-use rights

A lack of recognition of local rights to access, use and manage natural resources reduces the commitment of land users to invest in SLM and restoration practices. Uncertainty about land-use rights and the distrust this generates can lead to conflicts and further degradation. Investments in time and resources need to be supported by guarantees that households own the products and other benefits they obtain through their use of the land.

A review of rehabilitation projects in sub-Saharan Africa (Blay, 2004) showed that most successful initiatives are conducted in a political and policy environment that provides a clear legal framework recognizing land ownership and/or usufruct rights for households.

Secure land tenure is fundamental to achieving SLM and improving livelihoods because it can be a major incentive for stakeholders to become engaged in and committed to long-term SLM efforts and investment. Proponents of restoration efforts should carefully assess the tenure situation before implementation. A valuable resource for this is FAO's *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests in the context of national food security* (FAO, 2012b), which provides guidance on the recognition, respect and safeguarding of legitimate tenure rights. The guidelines were developed through an inclusive consultation process followed by intergovernmental negotiations, and they received the high-level endorsement of the Committee on World Food Security in 2012.

FAO provides guidance and principles on tenure specific to the forest sector in *Reforming forest tenure: issues, principles and process* (FAO, 2011a). Key principles identified in this publication include human dignity and equity; gender equality; a holistic and sustainable approach; and consultation and participation to contribute to the responsible governance of tenure. The legitimate tenure rights of individuals and communities, including those with customary tenure systems, should be recognized, respected and protected on state-owned lands and forests.

Biocultural community protocols (Box 3.5) are an effort to bridge the gap between customary rights and national and international legal frameworks; they aim to enhance the capacities of communities to advocate for the recognition of their customary sustainable use of natural resources.

Strengthening forest producer organizations

Families, communities and indigenous peoples own or manage more than 30 percent of the world's forests, including in drylands. They have a demonstrated capacity to manage their forests sustainably and restore them but have received little policy attention from national governments and international agencies. A number of factors account for the long-term success of forest and landscape restoration by families, indigenous peoples and local communities. In all cases, however, FPOs have played central roles. FPOs are formal or informal associations of forest producers – women and men, smallholder families, indigenous peoples and local communities – who have strong relationships with forests and (often) farms in forested landscapes (deMarsh *et al.*, 2014).

BOX 3.5

Biocultural community protocols

The development of biocultural community protocols (BCPs) is an approach to enhancing local capacities for the implementation of international and national environmental laws at the local level. BCPs aim to bridge the gap between the customary management of biocultural resources (e.g. traditional knowledge of biodiversity management and sustainable livelihoods) and external management, as imposed by legal frameworks (such as international conventions, REDD+, and payments for environmental services).

BCPs are the outcomes of community-led processes that aim to reflect a community's key values, customary laws, ways of life and priorities; they are community-specific and locally appropriate. Based on such processes, communities are able to generate clear terms and conditions to regulate external access to their knowledge and resources. BCPs empower communities to engage with national and international laws in a nuanced and integrated way. Among other things, BCPs have helped enable the recognition of territorial sovereignty, community-based natural resource management systems, and sacred natural sites. They vary in the ways in which they are documented, shared and used. They are inclusive and driven by locally empowered communities, thus reducing the power asymmetries that can exist between communities and governments. BCPs are a meaningful tool for engaging with national and international processes, and they are often a strong source of pride in communities.

Source: www.unep.org/communityprotocols/PDF/communityprotocols.pdf.

Encouraging the establishment and successful development of FPOs should be a priority for governments wishing to promote sustainable forest management, forest and landscape restoration, and prosperous rural communities. The Forest and Farm Facility has developed a discussion and guidance paper exploring the factors that help build constructive relationships with government counterparts and the policy and institutional conditions that encourage or hinder the development of FPOs (**case study 3**).

Strengthening local institutions

On communal lands, only empowered community institutions are able to sustainably manage and restore land. In many places, such institutions have been weakened, however, and decentralization is needed to strengthen or create new community institutions and to provide them with policy and operational autonomy. Most importantly, decentralization processes also need to provide community institutions with sufficient capacity and resources to consolidate, become operational and be maintained in the long term. To successfully manage and restore land, community institutions must have the power to establish and enforce rules governing access to and use of the land. In cases where such rules exist for forests and rangelands at the national or subnational level, they need to be adapted to local realities.

In the semi-arid state of Haryana, India, a joint forest management approach has been used successfully in the management of common-property resources. With key support from the state forestry department, village-level organizations have developed local participatory and democratic processes to enhance the protection and management of forests and natural resources (**case study 4**).

Promoting the equitable participation of stakeholders

Lessons learned in recent decades on natural resource-based community development show that land degradation trends can only be reversed successfully with the participation of local actors. Local and national-level institutions must support local-level processes by providing technical and financial assistance and adequate governance structures and policies. Bottom-up and participatory decision-making processes should be encouraged, as well as social dialogue and partnerships among actors at a landscape scale. Negotiation and prioritization among actors and institutions should be promoted as a way of harmonizing diverse interests and finding common ground for land development strategies.

Power asymmetries, however, cause unequal access to and control over resources and information. Weaker or marginalized groups often lack the capacity to negotiate and protect their rights and livelihood choices, prioritize their needs and overcome constraints, thus preventing them from truly participating in local decision-making processes.

Disadvantaged actors, therefore, need to be empowered to voice their needs and concerns. Tools such as Participatory and Negotiated Territorial Development (developed by FAO) are available to help in reducing power asymmetries, facilitating the development of socially legitimized agreements, and involving all stakeholders. Such tools can help increase the commitment of disadvantaged actors, their ownership of the development process, and their capacity to negotiate on land development (Hatcher, 2009).

Participatory and Negotiated Territorial Development was used successfully to increase participation, planning and consensus-building capacity in four communities on the border of Ghana and Burkina Faso (Liniger *et al.*, 2011).

Empowering women

Women are greatly affected by land degradation. In most developing countries, they bear significant responsibilities and workloads in farm labour and household activities, and they often have low social status, lack access to productive assets (such as land, water, livestock, technologies and capital), and rarely participate directly in decision-making processes on an equal basis with men (although they may influence decision-making through their husbands, brothers or sons). Given appropriate opportunities, however, women have the creative and productive potential to be agents of change. For example, many development programmes, particularly in Africa, have demonstrated that women generally make more optimal use than men of investments at their disposal, and benefits are always shared with the family and the community. Women have also been shown to

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Direct sowing of herbaceous species under the guidance of a forester from the Tree Seed Centre in Bangaré, the Niger

generally be more reliable in their management of loans and equipment. A gender-sensitive enabling environment would provide women with equal access to the resources (such as power, rights, knowledge, productive assets and income) available to men in the same communities.

A number of global agreements, including the UNCCD, recognize the importance of gender mainstreaming. Special attention should be paid to (UNCCD, n.d.):

- *Knowledge* – women need better access to knowledge and educational opportunities, including through the strengthening of women's organizations. Priority should be given to the design of technologies that are relevant to women and which build on their existing knowledge. Illiteracy among women should be eliminated.
- *Rights, particularly land rights* – gender-sensitive land-ownership regimes should be promoted and women's land rights legalized.
- *Participation* – the direct involvement of women in decision-making should be promoted.
- *Access to micro-credits and loans* – many examples in developing countries have shown that when women's organizations and individuals are financially supported, significant benefits accrue to families and communities.

3.6 CREATING THE RIGHT CONDITIONS FOR INVESTMENT AND RESOURCE MOBILIZATION FOR RESTORATION

There is a large array of potential funding sources and investors in forest and landscape restoration: international institutions, governments, the private sector,

NGOs, and, most importantly, local communities and households. Due to a number of barriers, however, investments are still small compared with what is needed. A discussion paper prepared by FAO and the Global Mechanism of the UNCCD (FAO and GM-UNCCD, 2015, in preparation) provides an overview of the main types of funding sources, as well as approaches and opportunities for attracting and strengthening investment in forest and landscape restoration. Box 3.6 provides a non-exhaustive overview of the types of investors in, and funding sources for, restoration in drylands, drawing from that discussion paper.

Encouraging and supporting investment in restoration at the local level

It is important that land users and communities themselves invest in restoration to ensure a sense of local ownership of any initiative and to increase the likelihood that local people will earn sustainable outcomes from it. Appropriate and inclusive policies are needed to encourage such investment.

Individual land users often have limited resources; providing them with access to credit and market information may be necessary, therefore, to enable investment. If returns on investment are uncertain and realized only in the mid-to-long term, governments may need to provide land users with a certain level of financial support or other incentives to encourage them to commit their resources.

The decentralization and devolution of budget management to the local level may allow and encourage local authorities to invest in the restoration of degraded drylands. Their awareness of the benefits of restoration may also need to be raised, because local authorities are unlikely to allocate funding unless the benefits to communities and community members are significantly greater than the costs (of all types).

BOX 3.6

Potential funding sources and investors in dryland restoration

Local communities and households	Under the right conditions, farmers, landowners and communities will benefit from investing their own resources in the restoration of their own lands or community-managed lands at the local level. A reason for such investment would be to increase yields, the range of products, and income.
National budgets and national resources from finance ministries	Governments are important investors in restoration because many dryland areas are publicly owned and play important roles in the provision of social and environmental benefits. National budgets are channelled through national forest funds and national environmental funds. They can support projects in national programmes and strategies such as those on forestry, rural development, food security and poverty alleviation. Budgetary aid and debt conversion from donors might also be used to initiate large-scale restoration policies and programmes.

Non-governmental funding	Non-government sources of funding include non-governmental organizations (NGOs) and philanthropic foundations such as the World Resources Institute, the International Union for Conservation of Nature, Conservation International, WWF, and the Bill and Melinda Gates Foundation. Community-based organizations and other local and national NGOs can play key roles in mobilizing funds for restoration and in channelling resources to local communities and their restoration actions.
Climate financing instruments	Restoration in drylands can make a significant contribution to climate-change mitigation and adaptation. Many climate-related financial instruments, such as the Green Climate Fund, are putting forests and restoration at the centre of efforts to address climate change.
Development banks (loans and grants)	Development banks that might invest in restoration initiatives in drylands include the World Bank (including the "Green Bonds" initiative), the International Finance Corporation, bilateral development banks, the French Agency for Development, the KfW Development Bank, the African Development Bank, and the European Investment Bank's Natural Capital Financing Facility.
Environmental funds	Environmental funds are key financing instruments for forest and landscape restoration; they differ in funding source (e.g. private, public, national or international), the type of investment (including its scale) and geographical scope (e.g. multilateral, such as the Global Environment Facility, or bilateral, such as the French Facility for the Global Environment).
Private investors	Some private investors may expect direct financial returns on their investment, but others may not; corporate social responsibility is often the rationale for the latter.
Non-traditional or innovative funding	Dryland forests provide a large number of environmental services, such as water regulation, biodiversity conservation and carbon sequestration, for which markets may be lacking. Crowd-sourcing is gaining in popularity as an innovative funding mechanism that could be used to support forest and landscape restoration initiatives.

Source: FAO, GM-UNCCD (2015, in preparation).

Multistakeholder engagement, including communities and the private sector, may contribute to long-term financial sustainability. Equitable and productive company–community partnerships can have strategic value for investors beyond typical corporate social responsibility goals.

Many successful restoration initiatives have demonstrated the advantages of equitably sharing benefits and costs with local actors, which also helps empower local communities. In a community resource management project in the drylands of Kenya, one reason for success is the cost-sharing strategy adopted by the project. The financial and in-kind contributions of the local community are planned to increase over time in conjunction with the revenue generated, thus enhancing the sustainability of activities (Blay, 2004).

Promoting simple and inexpensive technologies that directly support livelihoods

Farmers and landowners are sometimes unable to afford the cost of improved land preparation techniques and equipment (for example to improve the delivery of water to seedlings), thereby limiting their use. Some water-saving techniques may be efficient but cost-prohibitive. A lesson learned from many case studies is that simple, inexpensive technologies are most likely to be successful because they are easier for land users to adopt and financially more accessible. Such technologies should therefore be promoted as a priority.

Successful projects are often those that local communities perceive as having the potential to generate direct benefits for their livelihoods in the short term – such as the production of wood and non-wood products for use or sale.

Supporting small and medium-sized enterprises: making business with restoration

Economic and financial viability is a necessary condition for all stakeholders if they are to invest in and allocate sufficient resources for restoration and sustainable management. Improving the income opportunities arising from forest production is one way of providing incentives for local stakeholders to participate in restoration and management (ITTO, 2002). Small-scale tree and forest product enterprises can support livelihoods by broadening local income opportunities.

It is important, however, that such enterprises integrate environmental sustainability, economic viability and social sustainability and provide equitable, gender-balanced benefits. A tool designed to assist in such integration is Market Analysis and Development (MA&D),[5] which FAO developed as a participatory training approach to assist local people in developing income-generating enterprises while conserving tree and forest resources. The planning of restoration and management activities should be linked to or integrated with business planning. For example, species to be used in restoration should have commercially important traits or help improve household productivity.

The development of small and medium-sized enterprises can be facilitated by microloans, which have been shown to lead to rises in family income in rural areas

5 www.fao.org/forestry/enterprises/25492/en.

(FAO, 2013a), as well as by supportive structures such as networks of producers and buyers and certification schemes.

Mainstreaming restoration into existing social practices

Land restoration is achieved through social as well as technical means. In Burkina Faso and many other Sahelian countries, existing traditional social networks offer farmers informal and often non-monetary solutions to their soil and water conservation needs (Mazzucato *et al*., 2001). Even if farmers master a wide range of soil- and water-conserving techniques, they sometimes lack the resources, such as land and labour, to deploy those techniques. For a variety of reasons, traditional forms of reciprocal and mutual work have been partially or completely abandoned in many areas. Interventions can therefore work to broaden the scope and scale of social networks and facilitate exchanges as well as non-market channels, with the aim of encouraging the rekindling of traditional social networks that can provide the resources needed to carry out restoration without imposing unaffordable costs on local communities.

Promoting payments for environmental services

Payments for environmental services (PES) are voluntary contracts under which the users of an environmental service (who may be direct beneficiaries or consumers, or taxpayers and the general public via a public administration) make payments to the providers of that service, conditional on the continuous provision of the service. By contributing to a governance context that favours restoration (Mansourian *et al*., 2014) and innovative practices, PES schemes show potential for promoting rural development.

In general, access to international financial mechanisms and payments for forest environmental services seem to be constrained by the complexity of rules, an absence of standards, uncertainty over long-term sustainability, price fluctuations, and high transaction costs (FAO, 2012d). One of the most important conditions for efficient PES schemes is their targeting areas where there are real opportunities for improving the delivery of environmental services or where environmental threats would occur in the absence of PES (Prokofieva, Wunder and Vidale, 2012). Two other conditions for success are that: 1) there must be sufficient demand for the environmental service and thus a willingness to pay; and 2) the cost of the restoration activity must either be lower than the cost of an alternative method that achieves the same results, or the (environmental or social) co-benefits of the restoration option must be sufficiently attractive. An example of PES is ecotourism. The high rate of endemic biodiversity in drylands and their human and cultural diversity (Davies *et al*., 2012) offer considerable potential for the development of ecotourism in protected areas. Income can be generated directly by visitors, for example through payments for the right to enter an area and observe wildlife, or indirectly, through levies imposed on tourism-related enterprises. Part of the income earned by such measures would be used for the sustainable management and conservation of the area.

In Bandia, Senegal, a private wildlife safari reserve was created in a severely degraded area. It now generates substantial income, some of which is reinvested in the management and conservation of the area and in neighbouring communities through employment, the payment of rent and taxes, and infrastructure development (**case study 5**).

3.7 KNOWLEDGE, RESEARCH, LEARNING AND EXPERIMENTING

Learning is a process that can induce permanent change; it is therefore important that restoration initiatives assist stakeholders in acquiring relevant new knowledge, skills, behaviours and values. Developing collaborative and adaptive learning and experimenting processes based on traditional knowledge and innovative research, and promoting the sharing of knowledge among land users, are keys for successful restoration.

Restoration initiatives should include actions to ensure the sustainability of capacity-development processes, including individual learning processes. Sustainability can be achieved through a variety of means, such as (FAO, 2010a):

- the ownership and involvement of local stakeholders in the design, implementation and monitoring of restoration interventions; and
- the institutionalization of results and processes by integrating new knowledge and practices into the curricula of educational institutions.

Learning collaboratively and through experience

Adaptive and collaborative management through learning and experimentation helps build resilience in socioecological systems (Simonsen *et al.*, 2014). Learning by doing and testing alternative management approaches are integral parts of adaptive management: they allow farmers to increase their knowledge and problem-solving and decision-making capacities and help prepare them for unexpected change.

Learning should be a collaborative process. Knowledge can be shared among actors (e.g. communities, technicians, policymakers, researchers, NGOs and private enterprises) through a variety of means, such as field visits, learning centres, farmer field schools, cross-visits and learning platforms. Knowledge-sharing helps actors to jointly overcome problems in restoration. It can also encourage researchers to incorporate local cultural and economic perspectives in their research and to adapt their language and tools to local cultural contexts. Learning should preferably be carried out in mixed groups of farmers (e.g. farmers and pastoralists) to increase awareness of the interdependencies and interlinkages among them. The African proverb, "What is done together is always more valuable than what is done alone," is highly applicable to dryland restoration learning.

Various learning platforms have been shown to be effective, such as farmer field schools, which are an approach aimed at encouraging innovation and the sharing of knowledge and experience among farmers, researchers and extension workers in West Africa (Liniger *et al.*, 2011). Another example is the social forestry extension model used in the restoration of degraded woodlands in south and southeast Kenya (Adeel *et al.*, 2008).

Building on local needs, traditional knowledge and innovative research to ensure sustainability

Traditional and indigenous knowledge and techniques for soil and water conservation have evolved over time as farmers have adapted and experimented within the limits of available resources and the specific conditions of dryland environments. This knowledge should be understood, valued and integrated as a key tool for addressing land degradation as well as a way of increasing local engagement.

New materials and innovative techniques may be able to enhance the effectiveness of traditional practices. Applied research that combines modern science and the traditional knowledge of land users on soil and water management and the ecology and management of native species is a success factor in dryland restoration. Technologies that build on traditional practices and knowledge and are therefore adapted to the local context are most likely to be adopted and to have meaningful impact. Applied research has proved successful when linked to real income-generating activities because it provides land users with a concrete incentive to take part in sustainable practices.

Dryland research programmes must be guided by realities on the ground and take into account the needs of local communities; they must be planned and implemented in close collaboration with all stakeholders. To ensure effective collaboration and efficient follow-up, scientific and technical terms should be translated into simple language that is understandable to all parties.

Participatory technology development was used to implement SLM in olive orchards in the Syrian Arab Republic by creating a dialogue between farmers and researchers. The farmers' priorities were put first, thus allowing improved techniques to be tested and adopted successfully (**case study 6**).

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Farmer field school – farmers attending a weekly training session in Thiaye, Senegal

As part of their support for the Great Green Wall for the Sahara and the Sahel Initiative in four border regions in Burkina Faso, Mali and the Niger, FAO, the Royal Botanic Gardens, Kew, and other partners are engaging with local communities in the identification of priority native species that meet local needs and are also well adapted to dryland ecosystems. So far, 110 communities have been supported, and over 1 million seedlings of 50 useful native woody and herbaceous species have been used to restore over 1 000 ha of degraded lands (Sacande, Berrahmouni and Hargreaves, 2015).

4 Guidelines for practitioners: restoration in action

Practitioners are the doers of restoration, and this chapter provides guidance for them on the actions they should consider in restoration initiatives. Before taking action on the ground, practitioners should support facilitated processes for the formulation of restoration goals and interventions that address the needs of all stakeholders. Cost-effective strategies should be chosen and implemented collaboratively with relevant stakeholders. Practitioners should consider a range of restoration actions, from protection and management, to ANR, to planting.

4.1 PLANNING AND CHOOSING THE MOST COST-EFFECTIVE RESTORATION STRATEGY

Defining sustainable restoration goals

Fundamental questions in the restoration of dryland landscapes are *why*, *where* and *how* to act? Ideally, efforts should aim to "set an ecosystem on a trajectory toward the recovery of species and ecosystem functions, recognizing the impossibility [of achieving] a highly fixed end point due to the dynamic nature and extensive natural variability of ecosystems, the intrinsic limitations arising from the state of degradation, and the cultural factors that have intervened in the configuration of the desired state" (Aronson *et al.*, 2007). The identification of priority areas for restoration depends on the objective(s) of the intervention, which may include, for example, reducing soil erosion; increasing vegetation cover and species diversity; improving livelihoods; and increasing commercial production. Different objectives may result in the selection of different sites, approaches, species and restoration interventions. Restoration activities with multiple ecological, economic, social and cultural objectives often require trade-offs to balance socioeconomic demands and environmental outcomes (Clewell, Rieger and Munro, 2000). A landscape planning approach is therefore required, as described in Chapter 2.

Promoting equitable multistakeholder participation while planning

Tremendous efforts were made in the 1980s and 1990s in many parts of sub-Saharan Africa to encourage participation, especially in the Sahelian countries. Strategies evolved from "involving" local communities in centrally decided and planned programmes to "consulting" such communities and "associating" them at earlier stages of the process. The "devolution" of responsibilities has since been promoted but is still ineffective in many countries. The insufficient participation of local actors has been an important constraint in a number of dryland restoration initiatives in sub-Saharan Africa (Blay, 2004).

Traditional local governance entities and community-based organizations can be efficient in empowering local actors in the sustainable management of natural resources, and all stakeholders should be involved in the planning process to ensure that solutions are relevant and context-specific. The costs and benefits, and the roles and responsibilities of each stakeholder, should be identified clearly in the planning phase.

When local communities already have or are given responsibilities from the planning phase, they usually have increased access to and control over resources and related decision-making, which supports the development of sustainable livelihoods. Genuinely participatory approaches create a sense of joint ownership of decisions and actions and increase the commitment of stakeholders to the objectives and outcomes of initiatives. A variety of tools is available to facilitate such approaches, such as participatory rural appraisal, community mapping, and community-based monitoring.[6]

Conducting baseline assessments and studies

A baseline study describing the existing situation is needed before a landscape restoration intervention commences. Such a study should identify the barriers to SLM and the direct and indirect causes of land degradation, thereby assisting in the formulation of restoration objectives and priorities. In particular, the direct causes of degradation should be assessed for the extent to which they constitute threats to the implementation of restoration activities.

The baseline is also intended to provide initial values for indicators, which form the basis of credible monitoring and assessment. The selection of indicators during the planning phase allows the evaluation of the results and outcomes of a project.

A baseline study generally involves the analysis and overlaying of multiple sets of data in light of the specific objectives and intended stakeholders of a prospective restoration investment (Newton and Tejedor, 2011). The following types of assessment are likely to be carried out:

- *biophysical data* – e.g. land cover, geomorphology, soil properties (including water infiltration and erosion) and climate (including climate scenarios and projected climate-change-related disturbances);
- *ecological data* – e.g. species information, inventories, genetic diversity, distribution maps, ecological processes and environmental services;
- *socioeconomic data* – e.g. demographic variables (such as age and household size), living standards, livelihood strategies, ability to adapt, social environments, and gender relations (i.e. gender analysis); and
- *capacities* – e.g. stakeholder mapping and analysis, the enabling environment (especially the legal context for land rights), individual skills and capacities, organizational processes and systems, and behaviours.

Using reference sites

Landscapes in drylands are often highly modified. In a number of denuded landscapes in African and Asian drylands (and elsewhere), however, pockets of

6 See, for example, the tools described in FAO (2009).

natural vegetation remain protected from degradation (e.g. in "sacred groves") (Bhagwat and Rutte, 2006). A scientific understanding of these ecosystems is a good starting point in designing strategies for restoring degraded landscapes; if protected sites show little or no degradation, a high level of biodiversity and functionality and therefore resilience, and are located in similar biophysical conditions to those of the target site, they may be used as reference ecosystems and as models for the planning and evaluation of ecological restoration (Le Floc'h and Aronson, 2013). In other words, the restored ecosystem is expected to eventually emulate the attributes and species composition of the reference site(s), and the goals and strategies of the restoration project should be developed largely in light of that expectation.

Deciding on the most cost-effective restoration strategy

Diverse restoration strategies should be promoted, and planting is often only one of several possible activities (see Box 4.1). In many cases, the restoration of forests and other degraded lands in drylands requires a combination of protection and management actions. Protection measures may include avoiding further erosion and safeguarding existing vegetation and restored areas from threats such as damaging fires and uncontrolled grazing, both of which require an integrated management approach. Other simple interventions that can facilitate natural revegetation may be effective in the early stages of restoration, and, if communities are mobilized, they can also be low-cost, rapid and scalable (see section 4.3 below on ANR).

The need for seeding or planting should be assessed carefully; if the extent of degradation is relatively low, it may be desirable to first monitor the results of protection and other management interventions. It may be that restoration actions such as protecting a site from grazing, assisting natural regeneration, and undertaking enrichment planting are sufficient, with a substantial reduction in costs and limited site alteration compared with what might be required in a planting programme.

In a restoration project in the dryland mountains of Armenia, Azerbaijan and Georgia, optimal restoration strategies were chosen and developed through a step-by-step approach involving protection, site preparation, maintenance, regeneration and planting. A key lesson learned was the importance of making maximum use of natural regeneration (**case study 7**).

If planting is deemed necessary, planting locations should be chosen carefully. There may be hotspots in the landscape (e.g. where runoff occurs) where appropriate species, if planted, will have an optimal impact on degradation (and can then spread by natural means), thus reducing costs (Hooke *et al*., 2007).

An ecosystem restoration programme in the Shouf Biosphere Reserve of Lebanon aims to build "disturbance-smart" landscapes. Restoration will be implemented through the adoption of a wide variety of approaches, including planting (direct sowing and the planting of seedlings), rehabilitating old abandoned terraces, and fencing plots in overgrazed areas (**case study 8**).

BOX 4.1

Overview of the main restoration approaches in drylands

Type of approach	Goal	Common measures
Protection and management (see section 4.2)	To protect against potential threats and prevent further degradation, and to remove barriers to natural forest regeneration	Protection of soils against erosion (see Box 4.2) Grazing management Fire management
Assisted natural regeneration (see section 4.3)	Enhance the natural processes to regenerate tree and vegetation cover	Enhancing seed dispersal Farmer-managed natural regeneration
Planting (see section 4.4)	Planting trees, shrubs and herbaceous species, and ensuring their survival and growth	Species selection Production of planting material Site preparation Planting Silvicultural operations

4.2 PROTECTING AND MANAGING DRYLANDS

Using management plans

Management (as opposed to uncontrolled access to and use of forest and other wooded lands) should be promoted and implemented as a priority with the aim of facilitating the expansion, regeneration, growth and functional utility of forests and trees and the human activities essential for conservation and sustainable development in drylands (FAO, 2010b). Management plans can address the threats to and pressures on natural resources while also facilitating access to the many benefits of those resources.

It is important, however, to avoid overly detailed management plans, which by imposing unnecessarily onerous demands can act as a barrier for rural communities. Prescriptive legal requirements, time-consuming and inflexible registration processes, and complex management plan formats, when imposed as a prerequisite for community-based management, limit opportunities for local users to make real management choices reflecting their unique needs and conditions. Simple management planning approaches that fit local needs and capacities have already been used successfully and should be encouraged (FAO, 2004).

Protecting against soil erosion

Soil management is essential for preventing erosion and maintaining fertility. Soil

erosion is one of the main threats to drylands worldwide, and protecting soils from additional water and wind erosion is often a critical first step in restoration (Bainbridge, 2007). Soil fertility can also be maintained through measures that conserve soil organic matter and recycle nutrients. Box 4.2 provides an overview of important techniques used in soil and soil-fertility conservation, and Box 4.4 describes additional microcatchment techniques for conserving water (and protecting soils from water erosion).

In the Bagmati River Basin in Nepal, landscapes have been restored through integrated watershed management to address landslips, gully formation and streambank erosion. A combination of mechanical barriers and vegetative measures was used to control erosion and improve soil fertility (**case study 9**).

In the Anatolia region of Turkey, as well as in the China Loess Plateau, watersheds were protected from soil erosion through an integrated approach combining afforestation and enhanced agricultural and grazing practices (**case studies 10 and 11**).

BOX 4.2

Conserving soil and soil fertility

Controlling wind erosion	Wind erosion is caused by winds blowing over large areas with stunted or sparse vegetation and sandy or degraded soils that are mobile, bare and dry. The finer particles are blown into the atmosphere, contributing to sandstorms or "dry mist" (as it is called in the Sahel); when stopped by obstacles, medium-sized and large particles contribute to dune formation. The fundamental principle of dune fixation – one of the main measures for reducing sand and dust erosion caused by wind – is to use natural or planted vegetation or mechanical barriers to prevent sand from moving while other vegetation establishes. Two types of fixation can be distinguished (FAO, 2011b): • Primary fixation – the mechanical stabilization of sand masses by slowing their speed and movement or preventing the formation of such masses. Primary fixation can also be achieved by placing vegetative debris on dunes. • Biological fixation – the installation and protection of permanent vegetation cover by sowing grass or planting tree seedlings. **(Case studies 12 and 13)**

Conserving soil fertility	Soil fertility can be managed through a variety of means, such as the integration of leguminous trees and plant species in farming systems; composting; and the minimization of burning. A simple and efficient practice is "Yaaram Saas" employed by the Serer community in the Groundnut Basin of Senegal: this community actively protects the *Acacia albida* seedlings disseminated by cattle dung. A density of 50 *A. albida* per ha provides a fertilizing equivalent of 50 tonnes per ha of manure. Millet and groundnut yields on these soils are over 50 percent higher than on other croplands (CIRAD-CTFT, 1989). The application of organic amendments such as sewage sludge has been used widely in agriculture and commercial forestry as a way of improving soil fertility and water availability, promoting biological activity and facilitating seedling establishment. Another treatment that promotes growth is the incorporation of fresh organic waste (rather than composted waste) into plantation furrows (mixed with seeds) rather than spreading it as a layer on the surface. This is a common practice in agroforestry in sub-Saharan Africa.
Controlling erosion caused by rainfall	Rainfall in degraded drylands can cause various types of erosion, such as sheet, rill and gully, the latter being the most severe. This can have drastic direct consequences by reducing soil fertility, the area of arable land and groundwater recharge. Erosion caused by rainfall can also have negative downstream impacts on dams, waterways and the hydrological regime. The key to controlling erosion caused by rainfall is to reduce the velocity and volume of runoff. This can be done by increasing vegetation cover and establishing permanently vegetated contour bunds (biological method), and by the use of cross-slope barriers, such as tied ridging on contours (mechanical method).
Using vegetative strips in farmland	The establishment of strips of unploughed land, on which trees, shrubs and grasses form permanent, often cross-slope barriers to slow runoff, is an effective measure for improving water infiltration, preventing wind desiccation and erosion, limiting the loss of soil nutrients, creating microclimatic conditions conducive to further vegetation growth, and enhancing biodiversity in croplands. Such strips do not compete greatly with crops, and they may produce valuable products. Establishing natural vegetative strips usually involves only low-cost techniques and minimal labour.

Installing a palisade, mechanical dune stabilization, Mauritania

Using sustainable grazing management practices

Unplanned grazing can damage vegetation and cause land degradation. Grazing management is crucial, therefore, in dryland ecosystems; it involves an iterative and adaptive process for determining grazing strategies, mainly because the timing and distribution of rainfall can be highly variable in drylands. The continuous monitoring of livestock productivity and range condition and productivity, and learning from experience and practice, can help ensure appropriate grazing management responses to changing climatic and socioeconomic circumstances (Neely, Bunning and Wilkes, 2009).

Sustainable grazing management requires an assessment of the appropriate numbers and types of stock for a given grazing area. The best management practices for livestock grazing are highly context-specific and should be carefully matched with the landscape under management and the vegetation dynamics of the area. The rotation of grazing areas is likely to be necessary to avoid overgrazing in a given area and to enable regrowth of the vegetation in fallow areas.

In devising grazing management strategies as tools for improving degraded lands, land users should be aware of the following (Savory, 1999):

- Controlled grazing can generate a more even distribution of dung and urine, which can enhance soil organic matter and nutrients and increase plant productivity.
- Overgrazing is a function of time (grazing and recovery) and not of absolute animal numbers. Unmanaged grazing, and sometimes the complete exclusion of grazing (in grasslands that need grazers as part of their ecological cycles), can lead to degradation.
- Land and plants respond differently to different management tools, depending on the distribution of moisture throughout the year.

Actions that can help in managing livestock pressure include:

- controlling water points (e.g. closing them in overgrazed areas); and
- using community institutions and governance to control grazing (e.g. tribal leaders or community committees make decisions on who can graze where and on the areas where grazing needs to be discontinued).

If well controlled, grazing can be used as a management tool to enhance the vigour of mature perennial grasses by increasing their longevity and promoting the fragmentation of decaying, over-mature plants by encouraging basal bud activation, new vegetative and reproductive tiller formation, and seed and seedling production. The positive impacts of grazing arise from the effects it has on species composition and litter accumulation (Neely, Bunning and Wilkes, 2009). In some agrosilvopastoral systems, trees are pruned and pods collected for feeding cattle and small ruminants. The daily movement of animals in cropping land helps fertilize fields with dung and vegetal debris. This system also enables the natural regeneration of most tree species suitable for soil improvement and animal browsing.

The Ecograze grazing management system in northern Australia uses a combination of wet-season resting and rotations. It reduces soil erosion and increases pasture productivity and grass biodiversity (**case study 14**).

In some regions, rangelands are burned to replace old dry grass with re-sprouting young grasses that are more palatable to livestock. These fires can be damaging, however, and improved grazing schemes might help in avoiding the production of dry long grasses, thus minimizing the need for fire.

BOX 4.3

The Pastoralist Knowledge Hub[1]

The Pastoralist Knowledge Hub is formed by pastoralist alliances and networks that wish to join global policy dialogues and share their knowledge and views, and by international partners that wish to incorporate pastoralist voices in their discussions and share the technical knowledge they have gathered on pastoralism.

The Hub is hosted by FAO and combines the Organization's expertise in livestock production with its knowledge on civil society and indigenous peoples.

The objective of the Pastoralist Knowledge Hub is to fill the gaps identified in past years, especially the lack of global policy discussions on pastoralism and the need to bring attention to the challenges faced by pastoral communities. By systematizing information, literature and knowledge as well as technical tools, assessments and research results, the Hub aims to better inform evidence-based decision-making at all levels. Through its three pillars – knowledge repository, forum for pastoralist networks, and fostering alliances among key partners – the Pastoralist Knowledge Hub acts as a bridge between pastoralist communities and policymakers with the objective of incorporating pastoral issues into key policy discussions.

1 Available at: www.fao.org/pastoralist-knowledge-hub.

The International Institute for Environment and Development[7] has noted that national policies seeking to settle traditional pastoral communities and turn them into "modern" livestock keepers constrain their livelihoods and production. Many pastoralist groups are also traditional warriors and have taken up arms as a result of political and economic marginalization. Conversely, pastoralists have become victims of war and famine, leading to their displacement and impoverishment (e.g. when their herds become the targets of hungry soldiers). Many pastoralist groups pose challenges for policymakers because of their transnational status. FAO and partners have supported the establishment of the Pastoralist Knowledge Hub (Box 4.3) with the aim of promoting mobilization, advocacy and policy dialogue as well as the compilation and improvement of knowledge on pastoral systems and the provision of technical tools and innovations to improve pastoral livelihoods and resource management.

Using integrated fire management

An observed increased frequency of fires in drylands is likely due to a number of factors, such as population pressure, the vulnerability of agricultural lands, climate change, and the increased frequency of drought. Fire can damage ecosystems, have negative impacts on human livelihoods and safety, and cause greenhouse-gas emissions. On the other hand, humans have long used fire as a land management tool. In drylands, fire can be used in ecosystem management in a variety of ways, ranging from traditional burning practices to highly specialized modern techniques. The frequency, location and intensity of fire have implications for biodiversity in some ecosystems (e.g. subtropical savannahs and grasslands). A lack of appropriate land management, however, may lead to the accumulation of fuels (and consequent high-intensity fires) and homogenous or fire-prone landscapes.

Fire management should be part of an integrated land management strategy. Integrated fire management is a concept that addresses all dimensions (policy, social, economic, cultural and ecological) with the objective of minimizing the damage and maximizing the benefits of fire. It is now widely recognized that short-term and reactive fire-control policies should give way to long-term policies that address the structural causes of fire and integrate fire with land-management strategies. FAO and its partners developed voluntary guidelines on fire management (FAO, 2006), which set out a framework of priority principles to aid the formulation of policy-related, legal and regulatory approaches to integrated fire management.

In Lebanon, the government approved a National Forest Fire Management Strategy in May 2009 with the aim of reducing the risk of intense and frequent forest fires while allowing for fire regimes that are socially, economically and ecologically sustainable (**case study 15**).

Alternatives to the use of fire can decrease its negative impacts, but there may also be situations where fire is the best option. Particular focus should be

7 www.iied.org/misconceptions-drylands-pastoralism.

on the responsible use of fire through an understanding of traditional fire use, a reinforcement of the use of prescribed and controlled burning, and the use of suppression fire as an additional tool in fire-fighting (Rego *et al.*, 2010).

Restoration strategies in fire-prone ecosystems should favour plant communities and management schemes that are adapted to prevailing conditions and expected future disturbance regimes with a view to ensuring the sustainability of the restored lands in the face of global change. The prospects for decreasing the incidence of fire under climate change may be low. Accordingly, fire management should aim to reduce the severity of damage caused by fire to landscapes through, for example, area-wide fuel treatments and fuel-type conversions (preferably to fire-resilient vegetation types, regardless of their flammability) rather than by fuel isolation (Fernandes, 2013).

4.3 ASSISTED NATURAL REGENERATION

ANR involves the deliberate protection of degraded land from pressures to enhance and accelerate natural processes of forest succession with the aim of re-establishing healthy, resilient and productive ecosystems. It is usually cheaper and more efficient to promote natural regeneration rather than to plant seedlings or pursue other revegetation strategies – provided there are mature and healthy seed trees in or close to the restoration area. Depending on the tree species, the closest seed trees should be no more than 50–100 m from the restoration area (Heidelberg *et al.*, 2011). The protection and use of stump shoots, when available, can also help support restoration activities.

The ANR process usually takes at least three years and up to 20 years, depending on the intensity of degradation, the soil conditions, the species used, and the availability of seeds (Blay, 2004), and also on the rainfall during the period of restoration.

However, ANR may be difficult to implement because of pressures from other land uses, especially in highly populated areas. Uncontrolled grazing can have a major influence; in some cases, the temporary exclusion of animal grazing can achieve excellent results in the rapid recovery of the former vegetation and soil quality. It should be noted that some animals such as small ruminants (e.g. goats and sheep) can compromise natural regeneration by browsing the seedlings and sprouts, but cattle can have positive impacts by eating the grass, thus reducing competition for water, and by contributing to soil fertilization with their dung.

In the Tigray region of Ethiopia, exclosures have been used for the last two decades and have allowed the restoration of significant areas of degraded land (**case study 16**).

The presence of wild or domestic animal species such as birds and cattle can sometimes help accelerate the propagation of seeds and boost the growth of natural vegetation. Some communities in West Africa (e.g. in the Niger and Senegal), for example, have centuries of traditional experience in combining cattle breeding with the natural regeneration of agroforestry parklands.

Farmer-managed natural regeneration (FMNR) is the practice of "actively managing and protecting non-planted trees and shrubs with the goal of increasing the value or quantity of woody vegetation on farmland" (Haglund *et al.*, 2011). In FMNR, farmers usually select the healthiest, tallest and straightest stems of native trees and shrubs sprouting from stumps or roots on ploughed and grazed land, which they then protect. They remove unwanted stems and side branches to reduce water competition and facilitate the growth of selected stems, while at the same time quickly producing woodfuel and fodder. FMNR may also involve protecting and managing seedlings growing spontaneously from seedbanks in the soil and contained in livestock manure and bird droppings. The planting of seedlings may be incorporated into FMNR management practice to enrich existing vegetation, especially when coppicing stems are sparse and the soil seedbank is poor.

The only costs associated with FMNR are the time it takes farmers to protect and prune the regrowth and those associated with promoting and teaching FMNR practices (where this is necessary). FMNR is simple to implement and can be scaled up quickly, provided that latent seeds and living tree stumps and roots are present at the site.

Although FMNR is practised in Burkina Faso, Mali and Senegal, the Maradi region of the Niger has the longest history of its promotion and practice (**case study 17**; see also Buffle and Reij, 2012). A remarkable reversal in forest decline has been observed in the region, covering 42 000 km^2. The practice has increased the yield and diversity of crops, the diversity and density of farmland trees, and household income, and it has improved and diversified livelihoods. Greater socioecological resilience has also been observed in the Maradi and Zinder regions, where FMNR is most entrenched, than elsewhere in the Niger.

A key lesson gained from diverse experiences in FMNR is that property rights to trees are essential if farmers and communities are to protect them. Equally important is the need to transfer land rights and authority to local communities to enable them to access and use the natural resources they are protecting (GM-UNCCD, 2008; Buffle and Reij, 2012).

4.4 PLANTING

Establishing planted forests is a commonly used approach for restoring degraded lands. Planted forests managed for the production of wood or NWFPs can help communities raise their standard of living and contribute to sustainable development (FAO, 2010c); if poorly designed and managed, however, planted forests can have negative impacts on people, the environment and biodiversity. It is important, therefore, to adequately plan any planting scheme.

Selecting the right species for the right place

In choosing species, the following criteria should be applied:

- *Social preference* – restoration involving tree-planting is most likely to be successful if species are selected according to local preferences. Well-known species (including their management, uses and marketing) are usually

preferred. A consideration of cultural aspects and the identification of cultural keystone species (i.e. species of particular significance in the cultural identity of a people) can lead to a better appreciation of and respect for traditional systems in general (Garibaldi and Turner, 2004).

In the hyper-arid coastal forests of southern Peru, both cultural identity and natural capital were enhanced by the use of the keystone "huarango" tree species in restoration (**case study 18**).

- *Soil protection and improvement* – in landscapes with specific environmental risks (e.g. soil erosion, salinization or pollution), it is important to select species that are well adapted to such limiting conditions and have the capacity to reduce risks, such as those that improve soil conditions – e.g. soil architecture, fertility and infiltration capacity – or help re-establish the hydrological regime.
- *Hydrological balance* – in landscapes with major water constraints, species should be selected that are adapted to local conditions (and therefore not large water users) and are capable of capturing rain or fog water, retaining runoff water and facilitating water infiltration. When selected species and planting densities are not well adapted to environmental conditions, revegetation may have negative impacts on the hydrological regime, reducing river flows and groundwater levels.
- *Biodiversity conservation* – landscapes with endangered species may require specific selection criteria for *in situ* or *ex situ* conservation. An inventory of endangered flora and an assessment of their populations and reproductive strategies will help in the identification of species requiring restoration interventions. Assessments of endangered plant species may also consider the status of wildlife species associated with them. There are often tight but overlooked links between flora and fauna species.
- *Economic production* – restoration actions can produce short-term and long-term economic benefits, which help in gaining the support of local communities and amortizing costs. The economic value of species and the availability of markets should be assessed and discussed among stakeholders.

Kew's Millennium Seed Bank Partnership (MSBP) is supporting a range of habitat restoration and conservation projects in semi-arid areas in sub-Saharan Africa. Local communities are at the heart of restoration governance, and species are prioritized on the basis of local needs and existing knowledge. The methodology's holistic approach (from seeds and seedlings to markets) and in-built sustainability have been keys to success in many communities (**case study 19**).

Social preferences are major factors in determining the success of restoration initiatives. It should not be assumed that farmers in different regions will prefer the same sets of species and functions; their choices will be tailored to their local contexts. A participatory approach should ensure that farmers' preferences for species and tree functions are known and respected.

In a participatory project initiated in 2006 by the World Agroforestry Centre in West Africa (Faye *et al.*, 2011), farmer preferences for species and functions

differed significantly among five regions in Burkina Faso, Mali, the Niger and Senegal. For example, revenue generation was an important function of trees in many rural communities sampled in three regions, but it was not a priority in any of the communities sampled in the other two regions.

Many undervalued native species in drylands perform critical functions in ecological restoration and at the same time provide valuable products and services. Restoration activities should feature baseline inventories of native floral species to collect information on their ecological, cultural and socioeconomic values. Participatory approaches and scientific research can both facilitate the identification of these undervalued species and contribute to their collection, production and use in restoration work.

Favouring the use of native species

Wherever possible, native species (of trees, shrubs and grasses) should be used in restoration initiatives. Native species are adapted to local ecological conditions, in which they have evolved naturally, and they are most suitable for the natural re-establishment of native flora and fauna species, thus contributing to ecosystem resilience. However, there is often a lack of knowledge on the use of indigenous species (especially those with little timber value) in forest restoration, such as on their reproduction in nurseries and their potential in field plantations. More research might therefore be required.

The use of exotic species, on the other hand, may cause major environmental disruptions. The risk is especially high when using potentially invasive plant species, which can cause large-scale ecological disturbance by competing with and replacing native species and disrupting hydrological and other processes. In some cases, action may be needed to control or eradicate alien species.

Prosopis juliflora has been reported to inhibit the regeneration of other species in riverine forests in Kenya (Mukuria Muturi, 2012). In the fragile fynbos vegetation of South Africa, invasive alien plants had devastating impacts on the native flora and the water supply. The Working for Water programme removed invasive plants throughout the country with the aim of restoring land productivity and natural ecosystem functioning and also generating rural employment (**case study 20**).

Using appropriate genetic material

The sourcing of plant propagation material (e.g. seeds and cuttings) is an important part of any restoration project involving planting. Such sourcing should be done well before the intended seeding or planting period to allow sufficient time for identifying and producing optimal material to meet restoration objectives.

Propagation material should be matched to the environmental conditions and, to the extent possible, to the expected future conditions of the target site. Seeds from local tree populations are not always the best option. Where local tree populations are genetically impoverished or are too degraded or fragmented to constitute good sources of seed for restoration, seeds from other sources that are growing under ecological conditions similar to the target site or to conditions

expected in the future (for example, if they are well suited to drier sites) may be a better choice for increasing ecological resilience (Bozzano *et al*., 2014).

Provenance trials of the genetic material present at targeted sites can provide valuable information on the suitability of that material for restoration activities. For example, provenance trials can provide information on resistance to drought, adaptation to soil type, resistance to disease and fire, and commercially important traits such as fruit or stone size, pulp mass, and biofuel potential.

A clonal selection and breeding programme in the Horqin Sandy Land in northeast China designed for the *ex situ* conservation of *Populus simonii* generated high-quality and improved poplar genetic material. Fast-growing drought-tolerant and frost-tolerant poplars were produced successfully and subsequently used in afforestation (**case study 21**).

In a participatory tree domestication programme in the Sahel, rural communities established provenance tests to compare their germplasm with that obtained from drier sites with the aim of improving drought resistance and commercially important traits in species such as *Adansonia digitata, Faidherbia albida* and *Prosopis africana* (Simons and Leakey, 2004). It is expected that the introduced genes from the drier sites will increase the drought resistance of the parkland agroforestry systems practised widely in West Africa.

Communication and coordination among restoration practitioners, nursery managers and seed suppliers is essential; in the planning phase, restoration practitioners should inform nursery managers of the seeds (and materials for vegetative propagation, such as cuttings) they need and help them identify suppliers. The restoration initiative should be monitored using ecological, biological and socioeconomic measures and indicators (see Chapter 5) over a sufficiently long period to assess the reproductive success of the species used. Among other things, monitoring should be used to generate feedback for nurseries and seed suppliers (Bozzano *et al*., 2014).

Promoting diversity, connectivity and functional diversity

Given the uncertainty of future climate regimes and limited knowledge of the performance of many tree species, a cautious approach to restoration would aim to maximize genetic and species diversity from sources that are similar to existing site conditions. High genetic, species and habitat diversity is likely to provide a wide range of opportunities and options for coping with environmental change, thus increasing resilience. Connectivity refers to the extent to which species, resources and actors disperse, migrate and interact across patches, habitats or social domains in a socioecological system (Simonsen *et al*., 2014). It is a key element of resilience, and it should be planned for and managed at the landscape scale. In particular, biodiversity conservation can be enhanced by increased landscape connectivity that allows the movement of species and genes between habitats within landscapes.

An ecosystem is more resilient if more than one species or other ecosystem component can perform a given function (such as pollination) in the ecosystem (known as "functional redundancy"). Thus, the ecosystem will continue to

function if an ecosystem component is lost; also, if the ecosystem is disturbed, functional redundancy should bring about a diversity of ecological responses that may help maintain functionality.

Encouraging habitat diversity is another important strategy because biodiversity is a key factor underlying the resilience of forest ecosystems and trees to existing stresses and a basic ingredient for increasing their adaptive capacity in the face of future stresses (Braatz, 2012). Thompson *et al*. (2009) proposed the following key actions to increase resilience in forests: maintaining conductivity across the landscape by reducing fragmentation; restoring lost habitats; establishing ecological corridors; maintaining functional diversity; and eliminating the conversion of diverse natural forest to monotypic or reduced-species plantations.

Farmers in drier regions recognize the importance of diversifying tree species on farms because increasing the number of species per function minimizes the risk of "function failure". This strengthens resilience because, even in years of drought, at least some species will still provide the needed functions.

The World Agroforestry Centre initiated a participatory project in 2006 to improve the management and productivity of native tree and shrub species in West Africa. The first major activity was to determine farmer preferences for tree functions. Faye *et al.* (2011) showed that farmers preferred species that provided two or more essential functions (e.g. food for people or livestock; medicines; wood/energy/fibre; soil fertility improvement; soil/water conservation; shade; and revenue). In the Niger, the number of tree species used by rural communities and the number of species per function were greatest in the driest areas.

Producing high-quality planting material

In drylands, nurseries play an important role in producing planting material with optimal potential for establishment in dry conditions. It is important to choose the most efficient and cost-effective regeneration methods. The techniques used in tree and shrub nurseries will determine seedling quality (i.e. the morphological and physiological quality of the produced plants) and field performance (i.e. adaptation to current stress conditions and future climatic changes) and are therefore important factors in the resilience of planted trees. The quality of seeds and their treatments to boost germination are other aspects to oversee. The production of seedlings should consider the availability and proximity of suitable water, and the nursery should be located as close as possible to the planting site.

Knowledge about plant production techniques for dryland restoration is still limited, and more applied research is needed. In particular, the inoculation of propagules in the nursery with appropriate mycorrhizal fungi or rhizobia and other seed treatments could facilitate and accelerate seedling establishment by increasing water and nutrient uptake and improve the vitality of plants subject to various stresses (Bozzano *et al*., 2014). Such techniques have the potential to enhance the revegetation of degraded lands, but they remain poorly studied.

A research project on ecological restoration in the Albatera watershed in Spain focused on the production of native plant species using innovative nursery techniques. Technological improvements enabled the production of high-quality seedlings with morpho-functional characteristics adapted to water-limited environments, thereby improving the quality of restoration (**case study 22**).

Choosing planting period and density, and preparing the planting site

In drylands, the best time for planting is when the soil has sufficient water for germination and to satisfy the water needs of seedlings in the first few months. If rainy periods are insufficiently long and there is a risk of drought stress soon after planting, it may be necessary to increase water-harvesting and soil water storage potential – for example through soil preparation techniques – and to provide watering systems to increase seedling survival. The planting period should be well planned so that seedlings are ready for planting at the most appropriate time, with adequate root development to enable them to survive early periods of drought.

The planting ground should be prepared before the first rains of the season by digging holes (e.g. 60 cm × 60 cm × 40 cm deep) on clayey soils, or, on compacted, calcareous or lateritic soils, by using heavy-duty tractors with deep tines to dig furrows. On light or friable soils, planting holes can be made at the time of planting.

In semi-arid regions of Spain, research carried out by the Forest Technical Centre of Catalonia obtained good results using innovative soil conditioning combined with mulching to enhance water retention in soils. Higher tree survival rates were observed, compared with other techniques (**case study 23**).

The planting density of seedlings or cuttings is sometimes controversial. In drylands, the main factor determining planting density is competition for scarce water resources. Therefore, planting densities should be adjusted to the carrying capacity of the environment (in terms of soil conditions and water availability) and the species used. For example, a common way of determining planting density in dune fixation is to equate the number of seedlings or cuttings per ha with the average annual rainfall in millimetres (mm); for example, if average annual rainfall is 250 mm, the planting density would be 250 seedlings or cuttings per ha.

Among the techniques applicable in semi-arid conditions, soil conditioning and mulching (preferably combined) to conserve soil moisture and reduce weeds and therefore reduce maintenance requirements (except for non-biodegradable mulches) are likely to be more cost-effective than irrigation and weeding or the application of herbicides.

Using water in dry conditions

Assisted watering should be limited to specific periods of water stress in the first two years after planting, and it should only be considered if the benefits (monetary or otherwise) justify the substantial cost. The following three conditions should also be met: 1) the use of high-quality seeds, seedlings and cuttings, sufficiently hardened to face field conditions; 2) the adequate preparation of the soil with

effective techniques to help store the maximum quantity of water; and 3) the selection of the optimal time for planting at the beginning of the rainy season (in regions with predictable rainy seasons) when the soil is well moistened as a way of securing the water supply in the early stages of seedling conditioning, establishment and growth in the field. Meeting these three conditions should significantly reduce seedling mortality in restoration initiatives, especially in arid areas where precipitation is limited, irregular and unpredictable.

Many irrigation systems have been devised to deliver water to planted seedlings efficiently, including techniques such as small water inputs applied by drip irrigation, and condensation capture (Box 4.4).

BOX 4.4

Collecting and conserving water

Degraded ecosystems in drylands often have little capability for retaining and storing soil moisture, and elevated radiation enhances the intensity of drought. In such conditions, the goal is to "capture a maximum amount of rainfall, reduce water loss and stress with protective shelters, and provide uniform and efficient irrigation only when necessary" (Bainbridge, 2007).

Microcatchment water-harvesting (Mekdaschi Studer and Liniger, 2013)	Microcatchment water-harvesting systems consist of rudimentary irrigation systems designed to trap and collect runoff from relatively small catchment areas (10–500 m²). On sloping ground, microcatchments reduce runoff erosion by creating sinks. The most common technologies are the following: • Zaï consists of digging planting pits and filling them with manure and other biodegradable waste, as well as seeds, after the first rain. The excavated earth is ridged in a semi-circle to improve the water retention capacity of the pit. Zaï holes have been shown to significantly improve yields in both agriculture and tree-planting **(case study 24)**. • The Vallerani system[1] uses a special type of plough called a "Delfino", which creates ploughed lines with microbasins. This allows an increase in groundwater quantity by improving the infiltration of rainwater and runoff, and also improves other resources such as fine soil, organic matter, and seeds, with a continuous improvement in soil fertility. The substantial cracking and buffeting of compact soil facilitates the entry of roots and fosters the rapid absorption of water (**case study 25**). • Terraces are mainly used in erosion control to reduce runoff velocity on steep hillsides under low and erratic rainfall regimes as well as for growing trees and crops on sloping lands. The selection of suitable types of terraces depends on many factors, including physical and socioeconomic conditions.

	However, their construction depends on the availability of stones and labour and usually requires large investments, which can discriminate against less well-off land users. Because terracing requires substantial investment, it should only be introduced when soil erosion cannot be controlled by the application of simpler soil conservation practices. Terracing is useful in situations where runoff is common but cannot be adequately controlled by other soil conservation practices and where the intensity and volume of runoff surpass the water storage capacity of the soil. Terraces are generally recommended for slopes of 4–50 percent (Rufino, 1989). Short slopes with a gradient of less than 4 percent should be protected by contour vegetation barriers, contour planting or strip cropping. On longer slopes, the land should be terraced if the slope gradient is greater than 0.5 percent (FAO, 2000a) (**case study 26**).
Macrocatchment water-harvesting	Macrocatchment water-harvesting systems usually consist of four components: the catchment area (2–200 ha), the runoff conveyance system, the storage system and the application area. Such systems are applicable in areas where it is necessary to store water to bridge dry seasons or to mitigate the impacts of dry spells (Mekdaschi Studer and Liniger, 2013).
Floodwater-harvesting	In floodwater-harvesting systems, storm floods caused by runoff from mountainous catchments are channelled through diversions to bunded basins on cropped land. Such systems are applicable in areas with extreme and highly variable rainfall regimes (Mekdaschi Studer and Liniger, 2013).
Devices to capture air humidity	Fog fences and fog collectors are simple devices usually made of large vertical pieces of canvas in various shapes that collect liquid water from fog. They don't require external sources of energy but can only be used in favourable climatic conditions. The "Groasis Waterboxx"[2] is a device in the shape of a plastic bucket designed to capture condensation (at night, when the air is cooler) as well as rainfall. The water is then stored, protected from evaporation, and slowly released to seedlings.
Use of treated wastewater in forestry and agroforestry systems	Treated wastewater[3] can be used in forestry and agroforestry systems near villages or urban areas. In recent years scientists have developed safe, environmentally sound and cost-efficient ways of treating municipal wastewater to be used for irrigation. The re-use of wastewater allows the recycling of nutrients for productive purposes and reduces the discharge of blackwater into rivers and seas, freeing other freshwater resources for more vital uses (**case study 27**).

Rooftop and courtyard water-harvesting	Rooftop and courtyard water-harvesting provides water close to home. Rainfall is collected as it runs off house roofs or the compacted/paved surfaces in and around courtyards. This technique provides a safe and convenient source of good-quality water, although the quantity may be limited (Mekdaschi Studer and Liniger, 2013).

1 www.vallerani.com.
2 www.groasis.com.
3 www.fao.org/forestry/tww.

Managing and protecting planted trees

In drylands, the major factors affecting the establishment and growth of seedlings are fire, drought, livestock, and termites:

- Regardless of the management objectives, seedlings and cuttings need to be protected from fire in the first years after establishment. This can be done by establishing a network of firebreaks and, where possible, by fencing or guarding. An integrated approach to fire management will be most effective (see section 4.2).
- Weeds will compete for soil and water resources and need to be controlled in the first years after establishment. In drier areas, low inherent soil moisture requires that weeds are completely removed, either manually or mechanically.
- Browsing animals may be a threat to growing trees, but fencing is costly. Integrated grazing management (as described in section 4.2) can be effective in reducing the destruction caused by grazing animals to young trees.
- Attack by termites (especially in Africa) and other pests may be a major threat in restored dryland areas. Vigilance is required to detect such attacks; in the absence of effective biological controls, replanting may be necessary (Chidumayo and Gumbo, 2010).

Silvicultural practices to ensure the supply of wood, fruits, leaves, resins and other non-wood products may include techniques such as pruning and thinning. Pruning is the cutting of side-branches level with the trunk with the aim of improving the shape of the bole and the quality of wood (FAO, 2000b). In drylands, pruning is generally practised to produce fodder or woodfuel and to reduce crop shade. It must be done carefully so as to ensure the continued growth and productivity of the tree.

Thinning is the removal of a proportion of the trees in a growing forest with the purpose of encouraging the increased growth of the retained trees (FAO, 2000b) by providing them with more space for crown and root development. Thinning might also serve to remove undesirable trees (e.g. diseased trees) and to provide intermediate financial returns (Chidumayo and Gumbo, 2010). The timing and intensity of thinning should be carefully planned, and it should only be carried out after determining the costs and benefits of doing so.

5 Monitoring and evaluation

5.1 INTEGRATING MONITORING AS PART OF ADAPTIVE MANAGEMENT

Decision-making related to dryland restoration involves considerable uncertainties due to the dynamic nature of ecosystems and the unpredictable trajectories and end points of restored lands (Aronson *et al*., 2007). Monitoring involves the systematic collection and analysis of data over time to determine if conditions have changed or if actions have caused changes or trends. Monitoring, therefore, helps reduce uncertainties and inform decision-making to improve outcomes. It also helps in understanding why certain restoration techniques and practices work and, equally importantly, why others fail.

Conducted in a participatory process, effective monitoring is an essential element of adaptive management because it provides reliable feedback on project activities, results and management. By measuring progress over time, monitoring provides the evidence base on which strategies can be built and adapted and therefore helps build resilience.

Only a small proportion of restoration initiatives have carried out monitoring, however, usually where funding agencies have required it. In many cases, too, the monitoring effort has addressed contractual compliance only. There is a strong and widespread need, therefore, to improve monitoring and evaluation approaches in dryland restoration initiatives.

Adaptive management approaches involve the frequent review of initiatives to generate feedback on progress towards project goals. Such approaches systematically test assumptions and assess whether restoration actions are appropriate or require adjustments in response to findings, concerns and unexpected changes. Adaptive management requires the capacity to change assumptions in the light of evidence generated by monitoring and to systematically test alternative implementation actions to achieve desired outcomes.

5.2 STARTING MONITORING DURING THE PLANNING PHASE

Objectives, performance standards, indicators and protocols for monitoring should be incorporated into plans before the start of a restoration initiative. A monitoring plan should be designed and put into action in the planning phase.

Monitoring will help determine if a project has achieved its ecological and socioeconomic goals. Indicators are selected as part of baseline studies to measure change related to the identified goals. The choice of indicators will be determined by the availability of monitoring resources and by the level of detail needed.

Monitoring should permeate the entire restoration process, from needs assessment, design and implementation, to ongoing adjustments in the light of feedback,

to the analysis of intermediate and final results. In order to observe changes or improvements in a given parameter, monitoring should include an assessment of existing ecological and socioeconomic conditions in the proposed area as part of a baseline study, according to which the desired future conditions can be identified.

5.3 INVOLVING MULTIPLE STAKEHOLDERS IN MONITORING

All concerned stakeholders should be identified in the planning phase and their diverse interests taken into account in developing a comprehensive set of issues and parameters to be monitored. A multistakeholder monitoring process can be difficult because the various stakeholders may have conflicting objectives, but it is necessary for identifying the right questions to ask and for assessing the extent to which a restoration initiative is meeting desired outcomes and how it is responding to diverse concerns.

A participatory monitoring approach also promotes mutual learning as participants work together to better understand restoration efforts and impacts. Participants can expect to gain a greater understanding of ecological health, the economic and social well-being of local communities, and the interconnections between the environment, the economy and social conditions. They will also gain new perspectives of the restoration initiative and its potential outcomes.

The chronology in achieving target results may differ, but all participants in a monitoring programme should have access to the same information so they can develop common understandings of the issues. It may also be necessary for monitoring teams to spend time discussing their perhaps differing understandings of concepts. It is especially important to develop a common definition of what "success" will look like, so that stakeholders are able to share a common vision of what the restoration initiative is seeking to achieve.

Once commonly agreed indicators and sources of verification have been defined, tasks and responsibilities (as well as skills and tools) should be identified and agreed among members of the monitoring team.

5.4 MONITORING, EVALUATING AND SHARING EXPERIENCES IN DRYLAND RESTORATION

Many dryland restoration projects, programmes and other initiatives have been undertaken in recent decades. The lessons learned from the successes and failures of approaches, strategies, methodologies and techniques are potentially a great source of knowledge, but data need to be gathered, compiled, evaluated and disseminated in a consistent way. That is the purpose of the FAO Monitoring and Reporting Tool for Forest and Landscape Restoration, which has been used to gather information on good practices and facilitate the sharing of knowhow among dryland regions globally.

The FAO Monitoring and Reporting Tool for Forest and Landscape Restoration was developed to analyse, report on, monitor and evaluate restoration initiatives and to help project implementers in compiling the lessons learned and in analysing and monitoring performance and impacts. The tool can be used as a checklist for the

designers of restoration projects of the main elements involved in restoration. It has been field-tested, and various experts and workshop participants have contributed to its development. Box 5.1 provides an overview of the tool, by section; the full version will be available online from 2016.

BOX 5.1

FAO's Monitoring and Reporting Tool for Forest and Landscape Restoration

FAO's Monitoring and Reporting Tool for Forest and Landscape Restoration was developed as part of the process of producing these guidelines. It has been tested in 22 restoration case studies worldwide and reviewed and validated at two international workshops (in Konya, Turkey, in 2012 and Dakar, Senegal, in 2013). This comprehensive tool aims to guide project leaders in designing their projects and implementers in reporting on and tracking the progress of restoration, analysing the elements of success and failure, and compiling the lessons learned for adaptive management and corrective actions.

The tool consists of an easy-to-complete form to be filled out by technical staff. The quantitative components of the tool can also provide "scores", if required, to better measure improvements over time. The form is built around seven categories of information, described below.

The tool can be used for reporting and monitoring on restoration initiatives at the country level. FAO is working to make it available as a web-based tool to be filled in online on a voluntary basis by practitioners and managers of restoration initiatives. Over time, this will enable the development of a database linking and supporting networking and lessons learned among a community of restoration practitioners and enablers worldwide.

General information	Users provide a one-stop summary of the restoration initiative's main attributes, such as its location, geographic extent, timeframe and budget. The involved organizations and partners are identified, along with the nature of their contributions
Area description	Users characterize the restoration area according to five criteria: 1. climatic conditions, such as rainfall and temperature, wind, extreme weather events and climate-change impacts; 2. geomorphological and pedological properties, such as topography, altitude, hydrographic features and soil types; 3. ecological features, such as faunal and floral species, biotic interactions, and vegetation structure and cover; 4. socioeconomic properties, such as land use, land rights (e.g. ownership, access and management), and income-generating activities; and 5. the direct causes of degradation, such as poor grazing management, overharvesting, invasive species, pests and diseases, flooding, landslides and urbanization
Restoration objectives	Users state the restoration objectives and related specific actions. The scope of the intervention as well as its contribution to broader initiatives is also described

Supportive governance framework	Users assess the level of support for restoration provided by the governance framework. Stakeholder involvement should be detailed in a table showing roles and responsibilities. Information on local actors and providers of specific actions in capacity development, research, awareness-raising and institutional development can be listed in this section
Restoration strategy adopted, planning and implementation	The purpose of this section is to provide details about planned and implemented interventions and measures at the field level. Special attention is given to protection to facilitate natural regeneration and soil and water management measures, as well as plantation-related activities (e.g. site preparation, nursery techniques, the reproduction material used, and post-planting measures)
Monitoring	Users specify whether a monitoring plan has been developed for the restoration initiative and, if so, they are invited to provide additional information, such as the plan's timeframe, baseline, stakeholders and other aspects (e.g. ecological, social, economic, political and technical)
Results and sustainability	This section is intended to provide an indication of the degree of success of the restoration initiative, based on the measurement of processes and activities, with a focus on the following points: • Restoration objectives and outcomes – users are invited to provide an appreciation of the participation, relevance, effectiveness and adequacy of funding of the initiative. • Field restoration results/impacts – e.g. the increase in vegetation cover induced through restoration interventions such as assisted natural regeneration or planting (area, cost/ha, survival rates, timeframe, etc.). • Capacity development: e.g. institutional development and awareness-raising (number of people trained, cost, number of participating stakeholders, etc.). • Contribution to human well-being. • Impacts on policies (e.g. policy/legislation barriers overcome, policy/legislation changes). • Environmental impacts. • Sustainability (e.g. in terms of scaling up, ownership by local actors, the institutionalization of results in the long term, funding and capacities). Users identify and assess key problems and recommend ways of overcoming them, as well as key impacts and achievements (e.g. increased resilience, plant diversity, vegetation cover, vegetation quality, and reduced erosion)
Further sources of information	Users provide sources of information and references to relevant supporting documents (e.g. maps, publications, web pages and pictures)

6 Case studies

6.1 CROSS-SECTORAL WORK TO MOBILIZE TRADE AS AN INCENTIVE FOR INVESTMENT IN THE GUM ARABIC SECTOR[8]

Approach

Realizing that only a cross-sectoral approach involving all actors can halt land degradation, Mali started a process in 2007 to develop its Strategic Investment Framework for Sustainable Land Management (CSIF-SLM), in partnership with the TerraAfrica platform. Existing consultation frameworks enabled dialogue on the policy directions and strategies of particular departments but did not allow cross-sectoral analyses of the impacts of their respective programmes and activities. The development of the CSIF-SLM is taking place with a view to harmonizing the policies, planning and financing of all sectors involved in SLM, including trade.

Mali's Ministry of Industry, Investment and Commerce is engaged in the SLM process through the Enhanced Integrated Framework (EIF). To ensure consistency among the planned trade activities of different ministries, and in donor funding, it was important that the various sectors engaged in a common planning exercise to harmonize their trade priorities. The aims of the process were to highlight national priorities supporting SLM and to create political and financial synergies among the various trade and rural development processes.

To date, the harmonization process has included the following:

- the facilitation of dialogue between the technical SLM unit and the implementing unit of the EIF;
- the integration of trade and SLM;
- the harmonization of sectoral trade priorities;
- the development of a matrix of joint trade priorities for SLM sectors; and
- the identification of resources to finance projects and initiatives in the context of common priority concerns.

The gum arabic sector was used as an entry point to enhance intersectoral bonds; gum arabic is a versatile product derived from *Acacia senegal*, a tree species, with the potential to both ensure SLM and develop trade. A feasibility study and pilot project conducted in 2009 for the gum arabic sector facilitated the involvement of the ministries in charge of trade and the environment; the result was that the gum arabic sector was taken into account in the CSIF-SLM as a priority sector for financing. The International Trade Center assisted in updating the sectoral strategy for the gum arabic programme, which integrates the SLM dimension as a tool for enhancing the productive capacity of the sector and its resilience to climate change.

8 Prepared by Eleonora Canigiani and Salif Touré, GM-UNCCD (www.global-mechanism.org/dynamic/documents/document_file/aft_mali_fr.pdf).

Result

Mali successfully mobilized US$6.8 million through trade-related mechanisms to develop a five-year project designed to boost the productive and commercial capacities of the country's gum arabic sector. The project has the potential to make a significant contribution to Mali's efforts to address desertification and land degradation because *Acacia senegal* is highly effective in enriching soil by fixing nitrogen and in sequestrating carbon through biomass and its integration in agroforestry systems. Gum arabic is also highly marketable, with multiple uses in the pharmaceutical, food, cosmetics and printing industries, among others. The project aims to improve the production and quality of gum arabic and boost the trade of this product, thereby improving the livelihoods of dryland communities. This, in turn, will create incentives for those communities to invest in the sustainable use, management and restoration of *Acacia senegal* landscapes in Mali.

The GM-UNCCD supported the development of this project by facilitating dialogue between the ministries of trade and agriculture on the value of addressing trade and SLM together. The GM-UNCCD also helped ensure that the project addressed issues of sustainable production and environmental management, and it supported the identification and mobilization of resources for project implementation. In addition, the GM-UNCCD was central in bringing partners together along the value chain to ensure that the project was fully aligned with national and sectoral policies and development plans related to SLM, agriculture and trade. Mali's Ministry of Industry, Investment and Commerce is coordinating project implementation.

Lessons learned

The bonds between trade, agriculture and natural resources are obvious in theory but, in practice, sectors tend to work independently. The harmonization of the priorities of the various sectors requires specific efforts and resources.

Mali's process is helping to promote the exchange of knowledge among sectors and an understanding of the benefits of intersectoral synergies for achieving common development objectives; it is also helping improve institutional mechanisms for intersectoral coordination. Experience shows the importance of facilitating intersectoral exchanges and understanding to support individual sectors in achieving their objectives. Mali's process is helping build networks and alliances with development partners with a view to mobilizing technical and financial resources for the development, implementation, replication and scaling up of intersectoral initiatives. Improved coordination among donors, and the use of pool funds from different sources and sectoral programmes, are also necessary for boosting intersectoral cooperation.

The capacity to develop intersectoral projects is another area that requires additional support and efforts, especially in terms of human resources. National experts in trade, agriculture and SLM can act as intermediaries between the different sectors and ministries to facilitate coordination and undertake technical tasks such as the design and development of intersectoral projects and studies on

financial flows. "Multi-expertise" profiles are valuable – but difficult to find. It is important, therefore, to invest in the creation and development of institutional capacities along those lines.

It is becoming increasingly clear that cross-sectoral approaches that recognize the mutual benefits of tackling environmental sustainability, food security, poverty reduction and economic growth in tandem are the way forward. The GM-UNCCD will continue to support countries to leverage finance from trade mechanisms to ensure they can meet these broad development goals. Further projects are already planned in the areas of NWFPs and food crops with a view to tapping into trade-related finance.

6.2 MAINSTREAMING FOREST LANDSCAPE RESTORATION IN THE POLICY FRAMEWORK OF THE UNITED REPUBLIC OF TANZANIA[9]

In 1998 the United Republic of Tanzania approved a revised national forest policy with the following overall goal: "to enhance the contribution of the forest sector to the sustainable development of the United Republic of Tanzania and the conservation and management of its natural resources for the benefit of present and future generations". The policy emphasizes participatory management and decentralization, and the main changes compared with the previous national forest policy are the intention to:

- minimize the replacement of natural forests with exotic plantations and monoculture plantations;
- incorporate the principles of biodiversity conservation and multiple use in the management plans of industrial plantations through the coordinated strategic planning of other land uses such as wildlife, ecotourism, environmental conservation and beekeeping;
- encourage the participation of local communities in the management of industrial plantations through joint forest management and the community-based management of unreserved forest areas;
- conduct environmental impact assessments for all industrial plantations to halt pressure that reduces forest functionality; and
- help local communities to select and set aside degraded and village forested areas to be conserved and managed as village forests.

To prevent forest degradation and deforestation arising from the actions of non-forest sectors – such as agriculture, livestock, energy and mining – the new policy aims to enhance multisectoral cooperation. Results from an analysis of 13 national sector policies and three national development strategies showed that, overall, these policies and strategies support forest restoration as a component of poverty eradication, livelihood improvement and environmental conservation. Knowledge and recognition of forest conservation values at a landscape level was observed to be low in six sector policies: agriculture/livestock; fisheries; energy; women's development and gender; minerals; and youth. Efforts are therefore required to intensify awareness among sector policymakers and planners of the

9 *Source:* Kaale (2001).

concept of landscape approaches to the management of natural resources.

An important starting point for landscape restoration is integrating forest functions into sectoral economic and environmental policies, from the village level to the national level. Policymakers and planners in the various sectors with policies supporting the conservation and sustainable use of natural resources should be at the forefront in devising systems of forest valuation and should help in creating awareness and building consensus on the real value of forests to livelihoods and poverty reduction. Training in negotiation techniques aimed at building consensus for introducing and promoting forest landscape restoration should help overcome current weaknesses in sectoral policies, including those of the forest sector.

Concerted efforts are required from all stakeholders to make full use of opportunities for introducing and promoting landscape restoration in the United Republic of Tanzania as a component of achieving national development priorities. Awareness creation and training in forest landscape restoration could increase understanding and create an informed consensus among stakeholders of the various functions of forest products and environmental services and their contributions to human well-being and poverty eradication.

6.3 MAKING CHANGE HAPPEN: WHAT CAN GOVERNMENTS DO TO STRENGTHEN FOREST PRODUCER ORGANIZATIONS?[10]

Encouraging the establishment and successful development of FPOs should be a priority for governments wishing to promote sustainable forest management, landscape restoration and prosperous rural communities. The Forest and Farm Facility developed a discussion and guidance paper to explore the factors that help build constructive relationships with government counterparts, and the policy and institutional conditions that encourage or hinder FPO development. Below are the summarized findings and recommendations to governments.

At least four fundamental conditions must be in place to enable sustainable forest management, including restoration by communities, families and indigenous peoples: 1) secure tenure; 2) fair access to markets; 3) access to support services, especially extension; and 4) FPOs. FPOs can ensure – through lobbying, and by providing services directly to their members – that the first three conditions are in place and are maintained.

Governments should encourage the development of FPOs because (among other reasons) FPOs can:

- improve policymaking by proposing supportive policies;
- provide coherent assessments of policy impacts from the perspectives of families and community forest producers;
- make services available to forest producers at a lower cost and with more effectiveness than is often possible by government;
- help increase the efficiency of markets and boost government revenues by formalizing previously informal revenue streams;
- help resolve conflicts over competing land claims; and
- protect and monitor forests more closely than governments.

10 *Source*: deMarsh *et al*. (2014).

FPOs can be characterized in a variety of ways, including on the basis of their purposes; their geographic scope; the composition of their membership; and the source(s) of their revenue. They can also be described by their autonomy in relations with governmental and other agencies and the extent to which the FPO–government relationship is collaborative or adversarial. Relationships that are either highly dependent or adversarial have a negative or zero-sum payback for governments, but relationships that respect FPO autonomy are much more likely to produce positive results for both sides.

Among other attributes, an "ideal" FPO will have an inclusive membership base; encouragement and support from government agencies; a firm spirit of self-reliance; an ongoing commitment to building trust in its relationships with government agencies; the involvement of women, youth and socially marginalized groups; and a direct but legally distinct relationship with related forest product industries.

Governments can facilitate the development and strengthening of FPOs in many ways. For example they can:

- create a suitable legal and regulatory framework;
- develop policies that provide a framework for, and actively encourage, ongoing engagement and cooperation with FPOs;
- create laws and policies that seek to establish a balance between large industrial corporations and locally controlled forest organizations in the marketplace and in access to public incentive programmes and other resources;
- provide opportunities for FPOs to participate in policy development;
- develop and stimulate the provision of capacity-building services;
- reduce business barriers;
- encourage and facilitate gender equality, good governance and the active involvement of youth in FPOs; and
- recognize and raise public awareness of the important contributions of community and family forestry.

Governments can further support FPOs by:

- working with FPOs to show early tangible results;
- ensuring that laws allow appropriate forms of legal status for FPOs;
- having a policy of engagement and a practice of dialogue with FPOs;
- ensuring "buy-in" at all levels of government and among staff;
- developing rural economies and improving livelihoods; and
- helping FPOs build their capacity.

Recommendations

National institutions should:

- gather data to assess the potential role of FPOs and learn from the experiences of other governments;
- establish a process to facilitate discussions among forest producers on the development of FPOs and to help mobilize support within government;

- conduct a participatory review of the status of the four fundamental enabling conditions (i.e. secure tenure, fair access to markets, access to support services, especially extension, and FPOs);
- hold village meetings to invite forest producers to voice concerns and describe the actions needed;
- convene summits to present the results of reviews and consultations, seek agreement on the analysis of gaps in policies and programmes, establish priorities, and identify partners; and
- take a long-term approach to strengthening the management of community and family forests and supporting the development of FPOs, for example by investing in forestry extension services.

International development organizations should:

- place more emphasis on linking project support with the encouragement of the first three fundamental enabling conditions, as well as the development and strengthening of FPOs and a commitment to ongoing dialogue and engagement between governments and emerging FPOs;
- support governments in their efforts to better understand sector dynamics in tenure, governance and markets and in their selection and implementation of policy instruments that support FPOs;
- give high priority to capacity-building programmes that support FPOs and the implementation, by governments, of policies that encourage the sustainable management of community and family forestry in general and FPOs in particular;
- increase the sharing of FPO experiences within and between countries;
- create consultative platforms and fora, where needed, and strengthen the participation of FPOs in formal policy development fora; and
- support the development of monitoring and assessment systems that can be used by all stakeholders to track the extent to which the institutional environment is "enabling", and how it is changing.

6.4 HILL RESOURCE MANAGEMENT SOCIETIES IN HARYANA STATE, INDIA: A SUCCESSFUL JOINT FOREST MANAGEMENT APPROACH TO COMMON-PROPERTY RESOURCES[11]

Joint forest management (JFM) emerged in India in the 1980s from community initiatives for the protection of forest catchments through village-based hill resource management societies (HRMSs). Forest protection groups took action using the "social fencing" of degraded forestland. JFM was adopted by support agencies, such as NGOs and state forest departments, when its full potential was realized. In 1990, the Haryana Government signed an agreement with The Energy and Resources Institute (TERI)[12] – underpinned with financial support from the Ford Foundation – to help establish HRMSs. Up to 14 million ha in India are

11 *Source:* WOCAT (2007).

12 Formerly the Tata Energy Research Institute.

cared for in this way, and the Shiwalik Hills in the northern part of Haryana are home to some of the most successful JFM experiences worldwide.

Threat

No community organization existed to address the lack of control over forest degradation in the Shiwalik Hills, which was leading to erosion and the siltation of water bodies, and a lack of forest products and grazing resources.

Approach

Aims: to develop a local participatory, democratic and powerful people's self-help institution to enhance forest protection and thereby improve the flow of forest products; and to boost agricultural productivity through irrigation in village fields using water obtained from dams in protected catchments.

HRMSs aim to secure environmental and production benefits through community cooperation in natural resource management. These state-sponsored, village-level societies are key to the success of JFM, and their links to the Haryana State Forest Department are crucial. The founding principles include appropriate social composition, accountability, and conflict resolution. HRMSs are open to all members of village communities – regardless of gender and caste – who pay membership fees and are officially registered as members. Management committees are elected, and each must include at least two women. HRMSs oversee forest catchment management activities by villagers, arrange the distribution of irrigation water (where applicable) and liaise with the Haryana State Forest Department and TERI.

Policy and land governance. User rights to forestland are made available equally to all to reduce potential conflicts between unequal "landowners".

Community development. A given HRMS plans activities with the Haryana State Forest Department. Under the guidance of the HRMS, communities provide labour (for physical works in a catchment, for example), for which they receive a certain amount of compensation; implement social fencing; and share the multiple benefits. Where there is a water-harvesting dam, all members have the right to claim an equal share of the water, irrespective of whether they have land to irrigate.

Extension methodology. The Haryana State Forest Department, in conjunction with TERI, provides land users with training in water-harvesting structures and their maintenance. Workshops and meetings are also held to create and maintain a water distribution system. Training is generally effective.

Research. TERI carries out research on various aspects of the work (including both technical and social issues). Results are published in handbooks and other publications.

Technological development. There has been a huge improvement in soil and water management techniques in forest restoration. Additionally, the levelling of land for irrigation in fields below the forest area has reduced its vulnerability to erosion.

Implementation costs and incentives. No credit is provided. For the establishment of dams and other infrastructure, up to 95 percent of labour is rewarded with cash wages. In recent years, HRMS funds (derived from water-use charges, etc.) have made contributions, which help cover maintenance. Machinery (e.g. bulldozers used to construct dams), hand-tools, and some basic community infrastructure (buildings) are financed and provided.

Adaptive management. Internal monitoring and evaluation reviews are carried out every 1–2 years. Several changes were proposed and carried out on aspects of the sharing of irrigation water and for income derived from forest products – especially bhabbar grass (*Eulaliopsis binata*), which is used in rope-making.

Income generation. HRMSs derive income from NWFPs, particularly the sale of bhabbar grass, and from water-use charges. This income is managed by the HRMSs and used for village development and community welfare.

Sustainability. The existence of an HRMS should ensure that forests continue to be managed into the future. Land users can maintain the infrastructure – such as dams and irrigation pipelines – that has been put in place; some general maintenance tasks are beginning to be carried out by the people themselves. The prevailing culture of paying wages for major works like dams, however, makes it unlikely that these will ever be done by voluntary labour. Technical guidance is required, and at least some budget is needed from the Haryana State Forest Department.

Replicability. The original experience in Sukhomajri has been replicated in 60 other villages in Ambala and Yamunagar districts, and also elsewhere in India.

Lessons learned

More awareness and capacity building is needed among land users to strengthen HRMSs, to implement and sustainably manage the rehabilitation technologies cost-effectively, and to develop micro-enterprises to strengthen market linkages for agriculture, livestock and NWFPs; this is especially necessary among women to strengthen their participation in HRMSs. The micro-credit concept and better access to improved seeds and technology will increase incomes and provide new business opportunities. Policy improvements are needed to encourage greater interdepartmental cooperation on natural resource restoration, and new rules and bylaws are required to ensure equitable access to benefits. The assistance and budgetary allocation provided to HRMSs by the Haryana State Forest Department for forest management and irrigation is not yet adequate.

6.5 RESTORATION OF A DEGRADED FOREST AND ITS CONVERSION INTO A WILDLIFE SAFARI RESERVE: BANDIA, SENEGAL[13]

Threat

The Bandia forest reserve is located 65 km from Dakar, next to the southern edge of the arid Thiès Plateau. The soils are typically lateritic and susceptible to rain erosion. Lower areas are mostly limestone-rich soils, except in hollows and waterways, where soils are mainly clayey. The savannah vegetation of the area is composed predominantly of *Acacia seyal*, *Bauhinia rufesens*, *Piliostigma reticulata*, *Adansonia digitata* and *Combretum glutinosum* in the tree stratum and *Combretum micranthum*, *Combretum aculeatum*, *Acacia ataxacantha*, *Boscia senegalensis* and *Salvadora persica* in the shrub stratum. Wildlife in the area was once very rich but has been depleted since the 1970s.

The Bandia forest was classified in 1933 and until 1954 it was managed for the production of fuelwood and charcoal over an 18-year rotation. About 560 ha of the reserve were harvested between 1933 and 1952, yielding 45 quintal of wood per ha[14] to provide energy for steam trains. Grazing by surrounding communities was allowed as part of their usage rights. The forest was also used by the Forest Research Directorate for site-based experiments. By the end of the 1970s, the forest was heavily degraded, with very poor regrowth in exploited areas and huge issues associated with agriculture encroachment, illegal woodfuel harvesting, overgrazing, and quarrying.

Approach

Restoration using exotic species. With support from the United States Agency for International Development, the Government of Senegal decided to implement a plantation project using fast-growing exotic species (*Eucalyptus camaldulensis* and *Prosopis juliflora*), mainly for woodfuel production. The project had a budget of US$3.1 million plus a counterpart contribution of US$660 000 from the Government of Senegal. The objective was to plant 3 000 ha in four years (1980–1984), but the project stopped after only 1 550 ha were planted. Despite the heavy mechanical equipment used to prepare the soil for planting, most of the trees died soon after planting when their roots reached the lateritic bedrock. It should be mentioned that, unlike the project site, the plantations in the area under the control of the Forestry Research Directorate have grown well.

Restoration through ANR and wildlife stocking. In the early 1980s, 500 ha of the Bandia forest were allocated to a private investor who fenced the area to protect it from grazing, cultivation and cutting. The fencing led to very rapid regrowth (within three or four years), encouraging the investor to bring in potential partners to initiate an ecotourism experiment. He and his partners negotiated a restoration protocol with the government, which involved the fencing and protection of 3 000 ha of the forest and the introduction of wildlife species (including non-native fauna) such as giraffe, rhinoceros, ostrich, gazelle and antelope, most of them brought from South Africa.

13 Case study prepared by Pape Djiby Kone.
14 One quintal is equivalent to 100 kg.

Impact

Successful restoration. In fewer than five years after the ANR began, there had been exceptional development of trees and shrubs in the area. The very scattered tree and shrub vegetation became a densely wooded savannah. The wildlife species reproduced well and their populations increased significantly, to a point that the enterprise was obliged to import fodder and water from outside the area in the dry season.

Contribution to local employment. In the last few years, the Bandia Wildlife Safari Reserve has become an important tourist destination, receiving over 45 000 mostly foreign visitors per year. A restaurant has been established, and there are plans to build a motel. The venture employs 125 rangers and guides, in addition to various seasonal workers, most of them from the local area.

Income generation and infractructure development. The Bandia Wildlife Safari Reserve pays a yearly rent of CFA 3 500 (US$7) per ha to the government and CFA 1 500 (US$3) per ha in fees to surrounding rural communities, in addition to the 18 percent value-added tax imposed on visitors' tickets. A medical centre and a school for the local communities have been built, and an ambulance for emergency medical evacuations has been offered.

Use of excess wildlife. The agreement with the government allows the Forest Service to use excess wildlife for introduction in other forest and woodland areas with the aim of developing similar reserves. Some of the animals in the Bandia Wildlife Safari Reserve have already been transferred to the Saloum Delta National Park to develop another ecotourism venture.

Lessons learned

From a very degraded forest, Bandia forest has become a biodiversity conservation centre, producing wild animals that government agencies responsible for wildlife management can use to enrich the national network of protected areas and to establish other ecotourism reserves in collaboration with investors. Lessons learned include the following:

- The introduction, at very high cost, of exotic, fast-growing species is not a guarantee of success if pedo-climatic factors are not taken carefully into account. Moreover, the management of such plantations can be problematic if surrounding communities are not involved.
- In many degraded dryland areas, appropriate ANR is all that is necessary to recover the original ecosystems. In the case of Bandia, however, it should be noted that the period of restoration coincided with relatively wet years (up to 500 mm of rainfall per year).
- Private investments, if framed by holistic and clear specifications and close monitoring and supervision, can yield positive results and benefit all stakeholders.
- The introduction of exotic fauna can be a problem in the absence of careful management.

6.6 PARTICIPATORY TECHNOLOGY DEVELOPMENT: THE V-SHAPED MICROCATCHMENT FOR OLIVE GROVES IN THE SYRIAN ARAB REPUBLIC[15]

Lead organization: the International Centre for Agricultural Research in the Dry Areas (ICARDA) as part of the Khanasser Valley Integrated Research Project.

Approach

Aim: to develop locally adapted options for agriculture in dry marginal areas alongside an integrated approach to SLM in these areas. This approach is now being applied in other ICARDA-coordinated projects in the region.

Participatory technology development implies a partnership between farmers and researchers, with the farmers' priorities put first. Experiments are carried out and assessed jointly. Improved farmer–researcher interaction helps farmers learn useful basic techniques from researchers, while researchers, in turn, learn from local innovators about potential improvements to the new technologies. Together, both farmers and researchers identify low-cost water-harvesting measures.

Extension and training methodology. The approach involved the following:

- An interdisciplinary team from ICARDA tested the approach. A community facilitator organized group discussions, and researchers were asked to be open-minded about local approaches while conducting and monitoring field trials.
- Demand-driven training in olive husbandry techniques (e.g. pruning, grafting and pest management) was conducted through public meetings, farm visits and on-the-job training. Training was reasonably effective.
- Farmer-to-farmer extension was used – innovative farmers showed their techniques to other olive farmers during farm visits. This was quite effective in spreading the concept among interested farmers.

Research. Research was reasonably important for the effectiveness of the approach because it provided greater insight into constraining factors for water-harvesting and helped clarify the potential amount of water saved. Technical and socioeconomic topics were treated as follows:

- Researcher-controlled on-farm experiments helped evaluate the impact of water-harvesting design on the volume of water harvested and the response of the olive crop.
- Farmer-managed trials were monitored to evaluate the performance of water-harvesting in on-farm conditions.
- A cost–benefit analysis was conducted to check economic viability.
- Perceptions of the advantages and disadvantages of the technology were analysed.

Community involvement. All water-harvesting was done in private olive orchards. Secure land tenure was essential for investments in water-harvesting structures.

15 *Source:* WOCAT (2007).

Investments and costs. All labour was voluntary and no external input was provided. The water-harvesting structures are simple and relatively cheap for farmers, who can continue the practice independently.

Lessons learned

The approach of engagement between researchers and local innovators can only be sustained if it is mainstreamed into national research and extension services. Extension in marginal agricultural areas is usually ill-equipped; therefore, outside support is necessary to facilitate extension activities.

6.7 THE RESTORATION OF FOREST LANDSCAPES IN THE SOUTHERN CAUCASUS[16]

Lead organizations: WWF Caucasus Programme Office and local partners.

Threat

Forests cover about 20 percent to climate change of the southern Caucasus countries of Armenia, Azerbaijan and Georgia. The energy crisis that hit the region in the 1990s brought an increase in legal and illegal logging, unsustainable forestry practices and overgrazing, resulting in desertification.

Approach

Aim: to increase the resilience to climate change of forest ecosystems in Armenia, Azerbaijan and Georgia through restoration with native species and innovative planting and seeding methods.

The project focused on pilot sites in the three countries covering dryland mountain forest, mid-altitude forests and floodplain forests. The restoration strategy followed a three-step approach comprising: 1) site inspection and the delimitation of the target surface; 2) the definition of potential forest composition and the selection of native species for restoration; and 3) the development of a restoration plan involving site preparation, planting methods and regeneration measures, and maintenance and protection.

Community involvement and beneficiaries. Government institutions and NGOs participated in the project, which also encouraged the involvement of local communities through the creation of temporary jobs for restoration work, the training of workers, awareness-raising, and capacity building in setting up and managing forest nurseries.

Impact

The project led to the restoration of a total area of 1 415 ha, for which 2.6 million seedlings were used. Besides the actual plantations, project outputs included the

16 Compiled based on a presentation made by Hannes Neuner (WWF Caucasus Programme Office, Georgia) at the First International Experts Workshop on Drylands Restoration (Konya, Turkey), and the FAO Forest Restoration Monitoring Tool.

publication of a forest restoration manual in four languages, site maps, an adaptation strategy, a monitoring tool, and a set of site templates.

Lessons learned

- The development of an optimal restoration strategy (e.g. site selection, species, and restoration methods) is key to success.
- Fencing is another key measure.
- Full use should be made of natural regeneration.
- The setting up of tree nurseries is crucial for obtaining high-quality planting material.
- The use of innovative tools and methods can increase the quality and effectiveness of restoration.
- Maintenance is important for ensuring the sustainability of restoration sites.
- The early involvement of local communities and authorities is important.

6.8 MEDITERRANEAN MOSAICS: STRENGTHENING RESILIENCE IN THE SHOUF BIOSPHERE RESERVE, LEBANON[17]

The United Nations Educational, Scientific and Cultural Organization (UNESCO) declared the Shouf Cedar Nature Reserve a "biosphere reserve" in 2005. The reserve is in the southern part of the Lebanon Western Range, which hosts, among other things, the last remaining stands of Lebanese cedar.

The Ecosystem Restoration Program,[18] funded by the MAVA Foundation,[19] aims to address the need to build "disturbance-smart" landscapes by "engaging local societies and decision-makers in the formulation and implementation of shared visions". The aims of the project's first phase (2012–2015) are to design and implement a pilot landscape restoration plan to increase the resilience of river and forest ecosystems to climate change; design innovative strategies to strengthen sustainable land uses and the development of tourism; and build an extended network of partners among public administrations, the private sector, NGOs and community groups.

Threat

The Shouf Cedar Nature Reserve harbours unique flora and fauna, including many endemic and threatened species. The Ammiq wetland is of particular importance for bird migration, but water-pumping for farmland irrigation threatens dry-season water levels there. Moreover, the mountainous terrain and steep slopes, combined with rain and melting snows, lead to rapid runoff and floods. Climate change is expected to affect the reserve through higher mean temperatures and lower annual precipitation, and restoration approaches should take these aspects into consideration.

17 *Source*: Colomer, Regato and Enciso Encinas (2014).
18 www.mediterraneanmosaics.org
19 www.shoufcedar.org

Approach

The project is focusing on seven areas of work:

- Direct sowing of *Quercus brantii* in areas characterized by steep slopes and scarce vegetation cover.
- Planting seedlings of a selection of native species to enhance habitat functionality and species diversity. This site is located at the highest altitude of the study area (1500–2000 m).
- Fenced plots to restore "woodland islets" in extensive overgrazed areas.
- Combined direct sowing and seedling planting in a quarry waste dump with very sandy soils.
- The border of the Ammiq wetland, where a "green" barrier will be created between the road and the wetland to increase the diversity of riparian forest habitats and enhance bird habitats.
- The rehabilitation of old abandoned terraces to restore viable traditional farming systems.
- Dalboun Oak Forest, where the objective is to remove part of the biomass of unmanaged, low-diversity coppice regrowth. Among other benefits, this will reduce fire risks and improve bird habitat.

6.9 ADDRESSING LANDSCAPE RESTORATION THROUGH INTEGRATED WATERSHED MANAGEMENT IN THE BAGMATI RIVER BASIN, NEPAL[20]

Coordination: the Bagmati Integrated Watershed Management Programme (BIWMP) was initiated and coordinated by Nepal's Department of Soil Conservation and Watershed Management in the Ministry of Forest and Soil Conservation, with the active support of the European Commission. An evaluation of Phase 1 of the BIWMP (1986–1992) produced suggestions for improving community organization, extension, the integration of activities, and income-generation activities, which were incorporated in Phase 2 (1992–2003).

Threat

The main environmental threat is land degradation caused by streams cutting into fields and by subsurface runoff causing landslips. These processes affect the stability of adjacent agricultural land, with its small-scale farming, and cause problems downstream.

Approach

Aim: poverty reduction through environmental-friendly income generation, soil and water conservation in agriculture and forestry, erosion hazard treatment and infrastructure improvement.

An innovative landscape restoration approach was taken that fostered multistakeholder partnerships and cooperation among local institutions (e.g. village development committees, local NGOs, community forest user groups and individual households), line agencies, district authorities and researchers.

20 *Source*: WOCAT (2007).

The programme paid special attention to the equitable involvement of women and socially disadvantaged groups, with an emphasis on local ownership, institutional capacity building and sustainability.

The planning, implementation and monitoring of identified activities were carried out in a participatory manner, and a flexible approach was taken that considered the priorities of villagers and allowed adaptation to new findings.

Policy and land governance. The BIWMP helped secure traditional land-use rights on government-owned land to facilitate the implementation of a combination of landslip, gully and streambank soil stabilization measures by clusters of neighbouring families.

Community development. The BIWMP built the capacity of community groups through community-level training and the establishment of communication facilities (e.g. telephone and radio) and by building community networks and empowering women and disadvantaged groups.

Extension methods. The BIWMP conducted participatory rural appraisals; training; farmer-to-farmer exchanges; workshops; seminars; and on-site demonstrations, with a high level of impact on land users.

Research. Multidisciplinary research on sociology, economics/marketing, ecology and technology development involving scientists and BIWMP staff was an important part of the approach and a key element of success. Land users and soil and water conservation (SWC) specialists worked together, providing opportunities for users to share, learn and test watershed management technologies.

Technology development. A group of neighbouring families was actively involved in the implementation of a pilot technological package new to Nepal to address landslips, gully formation and streambank erosion in the Middle Hills. Initially, ditches with bunds on the lower side were constructed along contours. Within gullies and along streams, cement bags (filled with cement, brick chips, sand or earth) were placed to avoid deepening channels, and fences made of woven bamboo were also used as checks in gullies. These structures were complemented by vegetative measures on degraded sites involving the planting of multipurpose plants such as the nitrogen-fixing Nepalese alder (*Alnus nepalensis*), bamboo (*Dendrocalamus* spp.), cardamom (*Elettaria cardamomum*) and broom grass (*Thysanolaena maxima*), with quick growth and the capacity to improve soil fertility and control erosion.

Implementation costs. Local stakeholders contributed three-quarters of the cost: 18 families (47 percent) adopted the technology with incentives (partly paid labour and the provision of seedlings, bamboo culms and cement bags), and 20 relatively

well-resourced families (53 percent) spontaneously adopted the technology because of its economic benefits on marginal land.

Income generation. Farmers generate income by harvesting the various plants used in the restoration process, obtaining economic benefits within a few years.

Cost–benefit analysis. The technology requires vegetative resources that are largely locally available and cheap: farmers already know how to propagate them, and maintenance costs are negligible. Once established, the stabilized and revegetated sites provide benefits for farmers within a few years (e.g. fodder, litter and timber), improve environmental conditions for birds and insects (thus favouring biodiversity), and help protect natural springs. Another advantage is that the location is used regularly as an unofficial demonstration site and is visited by various people (such as farmers and SWC specialists) interested in the technology.

Replicability

The positive outcomes of the BIWMP demonstrate that this is a suitable approach in Nepal for improving soil and water management on steep and very steep slopes in a subhumid climate, and it could be applied widely both in Nepal and elsewhere. While the technology was being pilot-tested in the BIWMP area of influence, farmers outside the area also took it up. The approach is easy to replicate through village initiatives supported by government, with minor investments in training and disseminating knowledge via farmer-to-farmer interactions. The involvement of village politicians, decision-makers and planners in monitoring the impacts of the BIWMP helped in the development of similar watershed management activities in other areas.

Risk assessment

Socioeconomic conflicts can arise due to a lack of equity and unfair benefit-sharing. The technology has been adopted to a greater extent by better-resourced farmers because of the high establishment costs, and the increase in benefits derived from increasing the value of land is not shared with the poor. Government programmes should involve poor farmers in land development (with incentives for the adoption of demonstrated technology) and in spreading the benefits. Establishment costs can be reduced by subsidies and the design of alternative low-cost structural measures that do not use cement.

6.10 ANATOLIA WATERSHED REHABILITATION PROJECT, TURKEY[21]

Lead organization: the Turkish Ministry of Environment and Forestry, supported by the World Bank and the Global Environmental Facility.

21 *Sources:* World Bank (2012); World Bank (2004); and the FAO Forest Restoration Monitoring Tool.

Threat

Rural poverty is a major cause of environmental degradation in watersheds, exerting pressure on land and forest resources through the overharvesting of goods and environmental services such as timber, fuel and fodder and the overuse of grazing and cultivation areas. In Turkey, the livelihood needs and activities of rural poor communities in sloping terrain contribute to deforestation, flooding and sedimentation, as well as to the degradation of land and water resources, thus reducing the carrying capacity and fertility of land in upper catchment areas. These threats, exacerbated by a lack of effective soil conservation and reduced vegetative cover, negatively affect the resilience of farming households and increase poverty in upland regions.

Policy and land governance. Turkish authorities have undertaken various watershed rehabilitation initiatives since the 1950s to reduce soil erosion, decrease flood damage and improve dam safety. Among them, the Anatolia Watershed Rehabilitation Project, which was launched in 1993 with the support of a World Bank loan, used a holistic and participatory approach to natural resource management at the watershed scale ("integrated watershed management") to improve land-use sustainability in 85 microcatchments. The project was consistent with the National Environment Action Plan, which aimed to promote the adoption of better agricultural practices, reduce soil and water pollution from agricultural sources, and increase the quality of forestlands, rangelands and farmlands. Nonetheless, the Forestry Sector Review, prepared jointly by the World Bank and the Government of Turkey in 2001, showed that several key issues were affecting natural resources and the environment, such as poverty, land tenure, soil erosion and the lack of multipurpose and participatory natural resource management. Institutional reorganizations were initiated to improve the effectiveness of environmental management and to more closely align the Turkish environmental policy framework with that of the European Union.

Approach

Aims: 1) to promote sustainable natural resource management methods, save topsoil from erosion, and alleviate rural poverty in 28 upper microcatchments in the Amasya, Çorum, Samsun, Tokat, Sivas and Kayseri provinces, saving an estimated 1.5 million tonnes of soil annually and raising the incomes of communities affected by resource degradation; and, in compliance with European Union environmental directives such as the Water Framework Directive and through Global Environment Facility-supported activities; and 2) to introduce farming practices that reduce agricultural leaching and runoff in the Black Sea watershed.

The Anatolia Watershed Rehabilitation Project involved the following:

- An integrated and participatory approach was taken to microcatchment natural resource management, including considerations of forestry, SWC, crop and livestock production, and off-farm income generation. For example, a team of local extension agents worked with villagers to identify resource

management problems and prioritize actions, while implementing agencies created conditions that encouraged the land users themselves to adopt more productive and protective land management systems.
- Activities included the rehabilitation of degraded natural resources, including forestland, rangeland and agricultural land rehabilitation, along with environmentally friendly agricultural practices; income-raising activities to provide participating communities with incentives to undertake conservation efforts, even if they incurred short-term or medium-term costs (e.g. the short-term closure of rangelands and the longer-term closure of forestlands) or if benefits could only be reaped in the long run (e.g. afforestation); the strengthening of policy and regulatory capacity with a view to meeting European Union standards; an awareness-raising, capacity-building and replication strategy; and project management and support services.
- Native species were used in the project's planting activities, but selected individual plants already growing on the sites were also retained. Seedlings were provided exclusively by 125 government nurseries.

Community involvement. The project used a community-based approach; that is, one based on public participation in decision-making and using decentralized implementation arrangements. Accordingly, all communities and related groups concerned with natural resource management were involved in all microcatchment management processes: decision-making, planning, implementation, monitoring, evaluation and assessment.

Extension and training methodology. Farmers and communities within and around the project area were provided with training related to, for example, new agriculture-based income-generation/diversification activities, environmentally friendly agricultural practices, sustainable manure management, organic farming and the marketing of organic products, and best practices in nutrient discharge. Field trips were organized to participating microcatchments to observe first-hand the economic and ecological benefits of project activities. Public-awareness programmes on the causes and effects of land degradation and measures for natural resource rehabilitation were undertaken in all 28 project microcatchments.

Impact

The overall result of the project was the conservation, rehabilitation and development of degraded natural resources on sloping land. The project led to:
- an increase in vegetative cover (by 74 percent), soil fertility, and agricultural productivity (e.g. by 182 percent for sainfoin, 89 percent for chickpea and 18 percent for alfalfa);
- poverty alleviation and increased household incomes (by 53 percent), in addition to employment opportunities;
- the adoption of environmentally friendly agricultural practices (by 30 percent of farmers in the project area) and technical innovations in domestic energy use;

- a reduction in nutrient leaching and runoff through improved manure management and decreases in the purchase of fertilizers (by 60 percent of farmers in the project area);
- the harmonization of Turkish legislation with that of the European Union (e.g. Nitrates Directive 143);
- improved water resource management (flow and quality); and
- community empowerment.

Sustainability

If the various interventions carried out within the framework of the project are maintained, the economic, social and environmental benefits are likely to be sustained beyond the project's life. If the nutrient load reduction activities are replicated on a much larger scale – in a coordinated, multi-country effort – it is hoped that water quality in the Black Sea will improve significantly in the long term. Promoting, maintaining and developing cooperation among implementing agencies and local communities on watershed-based activities is expected to strengthen the participation and capacity of communities to develop and implement microcatchment plans. Training and institutional strengthening to support sustainable natural resource management is needed to foster further watershed rehabilitation initiatives in Turkey.

Lessons learned

- Participatory design is the key to promoting project ownership.
- A flexible approach allows timely adaptations to changing needs and circumstances.
- Establishing a direct link between natural resource rehabilitation and tangible economic and social benefits is critical for increasing the uptake of natural resource management.
- The dissemination of information through public-awareness programmes is crucial for the widespread adoption of new practices and technologies.

6.11 RESTORATION IN THE CHINA LOESS PLATEAU[22]

Threat

The Loess Plateau in north-central China is a large, hilly, semi-arid region covering an area of 640 000 km² and home to 70 million people. Unsustainable farming practices such as overgrazing and intensive agriculture during the Cultural Revolution, and high population growth, left the former grasslands degraded and eroded. Desertification resulted in low food productivity. Waterways filled with silt, and the air in faraway cities suffered sandstorms born on the Loess Plateau.

22 *Main sources:* www.wri.org/blog/2014/12/taking-culture-account-restoring-china%E2%80%99s-loess-plateau; www.worldbank.org/en/news/feature/2007/03/15/restoring-chinas-loess-plateau; Jiang *et al.* (2013); and Jiao *et al.* (2012).

Approach

Restoration on the Loess Plateau began at the end of the 1950s, when the Chinese Government invested in afforestation campaigns to reduce soil and water erosion and ensure food security. The government invested US$100 billion in six forest restoration programmes covering 76 million ha in 97 percent of China's counties. The "Grain for Green" conservation programme, which was launched in 1999, is a land-use transition, watershed management and poverty alleviation programme involving millions of rural households to increase tree and vegetation cover, reduce erosion, terrace their lands, and earn payments for environmental services.

Two projects funded by the World Bank, the Chinese Government and other institutions between 1994 and 2005 enabled farmers to restore 4 million ha on the Loess Plateau by supporting activities such as the conversion of sloped land to terraced lands; the building of control dams, small water cisterns and other small-scale irrigation systems; grazing control; and the planting and protection of trees (including fruit and nut-bearing trees), shrubs and grasses.

Impact

More than 2.5 million people benefited directly or indirectly from the projects; the condition of natural resources was improved and sustainable and diversified farming practices were introduced. The main achievements of the projects were the following:

- Agricultural productivity increased, allowing project households to increase their incomes from US$70 to US$200 per person per year.
- Vegetation and soil resources were protected from uncontrolled grazing, excessive woodfuel collection and on-slope crop cultivation. Tree planting, coupled with grazing bans, allowed an increase in perennial vegetation cover from 17 to 34 percent.
- The sediment flow from the Loess Plateau to the Yellow River was reduced by more than 100 million tonnes yearly. A network of small dams has reduced flooding risks and enabled the storage of water for dry periods.
- The diversification and increase in productivity of agriculture and livestock production allowed increases in on- and off-farm employment, including increased opportunities for women.
- Increased and more stable yields enabled a significant increase in food supply. Food production diversified and shifted from a narrow range of food and low-value grain commodities to high-value products.
- The project contributed significantly to the restructuring of the agriculture sector and adjustment to a market-oriented economic environment, and it created conditions for sustainable soil and water conservation.

Lessons learned

- The large-scale economic and ecological changes that have occurred on the Loess Plateau are the result of efforts made with strong governmental

support, involving policy improvements, technical support, long-term investments and local ownership. The outcomes demonstrate the clear link between ecosystem restoration and livelihood improvement.

- Despite the success, in some areas afforestation has resulted in negative impacts, including high tree mortality rates, increased soil erosion, exacerbated water shortages and deep soil desiccation.
- Afforestation is reported not to have provided additional benefits in terms of species diversity, soil nutrients and reduced soil erosion compared with natural recovery. The use of inappropriate species has been reported to be the cause of water scarcity due to competing uses.
- Studies show that not all soils on the Loess Plateau are well suited to afforestation and that, in many areas, priority should have been given to restoration with native grasses and herbs rather than trees which were not part of the natural vegetation. Natural revegetation without intensive human interference (such as farming and grazing) is recommended as the more appropriate restoration approach. Soil moisture should be used consistently as a restoration success indicator.

6.12 AFFORESTATION OF THE DRIED ARAL SEA FLOOR TO COMBAT DESERTIFICATION AND CLIMATE CHANGE IN UZBEKISTAN[23]

Lead institution: Uzbek Forestry Research and Scientific Institution (UFRSI).

Threat

The Aral Sea was once one of the world's largest inland water bodies, but it underwent a dramatic drying process in the second half of the twentieth century due to the diversion of water from its tributary rivers to feed intensive agriculture (mainly cotton) in Kazakhstan and Uzbekistan. The desertification process had unparalleled catastrophic effects, leading to a dramatic decrease in agricultural yield, changes in the climatic conditions of Central Asia, and a sharp decline in the livelihoods of riverine communities. Today, 6 million ha of dried-up sea bed lie fallow, and 450 000 ha of salt marshes have been created. The area is subject to frequent sandstorms, where sweeping winds can reach speeds of 20 m per second.

Approach

Aim: to fight desertification, climate change and the loss of soil and fertility on the dried Aral Sea floor and the surrounding region, while producing oxygen and absorbing carbon dioxide through the creation of new forests.

UFRSI led an integrated afforestation project on sandy and loamy soils and shifting sands using well-adapted, salt-tolerant local species, especially the tree *Haloxylon ammodendron (*black saxaul). After a preliminary research and impact evaluation phase, the project promoted the harvesting of seeds from selected wild

23 Compiled based on a presentation made by Zinoviy Novitskiy (The Landscape and Forestry Research Center, Uzbekistan) at the First International Experts Workshop on Drylands Restoration, held in May 2012 in Konya, Turkey.

populations of target species and the establishment of a network of nurseries. Seedlings were then planted using mechanized procedures and dung used as a fertilizer. The new plantations were protected by fixing sand dunes with grids of dried canes and by planting pioneer grasses. Afforestation also included the use of herbs and bushes (*Aellenia*, *Astragalus* and *Eurotia*, etc.) to create new pastures.

Community involvement and beneficiaries. Workshops and practical field training sessions were organized to raise awareness and build capacity in local communities on the use of black saxaul plantations and restored pasture sites. The project also helped develop capacities in the local forestry administration and among students of the Tashkent Agrarian University to ensure the future management of the newly forested sites and to expand the breadth and width of the initiative – including into neighbouring Kazakhstan.

Impact

The project has already brought about a significant improvement in the local environment. The desertification process has been halted where the forest plantations have been established. Wind speeds have decreased significantly in 3-year-old plantations, and the transfer of salt and dust has declined six-fold. In 6-year-old plantations, the wind speed has dropped even more, and salt and dust transfer is almost zero. It has been calculated that 1 ha of 4-year-old black saxaul absorbs 1 158 kg of carbon dioxide and releases 835 kg of oxygen per year. To date, 400 000 ha of forest plantations have been established on dried seabed, which annually release 334 000 tonnes of oxygen and absorb 4.632 million tonnes of carbon dioxide – a significant contribution to the Kyoto Protocol by Uzbekistan.

6.13 FIGHTING SAND ENCROACHMENT IN MAURITANIA[24]

Lead organization: Ministry of Environment and Sustainable Development of Mauritania, supported by FAO, the Walloon Region of Belgium, and the Association pour la Promotion de l'Education et de la Formation à l'Etranger (APEFE).

Threat

Since the late 1960s, Mauritania has been severely affected by repeated droughts. The main effect of desertification is sand encroachment, which has reduced the area of arable land, grazing land and forests and the supply of water, and is a major threat to infrastructure. The region of Nouakchott has been particularly affected by land degradation and sand encroachment following rapid population growth and consequent increased pressure on natural resources.

Approach

Desertification control has always been a national priority and is incorporated into the country's overall process of sustainable development, encompassing

24 *Main source:* FAO (2010d).

technical, socioeconomic, legal and institutional factors. Within this framework, national-level programmes and projects have been implemented with the support of development partners with the aim of fostering conservation and agrosilvopastoral development and fighting sand encroachment through dune fixation and the development of planting and management schemes to protect land and infrastructure.

In 1999, the Government of Mauritania sought the assistance of FAO and the Walloon Region of Belgium to launch a programme aimed at rehabilitating and extending tree plantations established near Nouakchott. The first step was to mechanically stabilize dunes by erecting fences of unwoven branches of *Leptadenia pyrotechnica* and *Prosopis juliflora*, which were placed directly in previously dug trenches. Once the dunes were stable they were fixed permanently by planting perennial grassy and woody vegetation after the first rains. Tree nurseries were set up and managed by communities, giving priority to the production and use of indigenous woody and grassy species. Restored areas were protected by permanent guards, who were posted to prevent livestock from wandering from dedicated livestock corridors and to reduce illicit human activities (such as the collection of wood and the cutting of fodder).

A participatory approach was a key to achieving long-term, sustainable results. The approach linked administrative and municipal authorities, technical services and communities directly affected by sand encroachment in the target zones. Local communities and national authorities played important roles in planning and delivering activities and in selecting appropriate local plant species. Regular meetings were organized with administrative and municipal authorities and the leaders of cooperatives and NGOs. Guards were recruited in villages near the planted areas to protect restored areas.

Result

A total of 400 000 plants were grown in nurseries and used to fix 857 ha of threatened land between 2000 and 2007. Significant natural regeneration of grasses – particularly *Aristida pungens, Panicum turgidum, Cyperus rotundus, Elionorus elegans* and *Eragrostis* spp. – was achieved in and around all the areas treated. The restored areas ensure the protection of human infrastructure (such as dwellings, mosques, crops, market gardens and roads) and farms and grazing lands against sand encroachment. Techniques for mechanical stabilization and biological fixation were improved, along with techniques for the production of seedlings. New techniques were also developed for the management of new plantations and the protection of infrastructure.

In 2010, the Government of Mauritania decided to strengthen the sustainability of these results and to extend their scope to the national level by strengthening the capacities of forest staff at the Ministry of Environment and Sustainable Development. A partnership between the Ministry and Belgium's APEFE was initiated to enhance the capacities of forest technicians in combating desertification, stabilizing dunes, and plantation management techniques through

a series of training courses. In total, 84 forest technicians are being trained through the programme, which will allow them to carry out extension work at the local level. Moreover, the scope of the initiative is being extended to the subregional level through cross-border exchanges and study trips.

Lessons learned

- Sand encroachment can be fought efficiently through dune stabilization using mechanical and biological means. This technique has the potential to protect urban and peri-urban land and infrastructure, as well as grazing lands and farms, provided that adequate nursery, plantation and management techniques are available, as well as efficient measures to protect restored areas.
- A participatory approach, with the continual involvement of local actors, is indispensable for sustaining results in the long term.
- An effective framework for capacity development allows the scaling up and sustaining of results. The strategy for training forest technicians is a key to the extension and implementation of successful techniques on the ground, as is raising the awareness of local actors and NGOs.

6.14 THE ECOGRAZE GRAZING MANAGEMENT SYSTEM IN AUSTRALIA[25]

Lead organization: Meat and Livestock Australia (MLA).

In 1992, MLA, a producer-owned company that provides services to the Australian red-meat industry, initiated the Ecograze project, an eight-year collaborative research project undertaken by Sustainable Ecosystems at the Commonwealth Scientific and Industrial Research Organisation and the Queensland Department of Primary Industries, with input from the Queensland Department of Natural Resources and Mines. Although formally concluded in 2001, many of the analyses and extension activities are ongoing.

Approach

Aim: to provide a flexible system for innovative grassland management options – rotation and resting – in the Eucalyptus woodlands of northeast Queensland, developed through collaborative applied research between researchers, farmers, the beef industry and the government.

Threat reduction: adjust grazing needs to prevent pastures in good condition from degrading, and restore/improve deteriorated pastures, according to climate and the state of the "3P grasses" (native perennial, productive and palatable grasses).

Intervention area: five commercial grazing properties that spanned different conditions and consequently allowed the extrapolation of results to a much wider area of northern Australia.

25 *Source:* WOCAT (2007).

The Ecograze system includes wet-season resting and is based on the establishment of groups of three rotational grazing units (paddocks) with two herds within a rotational system. The key is that all paddocks get wet-season rests in two of every three years. Wet-season rests have two phases:

1) The early wet-season rest, which starts after the first rains in November/December and continues for 6–8 weeks, is particularly good for perennial grass recovery.
2) The late wet-season rest lasts until March/April and aids both seed-set and vegetative recovery.

The average size of paddocks is 3 000 ha (commonly 6 km × 5 km), subdivided into three paddocks of relatively equal size using internal fences, although there is some flexibility to account for variation in the productive capacity of land types within paddocks. Paddocks are fenced and extra water points installed using polythene piping and water troughs; pumps are established as required.

Investment costs. Labour inputs for implementation are provided on a voluntary basis. The cost of fencing and associated gates is about US$1 200 per km, and the cost of labour for fencing is also about US$1 200 per km (equivalent to US$4 per ha). The Natural Heritage Trust and the National Action Plan for Salinity and Water Quality provided part of the funding for fencing and subdividing paddocks. Subsidies to attend training courses assisted in the uptake and adoption of Ecograze. Credit was not provided as part of the ongoing extension of the technology.

Management challenges. There are two main management challenges: the timing and length of the early wet-season rest, which depends on how effectively the early rains promote the vegetative growth of perennial grasses; and the movement of animals during the wet season. The number of stock movements is fixed but the timing is flexible and should be responsive to the situation. The challenge is to assess the pasture condition, read the situation, and schedule the timing and length of rest periods accordingly. The main criterion is the recovery state of perennial grasses.

Community involvement. Ecograze is well-suited to individualized grazing systems, and private leaseholders have adopted the Ecograze principles. Local landcare groups often request assistance, and this is provided by research agencies and extension officers or through grants from the Natural Heritage Trust.

Research. Research teams are testing the costs and benefits of grazing management technologies in commercial situations to understand the real costs and implications of implementing the research-derived Ecograze recommendations. The on-farm tests are supported financially by a number of new initiatives on land management practices to reduce runoff erosion, sedimentation and the nutrient pollution of water bodies. Through the central involvement of research, management options have been identified to suit various land users, climates, grazing pressures and pasture

conditions.

Extension and training methodology. The national government extension staff based in northeast Queensland actively promoted the Ecograze management principles and assisted producers in planning and implementing these new practices. Through ongoing research trials in cooperation with researchers and land users, extension agents built up their capacity to support farmers with free advice. Many of the Ecograze principles are included in the Grazing Land Management Education package, delivered via three-day workshops. There is also significant interaction among neighbouring properties in sharing ideas, successes and failures. Commonly, these neighbouring properties are linked through catchment or landcare groups.

Cost effectiveness. The return on investment can be realized within a few years.

Impact

Around 700 (of a total of 15 000) farmers across northern Australia have already adopted at least some aspects of Ecograze. Three of the five farm families involved in the on-farm research and development of Ecograze have taken up some aspects of the research. Erosion and sediment flows have reduced, pasture productivity and soil carbon reserves have improved, and perennial grass biodiversity and cover, animal carrying capacity and associated profit have all increased. Surveys indicate spontaneous adoption beyond the region, and research continues to have a very positive impact. State government extension agencies readily accept Ecograze and are actively promoting its principles with landholders.

Risk assessment

Although many farmers are expected to adopt the technology in the short and medium terms, it is recommended that options be investigated for government subsidies to help reduce investment costs (especially in fencing and new water points), and that more educational and demonstration efforts be undertaken to raise farmer awareness of the advantages of Ecograze and its long-term economic benefits and to accelerate the rate of change.

6.15 PLANNING FOR FIRE-SMART LANDSCAPES IN THE MEDITERRANEAN: LEBANON'S NATIONAL FOREST FIRE MANAGEMENT STRATEGY[26]

Lead organization: Government of Lebanon (Ministry of Environment, Ministry of Agriculture and Ministry of Interior and Municipalities), supported by the Association for Forests, Development and Conservation and the International Union for Conservation of Nature.

26 *Sources:* FAO (2010e); Ministry of Environment (2009).

Threat

The growing trend of large-scale, devastating fires with huge economic, social and environmental costs have pushed the authorities of several Mediterranean countries to revise their legislative frameworks with a view to improving fire and fire-disaster management.

In Lebanon, the lack of a holistic, intersectoral and participatory approach to forest fire management (in policy, implementation, rehabilitation and monitoring) has been implicated in an increase in fire problems that threaten forest ecosystems and economic development.

Approach

Aim: to reduce the risk of intense and frequent forest fires while allowing for fire regimes that are economically, socially and environmentally sustainable, as per the National Forest Fire Management Strategy approved by the Government of Lebanon in May 2009.

The strategy integrates the following five components with a climate-change adaptation focus:

- research, information and monitoring;
- risk modification, including fire vulnerability reduction and the prevention of damaging fires;
- readiness, covering all provisions intended to improve interventions and safety in the event of fire;
- response, including all means of intervention for fire suppression; and
- recovery, including the rehabilitation and ecological restoration of healthy forest conditions and the provision of support to individuals and communities in the short-term and medium-term aftermath of fire.

The strategy also proposes mechanisms for the participation of, and capacity building among, all concerned stakeholders, and promotes incentives for restoring healthy forests and adopting resilient land uses.

6.16 COMMUNITY-MANAGED EXCLOSURES IN THE TIGRAY, ETHIOPIA[27]

Threat

Ethiopian drylands face severe degradation, including soil erosion, due to deforestation, the expansion of agricultural land, and overgrazing. In the Tigray in the highlands of Ethiopia, food security and livelihoods are affected by a reduction in agricultural productivity associated with land degradation.

Approach

Exclosures have been used mainly in the last two decades (1991–2013) in the Tigray. They are areas that are protected from woodcutting, grazing by domestic animals, and other agricultural activities, with the goal of promoting the natural regeneration of plants and the rehabilitation of degraded communal grazing lands.

27 *Source:* World Agroforestry Center (2014).

The process starts with representatives of local communities (i.e. a development committee) and development agents from the Ethiopian Government identifying potential sites for exclosure. Sites are selected based on physical criteria, the interests of local people and other socioeconomic criteria. Exclosures are protected using guards rather than fences, which reduces establishment costs.

Impact

In the Tigray it is estimated that more than 1.5 million ha of land have been rehabilitated in a period of over 20 years, benefiting about 2 million people. Several hundred thousand ha are now under exclosure regimes.

The conversion of degraded land through the deployment of exclosures is relatively low-cost. It reverses land degradation processes, with many associated advantages: it reduces runoff and soil erosion; improves the microclimate and water infiltration; restores soil nutrients; produces livestock fodder, woodfuel and grass for house construction; and enhances biodiversity. Moreover, it has the potential to increase carbon stocks at a rate of 246 kg per ha. If all benefits are taken into account, exclosures provide a better return than other agricultural land uses such as intensive cultivation and livestock grazing. Surveys of local people showed that more than 75 percent of households had a positive view of the effectiveness of exclosures in restoring degraded lands.

Moreover, although the initiative started at the community level, its success influenced the revision of agricultural policies in Ethiopia and contributed to a national strategy called "climate-resilient green economy". Community bylaws related to the protection and management of exclosures were translated into law, contributing to the spread of these systems to drylands elsewhere in the country.

Lessons learned

Community-managed exclosures are a proven and cost-effective management option in Ethiopia for enhancing resilience while restoring land and providing goods that can be harvested during dry seasons and droughts. The sense of ownership of the technology in the community, and the equitable distribution of benefits among community members, are keys to success.

6.17 THE FARMER-MANAGED RESTORATION OF AGROFORESTRY PARKLANDS IN THE SOUTHEAST OF THE NIGER[28]

Threat

Severe droughts in the Sahel in the twentieth century caused major human and environmental crises. Declines in agricultural productivity and tree cover, food shortages, and an increase in soil degradation and wind erosion can be attributed to the combined effects of climate change, demographic pressures, and sociopolitical changes.

In the Maradi region of the Niger, crop yields were declining in the early 1980s

28 *Source:* Reij, Tappan and Smale (2009).

and cultivated land was expanding at a similar rate to the population. The landscape was denuded and exposed to severe wind erosion, causing sandstorms and dust storms and damaging crops and health. Hausa farmers were forced to move away from densely populated areas, and they settled in land officially reserved for pastoral communities.

Approach

Farmers began perceiving ownership of their on-farm trees in the mid-1980s. This change in perception may have been stimulated by shifts in national policy but also by weakening governance due to a political and economic crisis. Land rights were reinforced by a new forest regime established in 2004, which provided farmers with rights to the private ownership of trees.

FMNR "adapts centuries-old methods of woodland management to produce a continuous harvest of trees for fuel, building materials, food and fodder without the need for frequent, costly replanting" (Reij, Tappan and Smale, 2009). Native trees and shrubs that regenerate naturally from dormant seeds, stumps and roots are protected and managed among crops.

Farmers use four steps to produce parklands. When land is cleared to plant crops, tree stumps are selected from the mature root systems that are present in the soil and according to species' preference (for food, fuel or fodder). The tallest and healthiest stems are selected, pruned and protected, and the others are removed. Finally, farmers remove new stems as they emerge and prune surplus side-branches.

The most common species that regenerate naturally and are protected by farmers in the Niger are *Faidherbia albida* (known as *gao* in the Niger), *Combretum glutinosum*, *Guiera senegalensis*, *Piliostigma reticulatum* (camel's foot) and *Bauhinia rufescens*, as well as *Adansonia digitata* (baobab) and *Prosopis africana* (ironwood).

In total, 5 million ha of degraded land were restored using FMNR in the Niger, involving 1.25 million households and benefiting 2.5 million people (in a total population in the Niger of 14.2 million in 2007). The average cost per ha (household labour spent on protection) was US$20. According to interviewed farmers, trees generate multiple benefits, including by providing protection from the wind and reducing evaporation. Trees also produce at least a six-month supply of fodder for on-farm livestock, as well as woodfuel, fruits and medicinal products.

Impact

Crop productivity. Average cereal crop yields increased by 100 kg per ha, which suggests that FMNR contributes to the production of an additional 500 000 tonnes[29] of cereal. The number of on-farm trees increased by over 200 million countrywide, and aboveground biomass reached 4.5 tonnes per ha in a study area southeast of Zinder. Nitrogen-fixing species such as *Faidherbia albida* significantly enhanced soil fertility.

Food security. Food security is increased by the higher crop yields achieved in FMNR fields. FMNR also has an indirect impact on food security by producing

29 Reij, Tappan and Smale (2009) reported increases in these units.

tree-crop products such as fodder for livestock, woodfuel, leaves, medicines and construction materials, and they can help families cope with periods of food shortages through the consumption and sale of tree products.

Equity. In three districts in Zinder Department, women have free access to dead wood in the fields, as well as to other products. Wood and baobab leaves are used or sold, which improves the economic position of women involved in FMNR and their capacity to feed their families. Women may therefore be the biggest winners from FMNR.

Agroenvironmental impacts. In a study area in the Niger, tree cover increased from less than 1 percent of the land area in 1975 to 8 percent in 2005, and it is expected to increase even more due to the high density of young trees. This indicates the potential of FMNR to increase tree cover over time and to sequester carbon in biomass.

Lessons learned

FMNR has many advantages that make it rapidly scalable:

- Its implementation depends largely on individual and community initiatives, and there are no external costs. The technique is cheap, which makes it easy for land users to adopt it.
- It is easy to learn, with no need for high literacy.
- It provides direct and long-term benefits to land users within a short timeframe
- It has strong potential to diversify economic opportunities.

6.18 HABITAT RESTORATION AND THE SUSTAINABLE USE OF SOUTHERN PERUVIAN DRY FORESTS[30]

Lead organization: the Royal Botanic Gardens, Kew, supported by the United Kingdom's Department of Environment, Food and Rural Affairs' Darwin Initiative and the Universidad Nacional San Luis Gonzaga de Ica (UNICA).

Threat

Excessive human pressure (e.g. overgrazing, overharvesting for charcoal and firewood for the Pisco distilling industry, and excessive groundwater use for agriculture), poverty and the abandonment of traditional sustainable irrigation and grazing practices have fragmented and degraded the mosaic riparian dry forests, which have limited regeneration capacity. Degradation of the vegetation has also caused serious erosion problems, including the formation of gullies, and led to the invasion of exotic species.

Approach

Aims: 1) to increase knowledge of south-coast vegetation communities, flora and fauna, incorporating local knowledge; 2) to demonstrate community-based

30 *Source:* Whaley *et al.* (2010).

restoration techniques – with the active involvement of local policymakers – of the natural riparian dry habitats that play vital roles as corridors between the Andean foothills and the coastal plains; and 3) to raise awareness among landowners, businesses and the regional government of the importance of plant conservation in the restoration of people's quality of life by demonstrating income opportunities from tourism and the use of keystone *Prosopis* spp. (huarango) tree pods.

Restoration trials. These were established in three small local communities and at three agro-industrial sites. A memorandum of understanding was signed with UNICA's Faculty of Agronomy for the establishment of a plant nursery for the production of seedlings of 30 native species from seeds and cuttings. UNICA students monitored the trials monthly or bi-monthly (e.g. for seedling height, canopy area, phenology and health). In the local community restoration trials, areas were fenced in agreement with landowners, seedlings were planted and irrigated with water from nearby wells, and empty tree pits were irrigated to encourage natural regeneration. In the agro-industrial trial, native woodland species were planted to replace non-native species in windbreaks and hedgerows using drip-feed irrigation. Native species were established in comparative plots using low-consumption drip-feed, manual surface and subsurface irrigation regimes and grey (sewage) water. In addition to watering regimes, the trials compared planting techniques and densities. Locally referenced habitat restoration, including measures to attract birds, was also carried out, and drip-feed irrigation and traditional tree-pit watering were compared.

Extension/training methodologies. Extension and training involved workshops, local school programmes and festivals, supported with posters, handouts and didactic publications for local audiences. Staff at the MSBP and the Royal Botanic Gardens, Kew also provided training in the development of low-cost seed-storage, germination and propagation protocols.

Research. Research comprised botanical surveys, flora and fauna inventories and maps incorporating local ethnobotanical knowledge of the ten distinct vegetation communities occurring between sea level and 1 800 m, including the vitally important and poorly understood nitrogen-fixing microphytic communities of biological crusts.

Technological development. Technologies developed under the project included the following:

- During the fog season, fine nets were able to trap, on average, 10 l of fog water per day per m^2 of net (a *Prosopis* tree with a 3-metre-high by 4m wide crown captured up to 9 l per night).
- Traditional techniques were incorporated into practices (i.e. in schools' planting programmes), such as the use of "coated seeds" whereby clumps of mud and mixtures of seeds of native species are baked, dried and buried in the courses of irrigation channels and ephemeral streams to await natural flooding.

- In comparing irrigation regimes, it was determined that an inexpensive subsurface watering technique developed by the project using recycled plastic bottles to dispense 3–4 litres per week provided the best growth (by height and canopy area); compared with traditional tree pit-watering, the growth of *Prosopis* increased by more than 100 percent, *Acacia* by 20 percent and *Schinus* by 300 percent. This subsurface method thus proved an excellent way of avoiding excessive evaporation.

Impact

Restoration trials. The local community trials achieved mixed results in terms of plant survival (for example, *Schinus molle* and *Acacia macracantha* became well established, but *Capparis avicennifolia* proved difficult to grow), with survival challenged by shallow soils and water constraints. Pumping water proved uneconomic, and soils were nutrient-deficient. Viable restoration should be based on rebuilding the river-flooding system with traditional knowhow and techniques. Collective labour or machinery is required to move boulders into river beds to raise the water level and to capture sediments during seasonal floods, thereby reconnecting river flow with irrigation channel intakes. This technique may have considerably wider application in large-scale restoration.

In the agro-industrial trials, the project involved industry workers in the planning and field-planting of a 3-ha site with 24 native species, thereby helping the dissemination of local knowledge to workers. Under a low watering regime (1 litre per week) with an asparagus "straw" mulch, *Acacia macracantha*, *Schinus molle* and *Prosopis limensis* seedlings showed double the height growth and three times the canopy area compared with the control. Sewage dumping allowed the establishment of a high-biodiversity grove of *Prosopis limenis* and *Parkinsonia praecox* featuring birds, desert foxes and native bees. Planting densities affected height growth and canopy area in different ways, according to species: for example, the canopy area of *Prosopis limenis* doubled when grown at a low density compared with the highest-density plantings; *A. macracantha* height growth in low-density plantings was double that of high-density plantings; and *S. molle* height growth was ten times greater in high-density plantings than in the low-density plantings. The installation of bird perches and nesting poles attracted 39 bird species acting as pollinators and seed-dispersers and facilitating the recruitment of new plant species (70 new plant species appeared naturally where drip-feed lines provided sufficient humidity). The introduction of native plants promoted a significant increase in the biocontrol of pests by predator insects and birds.

Policy and land governance. The project's research results were used to support the approval of a regional government ordinance revoking all permissions to make charcoal and a decree banning the felling of *Prosopis* trees. A new police division in charge of environmental protection was created, an important step towards controlling illegal deforestation and charcoal-making.

Sustainability. The project's tree nursery continues to be funded by Trees for Cities (a British NGO) and Asociación para la Niñez y su Ambiente (ANIA, a local NGO), and a UNICA graduate has set up a successful private tree nursery for native species. The Huarango Festival is now organized under the auspices of the Ministry of Tourism and is firmly established in the official calendar. Most municipalities are aware of the importance of native woodlands and are using native species instead of ornamental trees. Several publications promote the many undervalued plant species in the region and their importance for human well-being and livelihoods. International media events have helped promote local pride and interest in culture–environment links and create tourism development opportunities. The involvement of agro-industries in the restoration programme has helped enlarge restoration efforts and secure further funding, mainly for incorporating restoration objectives in production operations.

Risk assessment. Neither the National Institute for Natural Resources nor the regional government have the necessary resources to enforce the new regulations on charcoal production, which continues throughout the project area.

Lessons learned

Reconnecting people and plants is a prerequisite for project sustainability. Communication and education efforts (e.g. media dissemination, lectures, learning tours, planting campaigns, and the Huarango Festival[31]) were maintained in local communities, with an emphasis on engaging youth. A school programme run by ANIA and local women to establish nurseries for native plants was an effective way of fostering the project's goals; the schools became hubs from which project staff were able to distribute seeds, information and technical advice on native trees and shrubs and the environmental services they provide to the families of schoolchildren and those landowners able to demonstrate sustainable water supplies.

Restoring traditional knowhow and techniques on seasonal floodwater-harvesting has the capacity to regenerate communities and cultures.

6.19 THE MILLENNIUM SEED BANK PARTNERSHIP[32]

The Royal Botanic Gardens, Kew's MSBP is one of the world's largest *ex situ* plant conservation initiatives, and it aims to safely store seeds from 25 percent of the world's "bankable" species by 2020. The MSBP is at the forefront of global plant conservation efforts, prioritizing the collection and banking of seeds from endangered wild plants and plants that may be of use in the future. As well as banking seed, the Royal Botanic Gardens, Kew deploys its considerable botanical knowledge in vegetation restoration and conservation projects around the world. Many of these projects are designed to support local communities in better conserving and sustainably using native species. Kew has worked with more than 50 communities in dryland Africa, from Burkina Faso, Mali and the Niger to Botswana, Kenya and South Africa, in developing approaches to restore multipurpose and biodiverse woodlots.

31 The Huarango Festival promotes cultural connections with the environment through the emblematic tree of Ica, including banquets offering products from native plant species.

32 Prepared by Moctar Sacande, Royal Botanic Gardens, Kew (www.kew.org/msb).

Approach

Kew's model for restoration success stems from the following five steps:

1) *Communities at the heart of restoration governance*: stakeholder communities are consulted and their commitment obtained. The consultation process enables an understanding of local needs and preferences, the gathering of uses of plant species and products, and the identification of restoration objectives in the communities, who contribute their managed land and their labour.
2) *Botanical knowledge and prioritization of species and activities*: through this process, the preferred native species (according to needs and activities) are analysed and prioritized. Prioritization is based on the capacity of species to adapt to local environmental conditions; uses; existing knowledge; and the collection and handling of seeds, including germination, propagation and storage. Some preferred species may require botanical verification and authentication prior to action.
3) *Operational processes*: this step involves the collection of high-quality seeds from selected natural stands, the capture of genetic diversity and physiological quality, and seedling production in nurseries. Soil preparation is a determining factor in restoration success in semi-arid areas, and the aim is to maintain maximum moisture from limited rainfall and for the maximum period of time, giving planted seeds and seedlings the best chance of establishment. "Half-moon" and "zaï" techniques that reduce water runoff are often used in the drylands of the Sahel. Seeds and seedlings are planted at the onset of and during rainy seasons to maximize the benefit of first-year rains.
4) The field performances of species, their maintenance and management, and the implementation of agreed activities, are monitored and evaluated in full consultation with communities, who contribute by helping collect technical information and data.
5) Village technicians are trained and capacity is strengthened, including adding value to and the development of plant products, marketing and local business management. Technical training is often extended to seed collection, nursery techniques, seedling production, planting, and plantation maintenance and management. Other important needs for skills – such as adult literacy, family health and nutrition standards – can also be addressed, in close consultation and conjunction with other specialized rural development sectors.

Impact

Following the successful restoration model devised by experts at the Royal Botanic Gardens, Kew, thousands of native tree species are being grown in village tree nurseries in Burkina Faso, Kenya, Mali and the Niger. About 4 000–5 000 seedlings from a minimum of ten local species are produced in each village tree nursery, which are managed by trained village technicians. These nurseries produce seedlings of species preferred by farmers that are also adapted to the habitats they restore and are often located in the vicinities of the planting areas.

The seedlings are planted in communal gardens and village agroforestry systems managed by the communities.

Restoration activities undertaken as part of the Great Green Wall for the Sahara and the Sahel Initiative in four transboundary regions of Burkina Faso, Mali and the Niger illustrate an important result. In the first year of the project (2013), more than 150 000 seedlings and 60 kg of seeds from 25 useful native species, including grasses for livestock, were planted on 320 ha of farmer-managed land in 21 villages. The keen interest these activities have created suggests that these numbers will rise many-fold in the years to come.

Lessons learned

The holistic approach (from seed and seedling to market) and sustainability built into the methodology have been keys to its success. The trusted partnerships that the Royal Botanic Gardens, Kew has developed with institutions in sub-Saharan Africa over many years are helping to sustain and expand collaboration around various conservation projects. The process of addressing farmer concerns and taking into account their preferred species has galvanized the adherence of farmers to the approach and their ownership of and commitment to the activities. Managing the expectations of stakeholders in large conservation projects such as these is vital to success, because one project cannot address all rural development issues.

Sustainability and scaling up

Following this successful restoration model, and in collaboration with FAO through the framework of the Great Green Wall for the Sahara and the Sahel Initiative, the MSBP is using its unique expertise to ensure that seeds of environmentally well-adapted and economically useful local species are collected and appropriately planted with the participation of local communities. The conservation capabilities of involved communities are being enhanced through training and the improvement of local facilities. Ensuring that communities are fully involved in key decisions and have ownership of project outcomes is a key factor in determining the sustainability of restored areas. With the success of the restoration model in these communities and villages, this pilot project provides an excellent basis for scaling up, potentially acting as a basis for future pan-African initiatives.

6.20 WORKING FOR WATER: JOB CREATION, WATERSHED MANAGEMENT AND THE CONTROL OF INVASIVE PLANT SPECIES IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA[33]

Water is a limiting resource for development in South Africa, and invasive alien plants have a negative impact on the supply of water from the ecologically fragile fynbos, the natural shrubland vegetation found in catchments in Western Cape Province. Conservative estimates indicate that invasive alien plants in

33 *Source:* Modified from a case study by Caroline Petersen in FAO *et al.* (2011).

these catchments use 143 million m^3 of water per year, which is equivalent to 4.1 percent of registered water use.

In 1993, a group of scientists and conservation managers called the Fynbos Forum decided to approach political decision-makers about clearing alien plants. A landmark presentation in 1995 described the devastating impact of invasive alien plants and suggested a revolutionary way of addressing the problem by creating work opportunities, an approach that had been piloted in a project on Table Mountain led by the Botanical Society of South Africa. This presentation led to the appointment of a leading scientist to work with the Minister of Water Affairs and Forestry to initiate a water conservation campaign based on the idea of controlling invasive alien plants while creating work for the previously unemployed. The objective was to increase water supplies by improving catchment and water-demand management rather than the construction of new dams – a revolutionary approach for the ministry at the time.

The Working for Water programme started in 1995, and ZAR25 million (US$3.3 million) was made available for the labour-intensive clearing of invasive alien plants throughout the country. Working for Water uses mechanical and chemical methods to remove alien plants from mountain catchments and river corridors. The programme creates temporary jobs and provides unemployed people with training, while also restoring land productivity and ecosystem functioning – for example, in the way water moves, fires burn, and plants and animals live. The project has a strong focus on work creation and capacity building for the previously unemployed – especially women and youth.

The Working for Water concept has since been extended and similar programmes initiated. Working for Wetlands, Working on Fire and Working for Land all aim to provide training and work for the previously unemployed while meeting environmental goals. Their consistent focus on work creation and delivery has secured them long-term political support.

In Western Cape Province, the target for the programme's cycle for 2000-2010 was to clear 636 000 ha of invasive alien plants in the Berg, Breede, Fish-Tsitsikamma, Gouritz and Olifants-Doorn catchments. If invasive vegetation was not cleared, the water wasted by invasive alien plants could have increased to 457 million m^3 per year, or 13 percent of registered water use.

Over its 14 years of operation, Working for Water has spent ZAR4 billion (US$527 million) in clearing nearly 2 million ha of invasive alien plants across South Africa (of an estimated total of 16 million ha infested). In so doing, the programme has created 27.5 million person days of employment. Numerous awards have recognized the remarkable achievement of this programme.

6.21 COMBATING DESERTIFICATION IN THE HORQIN SANDY LAND THROUGH INTEGRATED AFFORESTATION, INNER MONGOLIA, CHINA[34]

Lead organizations: the Chinese Government and FAO, with technical support from the Chinese Academy of Forestry, the Beijing Forestry Institute and the Three North Bureau, and financial support from the Government of Belgium.

Threat

Desertification is widely recognized as a major environmental hazard in China, especially in the north. It is the cause of an increasing incidence of sandstorms, which have severe consequences for the environment, agriculture, urban centres and infrastructure. The Horqin (or Korqin) Sandy Land (HSL) is a sandy dryland located in the far-eastern part of Inner Mongolia. The chief agents of erosion are very strong winds (above 8 Beaufort, or 62 km per hour), which occur on 25–40 days per year and are associated with the generation of sandstorms. The conversion of grassland and woodland to cultivated land, and over-grazing, are the main causes of desertification in the HSL.

Approach

Aim: the Afforestation, Forestry Research, Planning and Development in the Three North Region of China Project aimed to consolidate the genetic material used in afforestation; introduce appropriate mechanized afforestation techniques; and integrate forestry into efforts to combat desertification.

From 1960 onwards, approximately 22 million ha of vulnerable cropland have been protected in eastern Inner Mongolia through the establishment of shelterbelts in desertification-prone sandy drylands. Shelterbelts reduce the impact of sandstorms, wind erosion, shifting sands, droughts and frost, and they improve the microclimate in sandy drylands by regulating temperatures, wind speed, soil water losses and transpiration.

Impact

The project successfully introduced and improved poplar genetic material through the *ex situ* conservation of *Populus simonii*, implemented a short-term and long-term clonal selection and improvement programme, and secured new clones in the field. The project also enabled the development of mechanized afforestation techniques for medium-depth and deep tree planting. Other outcomes were the introduction and selection of conifer species and their use in afforestation, and advances in agroforestry.

The quality of afforestation in the pilot sites has improved, along with the level of scientific research and work efficiency. Contributions by the project in areas such as clonal selection, tree-breeding, site classification, mechanized

34 Compiled using the FAO Forest Restoration Monitoring Tool and www.fao.org/docrep/005/AC613E/AC613E00.htm#TopOfPage.

afforestation, the integration of forestry, agriculture and animal husbandry, species diversification and the development of afforestation models are directly relevant and applicable in the HSL, as well as in other regions, and are having important economic consequences.

Lessons learned

Major technical breakthroughs have been realized, especially in tree species selection, breeding and mechanized afforestation techniques, but extending these to the field requires considerable outreach efforts. The research results, including new technologies, techniques and planting material, should be made available to all involved in forestry activities in the HSL and similar areas.

Forestry research and development require long-term approaches. Both governments involved, and FAO, are aware of this and have supported the project for more than 12 years. Strong cooperation is required with reliable scientific research institutions to follow up on the project's outcomes and to conduct further research.

6.22 APPLIED RESEARCH FOR THE ECOLOGICAL RESTORATION OF DESERTIFICATION-PRONE AREAS IN THE ALBATERA WATERSHED, VALENCIA, SPAIN[35]

Lead organization: Centro de Estudios Ambientales del Mediterráneo in Valencia Region, Spain.

Approach

Aims: to repair ecosystem functioning by enhancing patches of vegetation that contribute to the regulation of water, materials and nutrient fluxes; to increase species diversity and contribute to improvements in ecosystem stability and resilience against disturbances; and to reduce the risk of soil erosion and floods.
The approach to applying research to the restoration of the Albatera watershed involved the following steps:

1) The identification of seven environmental units based on landscape heterogeneity (slope, aspect, degradation status, vegetation cover and previous land use) and the application of specific restoration techniques in each unit.

2) The selection and nursery production of native plant species (evergreen trees, shrubs and mega-herbs) meeting the following criteria: high coverage for soil protection; high capacity to develop dense canopies and accumulate litter; and rapid recovery from disturbances (e.g. fire). Seeds were collected in the same biogeographic area as the restoration project.

   Innovative nursery techniques were employed, comprising the following: the use of containers with high capacity (400 cm^3) and lateral rips to impede

35 *Source:* Chirino *et al.* (2009).

root spiralling and stimulate the development of good root systems with secondary roots; containers filled with a mixture of light peat and coconut fibre (at a ratio of 1:1); the cultivation of seedlings for nine months in similar light and climatic conditions as those prevalent in the restoration area; the adjustment of watering to species needs and the avoidance of excessive watering; the use of several mild drought cycles to stimulate drought resistance in a preconditioning phase before outplanting; the watering of seedlings to field capacity to ensure good water status prior to outplanting; and the application of basic levels of nitrogen (N)–phosphorous (P)–potassium (K) fertilizer during seedling growth and a hardening fertilization (4N:25P:35K) fixed at 50 parts per million of nitrogen during the preconditioning phase to inhibit root growth.

3) Restoration techniques for each environmental unit:
   - Environmental unit 1 (head of watershed) – no restoration action (vegetation in good condition).
   - Environmental unit 2 (old terraces with pines) – planting high-cover, re-sprouting shrub and tree species to act as soil-retaining vegetative barriers to reduce the impact of soil losses due to terrace collapses in unsuccessful past forestation efforts. Variable planting densities in holes (60 cm × 60 cm × 60 cm) or small furrows (300 cm long × 60 cm × 60 cm), with the addition of compost from sewage sludge (at 4 kg per hole) and the protection of seedlings with mesh to avoid predation.
   - Environmental unit 3 (south-facing slopes) – planting re-sprouting shrub species to increase vegetation cover in moderately degraded conditions, using microcatchments to improve runoff harvesting, tree-shelter tubes to improve microclimate and protect against herbivores, and soil amendments (composted sewage sludge and mulching). Planting density = 625 holes per ha (60 cm × 60 cm × 60 cm); compost from sewage sludge added at 4 kg per hole; mulch added to the soil surface; and tree-shelters used (75 percent shading).
   - Environmental unit 4 (north-facing slopes) – planting re-sprouting shrub species to increase vegetation cover and species richness in slightly degraded conditions, using soil organic amendments and a protective mesh against predation that also provides some shade (25 percent light reduction). Planting density = 400 holes per ha (60 cm × 60 cm × 60 cm); compost from sewage sludge added at 4 kg per hole; and mulch added to the soil surface.
   - Environmental unit 5 (north-facing slopes with pines) – planting re-sprouting shrub species to increase species richness in old pine plantations with scattered native shrubs in the lower part of the watershed. Planting density = 100 holes per ha (60 cm × 60 cm × 60 cm); mesh used to protect against predation.
   - Environmental unit 6 (river bed) – planting to increase the density and richness of riparian plant communities to create physical barriers and reduce

the transport of sediments (landslides) and the erosive power of the water. Planting density = 100 holes per ha (60 cm × 60 cm × 60 cm).

- Environmental unit 7 (water channelling) – constructing small terraces with stone walls and planting seedlings at a high density (2 500 seedlings per ha), using organic amendments in the planting holes and on the soil surface to allow the natural colonization of opportunistic species (grasses) and a rapid increase in vegetation cover to halt advanced erosion processes in water irrigation channels. Planting holes (60 cm × 60 cm × 60 cm) and small furrows (300 cm long × 60 cm × 60 cm) used; compost from sewage sludge (added at 4 kg per hole) mixed with soil; and tree-shelters used (75 percent shading).

Implementation period. Restoration actions were carried out in the winters of 2003 and 2004, and monitoring was in place from 2003 to 2007.

Result

Survival rate after four years. The average survival rate of seedlings after four years was 54 percent, which is moderately high compared with previous restoration efforts by the provincial forest service in the same area. The highest survival rate (>83 percent) was in the "river bed" and "water channelling" environmental units, and the lowest survival (30 percent) was in the "old terraces with pines".

Plant growth after four years. Sixty-three percent of the species planted reached height values greater than the global average (46 cm). Of these, *Tamarix africana* (172 cm), *Salsola genistoides* (113 cm) and *Stipa tenacissima* (102 cm) achieved the greatest height growth. The lowest heights generally coincided with the species with the lowest survival rates.

Lessons learned

- The combination of technological improvements with adequate plant species selection resulted in an improvement in restoration outcomes compared with previous restoration efforts in the same area.
- Adequate nursery culture protocols produced high-quality seedlings with morpho-functional characteristics adapted to water-limited environments. Nevertheless, survival and growth was highly variable between species, and some very common species, such as kermes oak (*Quercus coccifera*), showed low survival rates, reflecting unsolved problems in the use of such species in restoration. Some introduced species have flowered and fructified in recent years, which should contribute to the natural recovery of the area.
- Field treatments have improved conditions for the introduced seedlings and facilitated the natural colonization of a variety of native species in planting holes. Although plant competition could be detrimental to the survival and growth of introduced seedlings, the increase in vegetation cover and stability is an advantage in these degraded areas.

- The combination of a greater technological investment and adequate species selection in environmental unit 3 (south-facing slopes) may have compensated for the limitations imposed by the higher degree of soil degradation and greater climatic constraints (i.e. higher temperatures and water stress) to provide better results than those achieved in environmental unit 4 (north-facing slopes) with more favourable environmental conditions.
- The limiting conditions prevailing in many degraded drylands increase the cost of ecological restoration actions and require the best available technology. The introduction of keystone species and increases in vegetation cover were surrogates for the main goal – restoring ecosystem functioning and allowing self-sustaining ecosystem organization.
- Collaboration at the local level among scientists and stakeholders, along with community involvement, were keys to the successful application of the ecological restoration programme in Albatera. Monitoring and database development should be intrinsic components of all restoration projects.

6.23 INNOVATIVE FOREST RESTORATION TECHNIQUES IN SEMI-ARID CONDITIONS IN NORTHEAST SPAIN: SOIL CONDITIONERS AND MULCHING[36]

Threat

Mediterranean areas are characterized by a moderate to severe dry period in summer, coinciding with high temperatures. This annual drought, which is expected to become more severe with foreseen rises in temperature in the next decades, is the most limiting factor for primary production and subsequently for ecosystem restoration. Apart from its direct impacts (hampering vegetation survival, growth and spontaneous recovery after disturbance), summer drought leads to indirect impacts, including forest fires. The situation is especially critical in areas where annual precipitation is low, such as in semi-arid conditions where desertification is a major threat.

Degradation in these semi-arid areas is driven by either resource overuse or forest fire, and restoration is a challenge. In most cases, the spontaneous development of vegetation in such areas might not result in the successful recovery of ecosystem functions and components, especially in sites where erosion hampers the process because of steep slopes or light soils; in such situations, active restoration measures are needed. These tend to be expensive and frequently have to be supplemented (e.g. with emergency irrigation) if the first summers are excessively dry. Therefore, many forest restoration efforts are abandoned, and public entities face increasing problems to ensure the successful restoration of these areas.

The case presented here derives from a semi-arid area in Mequinenza, Zaragoza Province, in northeastern Spain. The area burned in 2003; after ten years it showed very poor vegetation recovery and had ongoing erosion, especially on south-facing slopes. The most important factors hampering

36 Case study prepared by Jaime Coello and Míriam Piqué, Sustainable Forest Management Unit, Forest Sciences Centre of Catalonia, Solsona, Lleida, Spain.

recovery were low water availability (370 mm annual precipitation, 20 percent of which occurs in summer), high summer temperatures, light soils (loamy-sandy texture), and steep slopes (40–60 percent).

Approach

The satisfactory restoration of degraded ecosystems in semi-arid conditions requires cost-effective techniques with the following features:

- sustained increase in soil water available to plants;
- minimum labour investment during installation/application and maintenance;
- applicability in remote, poorly accessible areas;
- low costs of purchases, transport, installation/application and disposal; and
- environmental friendliness, such as the use of environmentally benign products based on renewable or recycled raw materials.

Based on these factors, a consortium of ten European entities (six small and medium-sized enterprises and four research and development agencies) launched the Sustaffor project for the period 2013–2015.[37] The main objective is to develop and validate novel techniques for improving reforestation projects from an economic, environmental and technical point of view. The novel techniques are:

- the application of soil conditioner, a granulated product mixed with the soil at the planting pit, involving a new formulation of 23 ingredients, including a new complex of hydroabsorbent polymers;
- the use of groundcover or weed mat (mulching) to impede weed establishment and reduce soil-moisture evaporation near newly planted trees. Three prototypes of mulch were developed and used:
  - a biopolymer-based frame, 100 percent biodegradable, fused to a commercially available biodegradable film;
  - woven jute cloth treated with furan bio-based resin to extend the lifetime (100 percent biodegradable); and
  - recycled rubber-based mulch, ultraviolet-resistant, reusable in successive tree plantation projects, 1.5 mm thick.

These techniques were applied individually or combined (i.e. soil conditioner + mulch) and compared with reference techniques commonly applied for the same purpose: that is, commercial soil conditioner; plastic mulching; and commercial biofilm. The performance of the techniques was evaluated in terms of tree survival, growth and physiology, and soil features (temperature, moisture, organic matter and chemical properties). Two of the eight field trials of the project were installed in semi-arid conditions (Mequinenza) planted with Aleppo pine (*Pinus halepensis*) in March 2014, in both north-facing and south-facing conditions.

37 The research presented in this case study benefited from funding from the European Union's Seventh Framework Programme managed by REA-Research Executive Agency.

Impact

Tree survival and growth. The survival rate was very high overall (93 percent), with slightly higher survival (95 percent) among trees where soil conditioner was used compared with those where it was not (90 percent survival). The use of soil conditioner (both the novel formulation, and the commercial formulation) significantly increased tree growth compared with trees where soil conditioner was not used. Likewise, trees mulched with biopolymer, jute and polyethylene mulch grew significantly more than unmulched trees.

Tree water status. The highest doses of soil conditioner (80 g per tree) resulted in higher needle leaf water content than low doses (20 g per tree). Rubber and jute mulches created higher tree water status than trees mulched with commercial biofilm and unmulched trees.

Technical and environmental balance. The novel techniques were applied at the time of planting, do not require maintenance, and are biodegradable (except for rubber mulch, which must be removed). These are significant technical and environmental improvements compared with commonly used techniques such as emergency irrigation and plastic mulching. Moreover, the novel techniques are environmentally benign and based on recycled or renewable materials.

Lessons learned

Active forest restoration requires the consideration of plantation or tending techniques to ensure success. Moreover, the project must be adequately conceived in terms of soil preparation, species and provenance choice, seedling format, and protection against browsing damage, among others.

Given the low need for maintenance (except for non-biodegradable mulches), soil conditioning and mulching, ideally combined, are preferable to the recurrent and unpredictable use of emergency irrigation, herbicide application, and other techniques.

The novel techniques led to results that were similar or superior to reference techniques, suggesting the potential for their use at an operational scale, especially given the environmental benefits they provide compared with most currently available approaches. Uncertainty about the future climate and the funds available for forest restoration in Mediterranean conditions means that a sound approach would be to use planting techniques that best allow the autonomous and resilient development of seedlings without further tending operations. Larger investments per tree at the time of planting will largely be compensated by the reduced density of seedlings (given higher rates of survival) and the reduced need for maintenance.

6.24 FARMER-MANAGED SOIL AND WATER CONSERVATION IN THE CENTRAL PLATEAU OF BURKINA FASO[38]

Threat

Severe droughts in the Sahel in the twentieth century caused major human and environmental crises. The 1968–1973 drought was particularly severe and resulted in the deaths of many people, animals and trees. Declines in agricultural productivity and tree cover, food shortages, and an increase in soil degradation and wind erosion can be attributed to the combined effects of climate change, demographic pressures, and sociopolitical changes.

In Burkina Faso, groundwater levels decreased as well as crop yields, causing social disruption as men out-migrated in search of work. The area of barren land on the country's Central Plateau expanded considerably due to high population densities (50 persons per km² and higher) and the expansion of cultivated lands, including on land unsuitable for agriculture.

Approach

Innovations in SWC techniques began gaining popularity among farmers on the Central Plateau in the 1980s, with initial support from NGOs. Local farmers achieved two major technical advances based on indigenous SWC practices:

1) Improved zaï planting pits: farmers elsewhere in the Sahel have used zaï planting pits for many years, and the innovation here was to increase the depth and diameter of the pits. To reclaim severely degraded land, farmers dug grids of planting pits across their rock-hard plots and added organic matter to the pits. Soil fertility is improved in the planting pits by the capture of windblown soil and organic matter, as well as by attracting termites, which dig channels that improve soil structure, water retention and infiltration and decompose organic matter, increasing the availability of nutrients to plants. Water retained in the pits allows plants to survive dry spells. The area of cultivated land expands as farmers rehabilitate land where nothing grew before.

   There is no standard approach to preparing planting pits, and farmers adapt the technique to their own needs. Planting pits may be used to intensify crop production, and some farmers also use them for reforestation or to develop new agroforestry systems, either by protecting trees growing spontaneously in the pits (from seeds in the manure and compost) or by sowing tree seeds in the pits.

2) Contour stone bunds: these bunds, designed to reduce water runoff and encourage infiltration, are built with stones that are laid out in long lines with a base of 35–40 cm and reaching a height of about 25 cm. A simple technique was developed using hosepipes and water to enable farmers to easily identify contour lines and ensure the correct alignment of the stones.

38 *Source:* Reij, Tappan and Smale (2009).

Stone bunds trap sediments and organic matter from the catchment area and help retain the applied manure and organic matter in the pits, which improves soils in intervention areas.

It is estimated that 200 000–300 000 ha of severely degraded land have been restored using these SWC techniques, involving 140 000–200 000 households and benefiting 0.4 million–0.6 million people (out of a total population in Burkina Faso of 14.8 million in 2007). The average cost per ha of restoring land with the techniques was US$200 (project costs plus labour investment by farm families).

Impact

Crop productivity. Crop yields increased by 400 kg per ha and an additional 80 000–120 000 tons of cereal were produced. The average volume of wood was 15 m^3 per ha without SWC and 28 m^3 per ha with SWC.

Food security. Some families have become fully food-secure, and most have seen a reduction in their structural food deficit from 6 months to 2–3 months, which is an important gain.

Equity. The investment in labour required to install zaï pits and contour stone bunds is high. Access to such techniques may therefore be greater for richer farmers, potentially contributing to inequality among farmers. Poorer families are more likely to benefit from project-supported interventions that assist multiple households simultaneously.

Agroenvironmental impacts. The number of species, average tree density, and the percentage of trees with diameters greater than or equal to 11 cm were all reported to be significantly higher on rehabilitated land. New agroforestry systems have been developed on what used to be barren land. In Ranawa village, for example, a comparison of aerial photographs between 1984 and 2002 showed a clear trend of increasing tree cover in association with contour stone bunds.

Lessons learned

- The most successful innovations are often simple, low-cost improvements.
- A single technique or practice is usually insufficient to achieve meaningful environmental and economic change. Multiple innovations are more likely to bring more rapid environmental change by achieving synergies in the management of soil, water, crops, livestock and trees, as well as by diversifying economic opportunities.
- A "menu" of technical options can only be widely adopted on a large scale if it is adaptable, flexible and testable by farmers under their own heterogeneous economic, social and environmental conditions.
- Collective actions produce more sustainable benefits than do individual achievements.

- Farmers are much more likely to adopt a set of innovations if at least one such innovation can provide them with significant benefits in the first or second year.

6.25 DEGRADED ARID LAND RESTORATION FOR AFFORESTATION AND AGROSILVOPASTORAL PRODUCTION USING THE VALLERANI SYSTEM IN GOROM GOROM, BURKINA FASO[39]

Lead organization: Reach Italia (an NGO), in partnership with Deserto Verde (another NGO), LuxDev, Belgian contractors, and many others.

Threat

Northern Burkina Faso receives 300–500 mm annual rainfall. Oudalan, Seno and Soum provinces are facing serious problems of land degradation and desertification. Due to climate change and poor resource exploitation practices, the soils of this agropastoral land are heavily degraded, with consequences for soil fertility, groundwater recharge, tree density and herbaceous cover and the availability of water for humans and livestock. The proportion of bare, crusted and eroded areas is around 26 percent. Agriculture and livestock are the two main activities in the area, but agropastoralism has increased pressure on already precarious and fragile ecosystems, forcing people to engage in long-range transhumance activities. The degradation process is negatively affecting people's living conditions, with implications for local economies and food security.

Approach

Aim: to restore highly degraded lands for afforestation and agrosilvopastoral activities in order to enhance food security and environmental conservation and stabilize rural families in their local communities.

The approach taken in this initiative was as follows:

- A community-based approach to natural resource management prioritized the participation of villages in decisions and actions related to local implementation.
- Mechanical work was conducted using the Vallerani system; this system uses "Delfino" ploughs, which allow the mechanical creation of half-moon anti-erosion microbasins.
- Seeding methods included the direct planting of local forest species, whose germination and growth is made possible by the water collected in the microbasins and the use of goat dung containing seeds collected in the night after feeding the goats with ripe seeds made accessible by shaking trees. Seeds that have passed through the stomachs of animals are protected from predation until the arrival of the rains, and they sprout more easily because dung is an ideal fertilizer, which leads to early germination rates of 95 percent. Thanks to direct seeding, roots develop gradually and vertically in search of

39 *Source*: CILSS (2009).

water and become deep and more drought-resistant. Direct seeding in animal waste containing the seeds of local species (particularly *Acacia raddiana*), which are better able to resist harsh climatic conditions, supplemented by the transplantation of nursery species that are rare or difficult to collect (e.g. *A. senegal* and *A. seyal*), also increases biodiversity. Restoration areas are kept open to animals (i.e. no fences or guards) because the strong development of the herbaceous layer in the first year protects seedlings. The system does not use any water except rain, helping avoid soil salinization.

Community involvement. Technology is just part of the recovery process: important work with communities is required upstream and downstream. All communities are involved in the management process – in identifying the areas to be restored, clarifying the land uses of the affected areas, planning, and implementing (e.g. gathering and keeping forest seeds of local ecotypes, soil enrichment and sowing). Local villages are involved in the care and defence of new plantations and in the monitoring and evaluation of the results of vegetation regrowth through periodic measurement. Rules for SLM are adopted and respected by all; for example, it is forbidden to install camps in or near restored areas, to cut trees, and to mow for commercial purposes.

Extension and training methodology. Instructors provide local people with training and environmental education, for example by raising awareness on the need to avoid overgrazing. Training is also provided on how to use the Delfino plough and on techniques for improving land productivity.

Implementation costs. The use of the Delfino plough, combined with direct seeding, provides woody cover at less than half the price of traditional techniques typically used in the Sahel. The average cost of the process (including tractor, plough and tractor driver) is €150 per ha when an area of 800 ha is rehabilitated per year.

Impact[40]

- *Rapid and efficient treatment of large degraded areas within a short time*: more than 4 000 ha of degraded land had been restored in the Sahel by 2009.
- *Strong reconstitution of the herbaceous layer in the first year after the mechanical work*: grass fodder production increased by a factor of 5–30 compared with unmanaged lands. The production of herbaceous biomass varied from 420 kg to 2 090 kg (dry matter) per ha; thus, on average, 1 250 kg of herbaceous biomass (dry matter) per ha developed on sites where the Vallerani system was deployed, compared with an average of 90 kg (dry matter) per ha in control plots. This represents a surplus of 22–106 grazing days per tropical cattle unit per ha constructed. This extra fodder supply

40 These impacts were obtained from an evaluation of a sample of 605.09 ha (out of a total of 1426.59 ha) worked in Gorom Gorom between 2001 and 2008 by Reach Italia and Deserto Verde.

reduces the need to cut shrubs to meet livestock needs for fodder, even in years where the quality of pasture is low.
- *Significant improvement in forest cover* (685 live trees per ha, on average): trees are capable of spontaneous growth, even under pressure from traditional extensive grazing and in years of high water stress.
- *A tree survival rate of 79 percent*: by comparison, the survival rate of conventional plantations from seedlings raised in nurseries barely reaches 50 percent in the Sahel.
- *Improved floral richness*: 44 species were identified on treated plots, compared with 24 species in the surrounding control rangelands.
- *Improvement in the quality of restored pastures*: this improvement is shown by the high proportion of grassland species of good forage value, such as *Panicum laetum* and *Schonefeldia gracilis*, and the return of legume species such as *Alysicarpus ovalifolius* and *Zornia glochidiata*.
- *Improved soil hydrodynamic properties*: these include improved infiltration, which promotes better root development.
- *Minimal production of carbon dioxide* compared with the potential gain.
- *Improved income for rural families.*
- *A high level of community involvement*, as shown by the considerable interest in the community in restoring new areas.

Sustainability

It is recommended that: for effective site management, there is a high level of organization, particularly concerning rules governing the protection, use and upkeep of the site; the soil is worked properly with ploughs, which need good maintenance; intervention continuity is provided through the involvement and responsibility of local people for the sustainable use of the products; and investments are made in pastoral water projects to create new watering points, deepening the "boulis" (artificial pools) to avoid the transhumance of pastoral communities in the restored areas when searching for water.

Lessons learned

- The success of restoration interventions depends on various factors that affect the efficiency of plough use, such as the type of land (sandy loam to clayey soils seem to be most efficient, with structures lasting long enough to promote the regeneration of woody species), the skill of the tractor driver, the land management objectives (in terms of the area and density of half-moons), and the choice of local tree species adapted to the region (e.g. *Acacia raddiana, A. senegal, A. nilotica* and *Ziziphus mauritiana*).
- Large-scale application reduces the cost per ha and increases the impact of actions in reversing the degradation–desertification trend.
- The partial and limited application of the Vallerani system has produced disappointing results that are far below the system's potential.
- It is essential to involve and give responsibility to local people in every step

of the process.
- Safeguarding measures should be adopted for the period necessary for the "settlement" of the approach and the management of results.
- This type of approach seems highly suitable for implementation within the framework of the Great Green Wall for the Sahara and the Sahel Initiative.

6.26 RESTORATION USING BENCH TERRACE SYSTEMS IN DRYLANDS: THE COLCA VALLEY OF PERU[41]

Threat

Due to a lack of maintenance, the bench terrace systems in Peru's Colca Valley, which date back to 600 CE, have deteriorated, and local people have lost their traditional knowledge of repair techniques.

Approach

Broken sections are cleared and the various materials (e.g. stones, topsoil, subsoil and weeds) are removed and separated. The foundation is re-established, a stone wall (the "riser") is constructed, and subsoil is used to backfill the terrace. This earth is consolidated and then covered with topsoil. Simultaneously, complementary irrigation and drainage systems are reconstructed.

Supportive measures. Native (i.e. *Schinus molle, Buddleia* spp. and *Cassia* spp.) and fruit (*Prunus salicifolia*) trees and shrubs are planted (at an average density of 250 trees per ha) at the base of terrace walls as an additional measure for stabilizing the walls, diversifying production and improving the microclimate. SWC measures such as improved fallow, early tillage, ridging and intercropping are adopted to prevent future land degradation.

Incentives and costs. Ninety percent of land users (2 160 families) in the project area applied the technology with incentives (the project covered 65 percent of the overall costs of labour, tools and explosives, etc.), while the remaining 10 percent (240 families), aware of the need for SWC, adopted the technology without incentives.

Result

Forty percent of terraces have been rehabilitated in seven districts (eight microwatersheds) of the Colca Valley. Ninety-five percent of these rehabilitated terraces have been well maintained and land users are satisfied with the benefits, while the remaining 5 percent of rehabilitated terraces have been damaged again due to a lack of maintenance, although land users continue to cultivate them for crops.

41 *Source*: WOCAT (2007).

Impact

Traditional technology has been demonstrated to be of great value and adapted to local conditions. The community action used in this terrace rehabilitation project is part of a broader, integrated systematic approach that is now widespread in the Andean region; a Latin American network of watershed management has been established. In Peru, a broad range of NGO-driven development projects uses this approach. Nevertheless, there is only a moderate trend in the spontaneous adoption of terrace rehabilitation, and more awareness is needed among local communities.

Lessons learned

There is a need to reverse the current trend of individualism among farmers and to reactivate the lost traditional forms of reciprocal and mutual support in order to reduce costs and enable individuals to implement heavy works. Properties are private but not titled, an issue that restricts access to credit and technical assistance; there is a need, therefore, to legalize titles. More applied research, training and extension support is needed to enable local people to carry out the very specialized work of repairing broken sections of the terrace system. Terrace restoration should be complemented with SLM practices: for example, grazing should be prevented on short terraces with high stonewalls.

6.27 THE USE OF TREATED WASTEWATER FOR GREENING THE DESERT: ALGERIA AND EGYPT[42]

This case study reports on two countries in which FAO – with the financial support of the Italian Government and the in-kind contributions of several Italian scientific institutions (FAO project GCP/RAB/013/ITA) – responded to requests for support in the transfer of innovative methodologies on the use of treated wastewater.

Involved organizations: FAO, the General Directorate of Forests (Algeria), the University of Maskara (Algeria), the Undersecretariat for Afforestation and Environment (Egypt), the University of Alexandria (Egypt) and several Italian research institutions, including the University of Basilicata and the University of Tuscia.

Threat

In drylands, competition for freshwater between agricultural and domestic use has a significant effect on people's livelihoods. In urban and peri-urban areas there is often both a lack of freshwater and an abundance of wastewater. Untreated wastewater can be highly polluting, reducing water quality in rivers and other water bodies and causing soil salinization and desertification. Because of the lack of freshwater, however, people and farmers in urban and peri-urban areas often have no option but to use water of marginal quality.

In Algeria's Saharan oases of Brézina and Taghit, the combination of water

42 *Source:* www.fao.org/forestry/TWW.

depletion and growing populations is leading to groundwater contamination. In Brézina, the Seggueur River has, for centuries, recharged the groundwater that serves the cultivation of palms in Brézina and guarantees the survival of areas downstream as far as Daiet El Bagra. The Larouia Khang dam, at the confluence of tributaries of the Seggueur River, has greatly changed the hydrogeological balance of the Brézina oasis and the region downstream. The palm grove is dying and groundwater has been polluted by untreated wastewater released onto land. In Taghit, sewage water and industrial waste flow into depressions, where most of the oasis's palm trees are located. This is damaging the health of the palms and of animals that graze in those areas.

In Egypt, the use of sewage water to irrigate both urban and rural plantations is well anchored in the traditions of the Ministry of Agriculture and Ministry of Environment. The most spectacular is the Luxor *Khaya senegalensis* plantation, the growth of which is remarkable. However, these plantations need to be managed sustainably to ensure their survival and allow their expansion. The quality of the treated wastewater used for irrigation needs to be improved to reduce soil pollution and increase the positive filtering effects of trees.

Approach

Aims: in Algeria, to produce better-quality wastewater through the establishment of constructed wetlands; and, in Egypt, to ensure sustainable forest management and the future expansion of forest area through the effective and safe use of treated wastewater to mitigate desertification, increase soil fertility and create additional sources of income (e.g. through the production of high-quality wood, biomass and carbon credits) to sustain people's livelihoods and ensure the long-term sustainability of plantations.

In Algeria, in the oasis of Brézina, a wetland was constructed to treat secondary-quality water for the production of wood biomass. In the oasis of Taghit, four wetlands will be constructed to improve water quality and availability and to fight sand encroachment. The government requested improvements in the constructed wetlands because, while these are considered suitable for remote rural areas (which cannot afford the cost of building and operating conventional wastewater treatment plants), they can only be applied in small villages because the filtering process requires more time and large areas of land. In Taghit, the implementation of four constructed wetlands in the oasis will improve the quality and management of treated wastewater discharged into the Zousfana River, the only source of water in the area, and will therefore protect the oasis ecosystem.

In Egypt, FAO supported the development of a forest management plan for a forest plantation irrigated with treated wastewater located in the desert lands of Ismailia on the edge of the Suez Canal. FAO organized month-long training for national forestry technicians and experts in forest inventory methodologies and data collection. In coordination with all the national partner institutions, FAO also produced a forest management plan identifying constraints and opportunities

and making recommendations for the future development of the plantations based on the environmental, economic and developmental goals set by the Egyptian Undersecretariat for Afforestation.

In the desert area surrounding the city of Luxor, a huge sewage water treatment plant was established with the support of the Government of the United States of America, including a pumping station for the irrigation of planted forests. The current area planted is far smaller than the capacity of the irrigation, and it was decided to establish plantations of *Jatropha curcas* in addition to the *Khaya senegalensis* forest, with the objective of biofuel production.

Sustainability

There is interest in both Algeria and Egypt in scaling up project activities to improve the quality of treated wastewater. This requires the application of modern filtering systems to reduce carbon dioxide emissions and improve soil fertility, as well as training in the safe use of treated wastewater and in forestry and agroforestry practices. The safe use of treated wastewater requires that the system is properly maintained over time. The continuous involvement of governmental institutions at the national level and NGOs at the local level will be crucial.

Lessons learned

- Multiple stakeholder involvement is fundamental for achieving sustainable results.
- In the Algerian oases, local communities are the key actors and beneficiaries of the implemented activities. Their involvement is crucial for ensuring the continuation of project activities, and continued participation and involvement is also needed at the ministerial level.
- The regulatory framework on the use of treated wastewater should be reviewed and strengthened.
- In Egypt, project implementation was highly successful in the training and establishment of a network of forestry experts. To ensure the sustainability of the forest, however, the management plan needs to be put into action and the Ministry of Agriculture still has concerns about endorsing it because of the lack of an adequate normative framework.

7 The way forward

The restoration of degraded forests and landscapes in drylands is needed more urgently than ever; indeed, it is essential if the global community is to meet the challenges posed by desertification, food insecurity, climate change and biodiversity loss, among other negative trends. The many efforts that have already been made – with more or less success – provide the lessons that underpin these guidelines.

The restoration of drylands should be considered as a holistic process that includes a wide range of actions aimed at addressing multiple dimensions: policies, governance, the financial and technical capacity of organizations and individuals, and the design, management, monitoring and evaluation of restoration initiatives. It should be treated as part of broader ongoing, adaptive and multisectoral SLM strategies at the landscape level. Economic, social and environmental sustainability should be the ultimate aim of all restoration initiatives.

There is no ready-made recipe for restoration in drylands, however. These guidelines are intended to be global in scope, and they should be tailored to suit regional and local contexts. They present the essential components for the design, implementation and sustainability of restoration initiatives that help build ecological and social resilience and generate benefits for local livelihoods.

Practitioners cannot do restoration alone; policymakers and other decision-makers at all levels need to do their share. From the central level to the smallest administrative unit, dialogue among multiple sectors and stakeholders will help in addressing the root causes of degradation, improving policies and governance, securing tenure, supporting markets and attracting investment. Practitioners, policymakers and other decision-makers also need the help of networks, partners and donors to increase their technical and financial capacities.

Dissemination and adaptation of the guidelines to local contexts

The guidelines will be promoted, disseminated and translated into other languages as required to make them available to local actors while encouraging their use and adaptation to local, national and regional contexts. Capacity-development workshops and information events will be organized to support the dissemination and use of the guidelines and to provide opportunities for stakeholders to share their experiences from the field and compile good practices and lessons learned.

Continued networking and regional and international collaboration

An informal network of professionals with different skills and expertise (at the field and policy levels and from the research community, the private sector, NGOs and development partners) was established in the course of developing

these guidelines. Nurturing this network, and widening it to other countries and regions and potential partners, is essential for continuing the sharing of experience, knowledge and contacts for future collaboration, widening and facilitating the community of enablers, and building bridges between practitioners and policymakers to boost the implementation of the guidelines.

The dryland restoration community needs to capitalize on growing regional and international cooperation programmes and initiatives. Cross-border and regional collaboration is needed to improve the conservation of species and ensure a sustainable supply of seed for the restoration of comparable or transborder degraded forests and landscapes. Countries will have opportunities to demonstrate and make visible the contributions of drylands nationally, regionally and internationally by building on the 20×20 initiative in Latin America and other regional initiatives, such as the Great Green Wall for the Sahara and the Sahel Initiative and the Collaborative Partnership on Mediterranean Forests, and on global initiatives such as the GPFLR and the Forest and Landscape Restoration Mechanism[43] in achieving the Bonn Challenge and the Convention on Biological Diversity's Aichi targets.

These guidelines show that restoration needs to be considered across the entire market value chain, from seed to end-product. Seeds are often the starting point in restoration, whether it involves ANR or planting. Regional collaboration in developing a network of regional seed-supply centres is essential for developing value chains for native species suitable for building resilient forest landscapes in drylands. In the framework of the Great Green Wall for the Sahara and the Sahel Initiative, for example, and building on a partnership with the MSBP, Burkina Faso's National Forest Seed Center and the Tree Seed Center of the Kenya Forestry Research Institute were identified as leaders that could provide technical support for the development of seed value chains in Great Green Wall participant countries in West Africa and East Africa. Seed centres will be needed in other dryland regions to support the supply of seed for restoration.

A major effort is also needed to strengthen local governance and develop local leaders and restoration champions. This can be done by strengthening community-based organizations, local administrations, FPOs and small and medium-sized enterprises.

Enhance resource mobilization

Financing opportunities emerging from the various funding instruments – at the local-to-global level – need to be further explored and used to advance restoration and the implementation of these guidelines. On the ground, various stakeholders and partners in countries are developing and implementing Global Environment Facility co-funded projects in dryland countries; such projects are excellent ways of complementing domestic efforts to implement the guidelines.

43 The Forest and Landscape Restoration Mechanism: www.fao.org/forestry/flrm.

Strengthening bridges with research

A range of regional and global research networks is active in dryland regions, including the Society for Ecological Restoration's Global Restoration Network, the World Overview of Conservation Approaches and Technologies, and the Restoring Natural Capital Alliance. It is essential to create linkages between these initiatives, restoration practitioners and communities as a way of applying research results on the ground; combining new learning with traditional practices; defining the elements of success in dryland restoration by context; and supporting monitoring and the documentation and dissemination of best practices on the ground.

Continued monitoring, assessment and reporting on dryland restoration

FAO and the World Resources Institute, supported by the African, Caribbean and Pacific Group of States–European Union, IUCN and the Global Environment Facility, convened the first Drylands Monitoring Week[44] in Rome, Italy, in early 2015. Participants adopted the Rome Promise, which is a call to action to improve the monitoring and assessment of drylands for their sustainable management and restoration. In following up on this event, many partners are engaging collaboratively to conduct the first global assessment of drylands using Collect Earth (a simple remote sensing tool developed by FAO – see Box 3.1). This is a first step in the implementation of the Rome Promise and will build a robust baseline to support restoration monitoring efforts. Other tools are available for collecting baseline information at different scales and thereby helping in planning and monitoring restoration efforts. The monitoring and reporting tool discussed in these guidelines will be published online to help countries, stakeholders and partners to monitor and report on their restoration efforts in drylands.

44 www.fao.org/forestry/aridzone and www.fao.org/dryland-forestry.

Glossary

Adaptive management (MEA)	A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. In active adaptive management, management is treated as a deliberate experiment for purposes of learning
Afforestation (FAO, 2010f)	The establishment of forest through planting and/or deliberate seeding on land that, until then, was not classified as forest
Biodiversity (Convention on Biological Diversity)	Variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems
Capacity development (Organisation for Economic Co-operation and Development)	The process whereby people, organizations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time
Climate change (IPCC)	A change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer
Cultural keystone species (Garibaldi & Turner, 2004)	Culturally salient species that shape in a major way the cultural identity of a people, as reflected in the fundamental roles these species have in diet, materials, medicine, and/or spiritual practices
Desertification (UNCCD)	Land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities

Drought (UNCCD)	A naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems
Drylands (MEA)	Areas with an aridity index value of less than 0.65 – that is, areas in which annual mean potential evapotranspiration is at least 1.5 times greater than annual mean precipitation
Ecological restoration (Society for Ecological Restoration)	The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed
Enabling environment (FAO, 2010a)	The context in which individuals and organizations put their capabilities into action and where capacity development processes take place. It includes the institutional set-up of a country, its implicit and explicit rules, its power structures, and the policy and legal environment in which individuals and organizations function
Farmer-managed natural regeneration (Haglund *et al.*, 2011)	The practice of actively managing and protecting non-planted trees and shrubs with the goal of increasing the value or quantity of woody vegetation on farmland
Food security (FAO, IFAD and WFP, 2014)	A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life
Forest (FAO, 2010f)	Land spanning more than 0.5 ha with trees higher than 5 metres and a canopy of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use
Forest degradation (www.fao.org/docrep/015/i2479e/i2479e00.pdf)	The reduction of the capacity of a forest to provide goods and services

Forest landscape (Maginnis and Jackson, 2005)	A landscape that is, or once was, dominated by forests and woodlands and which continues to yield forest-related goods and services
Forest landscape restoration (Rietbergen-McCracken, Maginnis and Sarre, 2007)	A planned process that aims to regain ecological integrity and enhance human well-being in deforested or degraded landscapes
Invasive species (FAO, 2010f)	Species that are non-native to a particular ecosystem and whose introduction and spread cause, or are likely to cause, sociocultural, economic or environmental harm or harm to human health
Land degradation (UNCCD)	Reduction or loss, in arid, semi-arid and dry subhumid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation
Landscape approach (FAO, 2012c)	Deals with large-scale processes in an integrated and multidisciplinary manner, combining natural resource management with environmental and livelihood considerations. It differs from ecosystem approaches in that it may include multiple ecosystems. The landscape approach also factors in human activities and their institutions, viewing them as integral parts of the system rather than as external agents. This approach recognizes that the root causes of problems may not be site-specific and that a development agenda requires multistakeholder interventions to negotiate and implement actions

Other wooded land	Land not classified as forest, spanning more than 0.5 ha, with trees higher than 5 m and a canopy cover of 5 to 10 percent, or trees able to reach these thresholds *in situ;* or land with a combined cover of shrubs, bushes and trees above 10 percent. Does not include land that is predominantly under agricultural or urban land use
Participation (www.fao.org/Participation/ourvision.html)	The process of equitable and active involvement of all stakeholders in the formulation of development policies and strategies and in the analysis, planning, implementation, monitoring and evaluation of development activities. To allow for a more equitable development process, disadvantaged stakeholders need to be empowered to increase their level of knowledge, influence and control over their own livelihoods, including development initiatives affecting them
Payments for environmental services (www.cifor.org/publications/pdf_files/OccPapers/OP-42.pdf)	Voluntary transactions whereby a well-defined environmental service is "bought" by a minimum of one buyer from a minimum of one provider if and only if the service is provided continually
Reforestation (FAO, 2010f)	The re-establishment of forest through planting and/or deliberate seeding on land classified as forest
Resilience (Walker *et al.*, 2004)	The capacity of a social and/or ecological system to absorb disturbance and to reorganize while undergoing change so as to retain essentially the same function, structure, identity and feedbacks
Vulnerability (IPCC)	The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. A function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity

Water harvesting (Mekdaschi Studer & Liniger, 2013)	The collection and management of floodwater or rainwater runoff to increase water availability for domestic and agricultural use as well as ecosystem sustenance

References, further reading, tools and guidelines, other case studies and websites

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175
FAO FORESTRY PAPER

Global guidelines for the restoration of degraded forests and landscapes in drylands

Building resilience and benefiting livelihoods

Drylands cover nearly half of the earth's land surface and are home to one-third of the global population. They face extraordinary challenges, including those posed by desertification, biodiversity loss, poverty, food insecurity and climate change. Up to 20 percent of the world's drylands are degraded, and people living there are often locked into a vicious circle of poverty, unsustainable practices and environmental degradation. It is clear that serious efforts are needed to arrest dryland degradation and restore degraded lands, and the simple but urgent aim of these guidelines is to support such efforts
It is the first time that global guidelines on dryland restoration are made available. These guidelines target two main groups – policymakers and other decision-makers, and practitioners – because both have the power to bring about positive change. While they should be tailored to suit regional and local contexts, they present the essential components for the design, implementation and sustainability of restoration initiatives that can help build ecological and social resilience and generate benefits for local livelihoods.
As illustrated by the rich case studies provided, the guidelines involve a vast range of actions, from on-the-ground activities such as habitat protection, assisted natural regeneration, sand-dune stabilization and planting, to policy improvements, provision of financial incentives, capacity development, and continuous monitoring and learning. Moreover, they show that restoration needs to be considered across the entire market value chain, from seed to end-product, as well as at the landscape level, including the mosaic of land uses, needs and expectations of interest groups.

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